ZIMBABWE'S AGRICULTURAL REVOLUTION REVISITED

Edited By:
Mandivamba Rukuni,
Patrick Tawonezvi,
Carl Eicher
with Mabel Munyuki-Hungwe
and Prosper Matondi

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PART IV THE AGRICULTURAL REVOLUTIONS

Tobacco production requires adherence to schedules and quality control

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Tobacco research and development

Desirée L Cole and James S. Cole

Zimbabwe became the third largest exporter of high quality tobacco in the world, although the tobacco industry originated from modest beginnings. The production of tobacco was started by the indigenous population before the arrival of white settlers. Later, a small group of white farmers planted it as a potentially profitable venture before the end of the nineteenth century. In 1905, 100 farmers were growing the crop and by 1910 about 90,000kgs of flue-cured tobacco were being exported annually to Britain (Haviland, 1952). Sustainable production of any product hinges on its research and development. In the many changes of fortune that occurred during the ensuing years it became obvious that the internationally orientated export industry required specialized and up-to-date research support to solve the problems that were increasingly besetting growers.

The growth of the tobacco industry also saw growth and increased expertise in research which made a strategic contribution to the expansion of Zimbabwe's tobacco industry.[192] The tobacco industry made a major contribution to national development, rural and urban employment, training and resettlement. Funds for research originated from a levy on tobacco sales to finance research and development. The funds were collected by the Zimbabwe Tobacco Association which financed a large proportion of the Tobacco Research Board's flue-cured budget, the Tobacco Marketing Board and the Tobacco Training Institute. The Tobacco Training Institute offered a one-year diploma course and short courses on latest practices and techniques in tobacco production for farmers, managers and supervisors. The Tobacco Research Board liaised closely with the Tobacco Training Institute in a specialized teaching programme on all aspects of tobacco production. Training of smallholders was catered for at the Trelawney Training Centre, funded by government and managed by the Zimbabwe Tobacco Association. The course covered all aspects of small-scale flue-cured production, rotation and farm finance. A small-scale production unit was used as a production model. After completing the Trelawney Training Centre course, promising farmers were assisted financially and technologically in re-

[192] For a discussion of the history of tobacco production and research, see Stinson (1957), Weinmann (1972) and Dunlop (1971).

settlement areas allocated in conjunction with government agencies.

The Tobacco Training Institute was renamed Blackfordby Agricultural Institute in 1995, when tobacco monoculture was becoming less popular. The Commercial Farmers' Union and the Zimbabwe Tobacco Association formed a trust to finance the new college. A two-year diploma in general agriculture replaced the one-year diploma in tobacco production with tobacco as one of the main crops studied. In 1997 the Zimbabwe government passed the Tobacco Marketing Levy Act Amendment and took direct control of the tobacco levy. The Act provided for the opening of a 'tobacco levy account' for financing research and training in connection with the production and marketing of tobacco. The Farmers' Development Trust continues to be operated by the Zimbabwe Tobacco Association and runs the Dozmery as well as the Trelawney training centres.

The following section will examine the structure of Zimbabwe's tobacco industry, including the types of tobacco that are grown and their input requirements with regard to land, finance and skills.

Types of tobacco grown in Zimbabwe

Zimbabwe produces three types of tobacco: flue-cured, burley and oriental. The potential for expansion has not always been fully realized in Zimbabwe, partly because of the world campaign against smoking and partly because of the lack of infrastructure. This has resulted in some farmers diversifying into other export crops such as flowers, fruits and vegetables.

Flue-cured tobacco

Flue-cured tobacco requires substantial financial resources to purchase tillage units, fertilizers and crop protection chemicals. Permanent barns are needed to cure the field crop and facilities have to be constructed to grade and prepare the finished product for marketing. A well-grown, carefully handled and marketed flue-cured tobacco crop can be very rewarding financially but mistakes can be ruinous because of the high cost of production. Although best suited to large-scale commercial production, tobacco can be grown on a small scale provided the above ingredients are present. Finance can be secured through the market but technical and management skills and commitment can only be acquired by training and experience.

Because tobacco has been produced almost entirely for export, the availability of suitable markets has been a key motivating force for production. In 1950 there were 2,100 commercial growers of flue-cured tobacco and the number increased to 2,927 in 1965 (Tobacco Marketing Board, 1990a). But after mandatory economic sanctions were imposed in 1966 some farmers stopped growing tobacco and the number had declined to 1,547 at independence in 1980.

The number then fell further to 1,145 growers in 1981 but increased to 1,746 in 1991 and had risen to 8,537 by 2000. The area under flue-cured tobacco production increased from 61,180 hectares in 1950 to 87,770 hectares in 1966, declined to 40,952 hectares in 1968, rose to 91,905 hectares in 1998 and fell again to 84,857 hectares in 2000 (Tobacco Industry and Marketing Board, 2000a).

The quantity of flue-cured tobacco produced more than doubled from 47,294 tonnes in 1950 to 110,951 tonnes in 1966. Production rose from a low of 51,507 tonnes in 1968 to about 83,000 tonnes in the next ten years and then increased erratically to 133,866 tonnes in 1990. The ten-year period from 1990 to 2000 was a time of great change in the grower base and in 2000 production reached 236,946 tonnes, of which 6,000 tonnes came from smallholders. Farm yields increased linearly from 773kg per hectare in 1950 to 2,253kg per hectare in 1990,[193] an annual increase of 40kg per hectare; they had reached 2,792 kg per hectare by 2000, an 18 per cent increase since 1990. It is unlikely that an increase of this magnitude could have been achieved without a consistent and highly skilled research effort. The annual recorded increase in monetary value of the crop is significant in relation to what has been spent on research.

In 2000, the government resettlement programme gathered momentum, driven by the invasion of commercial farms by war veterans and others. Many farms were designated for resettlement and by July 2001, half the white-owned commercial tobacco farms had been designated. Tobacco output in 2001/02 declined by 56 per cent compared to the average in the 1990s and continued to decline during the fast track resettlement programme period due to a reduction in the number of operational white commercial farmers.

Burley tobacco

Burley, the air-cured tobacco produced in Zimbabwe, is grown on heavier, more fertile soils than those most suitable for flue-cured tobacco. This means it competes more strongly with food crops, such as maize, for land. Crop inputs are less than those required for flue-cured tobacco but more fertilizer is used. Barn construction costs are variable. The framework can be of rough timber, sides are usually removable and the light wooden frames may be covered with strengthened hessian. Construction and costs are more within the scope of smallholders, especially for the Malawi-type barns, but there must be sufficient air humidity (about 75 per cent daytime relative humidity) to cure burley satisfactorily and prevent leaves from drying prematurely. Because there are only restricted facilities to manipulate air humidity in barns, good quality burley cannot be grown satisfactorily in dry areas or seasons.

Organized burley tobacco growing started around 1960, much later than

[193] The coefficient of determination (r2) is 0.92 (P<0.001).

flue-cured tobacco growing. The quantity produced was always much smaller than that of flue-cured tobacco but it is an important cash crop, particularly for small-scale commercial and communal farmers. The quantity produced has risen and fallen with the price. The area under production in the large-scale commercial sector has not changed much but the combined area of small-scale commercial, cooperative and communal farmers increased tenfold in the 1980s. Markets could have been found for much more than the 1990 production of 5,893 tonnes but only for low nicotine, fluffy-textured, good quality burley grown and cured in a suitable environment. Production increased from 1990 to a peak of 16,797 tonnes in 1993 then fell back erratically, according to the season, to 8,165 tonnes in 2000 (Tobacco Industry Marketing Board, 2000b).

Commercial farmers more than doubled their yields during the mid-1970s from 1,125kg to 2,362kg per hectare. The average yield per hectare for smallholders, however, declined during the mid-1970s but rose slowly to 1,000kg per hectare in the 1980s. Between 1995 and 2000, yield was never more than about 650kg per hectare. Communal farmers and cooperatives usually managed to achieve higher yields in burley tobacco production than flue-cured and sometimes had yields in excess of 1,000kg per hectare.

Oriental tobacco

Oriental tobacco has few prerequisites. It can be grown as a family enterprise on 0,1 hectare of sandy, infertile soil in semi-arid regions. In agro-ecological areas where oriental tobacco does well, food crops often fail and tobacco can provide some cash income to sustain the family. Sufficient labour to reap and string about 4,5 million leaves per hectare is the limiting factor. Good quality oriental is produced from small leaves on closely-spaced plants grown in sandy soil, sparsely fertilized and with little rain. Leaves are threaded onto strings and hung on simple home-made moveable racks and stored, when cured, in small pits to maintain them in a pliable condition for grading and baling.

Oriental production increased slowly from 1966, through assistance from research and extension at the newly opened Oriental Research Station at Masvingo. Since independence, oriental tobacco sales have increased erratically from 13,343kg in 1983 to reach a peak of 43,844kg in 1990. Production then decreased to 38,794kg in 2000.

Tobacco research

Modern research is a sophisticated operation that enables techniques or industries to advance to more complex levels; it involves the generation of new ideas and testing them objectively. The research objectives may be to maintain a market position or to get ahead of competitors.

Tobacco Research Board

The Tobacco Research Acts of 1936 and 1938 made tobacco research the responsibility of the Tobacco Research Board. Although government financed the semi-autonomous board, the extension of the results to farmers remained under the authority of the Department of Research and Specialist Services in the Ministry of Agriculture. This was an unsatisfactory arrangement and in 1948 the government again took over control of research. But farmers pressed for research to be independent of direct government control and in 1950 the Tobacco Research Board resumed responsibility for research. The Rhodesia Tobacco Association, renamed the Zimbabwe Tobacco Association after 1980, agreed to pay 63 per cent of the annual research budget from a levy raised on the sale of the tobacco produced. The remainder came from government funds. There were three members of the Rhodesia Tobacco Association on the board, two representatives of the Ministry of Agriculture and two from the Tobacco Trade Association. The national average yield for the 1945–1950 period was 708kg per hectare. The objectives of the Tobacco Research Board were to improve the yield and the quality of the tobacco, to reduce input costs and to encourage good husbandry and soil conservation. Plans were laid for the provision of adequate laboratories and land for a complete research programme to cover the practical farm problems encountered in growing good quality tobacco.

In the early 1950s there were three tobacco research stations – at Prospect near Harare, Trelawney and Karoi in Mashonaland West province – where field experimentation on fertilization, crop rotation, soil management, plant breeding, and disease, nematode and insect control of flue-cured and oriental tobacco were in progress. Dr Stinson, a Canadian tobacco agronomist was appointed as director of the Tobacco Research Board. In 1953 the first aims of the new board were realized by the completion of laboratory and ancillary buildings at Kutsaga Research Station, a former tobacco farm near Harare. Specialists were recruited from the United Kingdom, United States of America, Canada and locally, and a research programme was started. By 1955 there were 14 professional officers stationed at Kutsaga (Harare) and Trelawney research stations, covering agronomy, agricultural engineering, biometry, entomology, nematology, plant breeding and plant pathology. Formal departments were instituted in 1958 and the number of professional staff increased to 22 by 1960 and 27 in June 1968. Although sanctions reduced the professional staff to 14 in 1969, by 1990 the professional staff complement was up to 34 and by 2000 it had increased to 42.

Early research thrusts

When the research programme was launched in 1950 the conventional wisdom of farmers was to wait for the arrival of the rains before planting seedlings from the seedbeds. However, regular rainfall when transplants are small tends to leach nutrients, especially nitrogen, from the root zone and growth is retarded. Research found that tobacco could be transplanted before the rains by filling the planting hole with water, which settled the roots in the soil and kept the plants alive for four or five weeks. A stress period after planting was found to be beneficial and if there were nutrients in the root zone, yields could be improved dramatically.[194] Research results on dry planting provided a firm basis for a general recommendation to farmers. The logistics of the operation also had to be developed because it was essential for farmers to store water to be able to apply it to the holes rapidly and efficiently. The development also provided the stimulus for building dams and irrigation infrastructure on farms.

Over time, the research programme evolved into a combination of in-depth, long-term studies and short-term, problem-solving exercises.

Nematology

The sandy soils were infested with root-knot nematodes (*Meloidogyne javanica*) which were a major constraint on yield potential. Research soon produced results that formed the basis of a recommendation for fumigating seedbeds with methyl bromide gas before seeding and fumigating a localized area of the ridges in the field with ethylene dibromide before transplanting seedlings. Both methods are still in general use. Rotation experiments with root-knot-resistant grasses provided evidence that nematode populations could be kept within reasonable limits by 3–4 years of pasture although field fumigation was still necessary. As research advanced, root-knot nematode resistance was initially incorporated in two cultivars on open release. By 2000, cultivars with root-knot resistance made up nearly half of the tobacco crop produced by large-scale and smallholder farmers.

Worldwide pressure to restrict and eventually ban the use of methyl bromide as a soil fumigant mounted between 1990 and 2000 and more resources were devoted to finding an acceptable alternative. None of the pesticides tested controlled the growth of weeds, fungi and nematodes as effectively as methyl bromide. A United Nations Development Organization funded programme was initiated in 1999 to intensify research in this area. Its scope included alternative methods of seedling production and research to replace methyl bromide began in 1996 with trials of soil-less culture of seedlings. The programme enabled the expansion of the range of soil-less culture techniques tested, some of which were already in commercial use in other countries. In 2000 it was agreed that soil-less culture of seedlings was the most economically feasible and practical alternative to the use of methyl bromide although suitable chemical treatments were also available.

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[194] A similar technique had been used previously in Zimbabwe (Nobbs, 1913).

Agronomy and soils

Much of the early research substantiated methods that were already used by innovative farmers but research was necessary to test and modify the methods for general application. In the decade up to 2000 the amount of irrigated tobacco produced increased substantially. Research during that period was able to resolve the problems involved in new techniques such as drip feed and centre-pivot irrigation, and to revise outstanding aspects of conventional sprinkler application methods and rates. Major progress was made in the automatic diagnosis of curing problems and fertilizer requirements, deficiency and toxicity symptoms by electronic expert systems (Flower, 1990; Flower *et al.*, 2000). The expert systems' databases were compiled from the accumulated knowledge of several sources and provide user-friendly, easily accessible text and photographs.

Constraints on early growth of transplants were given research priority including the problem of rain water leaching nutrients from the root zone in sandy soils. But despite the almost complete acceptance of early planting, it was impractical for farmers to plant all their tobacco early because reaping had to be spread over time to maximize labour use. Farmers did not know when and how much fertilizer to add to replace nitrate ions that had been leached by rainfall. Although considerable data have been accumulated on the mineralization of soil nitrogen and the movement of nitrate and ammonium ions in soil profiles (Ryding, 1988), a model was developed to predict when and how much side-dressing should be applied in relation to rainfall intensity and amount. General guidelines are incorporated in the Tobacco Research Board *Handbook of recommendations*, a loose-leaved booklet that is issued free to all registered tobacco growers and is available in English and Shona versions.

Crop protection

Chemical protection against insects and diseases in seedbeds is practical and essential for the production of healthy seedlings for transplanting. It is also permissible because seedbed leaves are not harvested. In 1953, tobacco anthracnose disease (*Colletotrichum tabacum* Boning), which can be seed-borne, was first diagnosed in Zimbabwe. A screening programme identified several fungicides that could control the disease satisfactorily (Cole, 1957 and 1959) and recommendations were widely adopted. The potential spread of the disease via seed led to the formation of the Zimbabwe Tobacco Seed Association in 1956, with a mandate to set international standards for producing certified tobacco seed in Zimbabwe. Research staff on the technical committee advised the executive committee on all matters concerning the protection of seed crops and the production of seed. Seedlings are regularly inspected for disease. Much research has focused on seedbed treatments as a way of ensuring healthy transplants which may be protected against disease for several weeks in the field.

Although compensation growth occurs in plants adjacent to missing tobacco plants in field crops (Shaw and Wixley, 1981) maximum yields are not possible where insects such as cutworms (*Agrotis segetum*) destroy a significant proportion of transplants. Shaw and Wixley estimated from their experiments at Kutsaga that a 10 per cent loss of stand should reduce the yield by about 7 per cent. From 1950, chemical control of soil insects was an important part of the research programme and the chlorinated hydrocarbons, such as DDT, aldrin and dieldrin were used for the purpose. At that time the detrimental effects of these agrochemicals were not fully realized. When the dangers became known, research on replacements facilitated the voluntary banning of the use of all chlorinated hydrocarbon insecticides on tobacco in Zimbabwe by 1970.

Research on compounds, not classified as pesticides, that are capable of inducing systemic resistance to several tobacco fungal and bacterial pathogens started in 1996. This marked a major advance in disease control by chemicals that are safe to use and do not leave harmful residues and a commercial compound that has been tested under local conditions is now available to farmers (Cole, 1999). The identification of new races of pathogens causing wildfire and angular leaf spot provided vital clues on why resistance in some recently released cultivars had broken down (Mapuranga, 1998; Cole and Mapuranga, 2001). A database of abiotic and pathogen-induced diseases was started in 1995 and was compiled from plant clinic records from 1985 so provides an invaluable record for such studies.

Pesticide and herbicide approval scheme

Although insects and diseases take their toll on unprotected leaves, the industry requires tobacco to have the absolute minimum residues of agricultural chemicals. The Tobacco Research Board was concerned about the effect of potential residues of agrochemicals on the end-users and on the market acceptability of Zimbabwe tobacco. A pesticide and herbicide approval scheme was formulated in the early 1960s in conjunction with the Tobacco Advisory Council in the United Kingdom whereby experiments with agrochemicals not only measured their biological efficacy but also the residues remaining after curing and the possible toxicological effects on smokers. Residue and taint tests formed an integral part of the testing programme. For a chemical to have full approval, the manufacturing company had to complete carcinogenic tests that were accepted by the Tobacco Advisory Council in the United Kingdom. Until they were completed and the results were satisfactory the use of the agrochemicals was countenanced, provided there were no *a priori* reasons for their exclusion.

In 1964 the Tobacco Research Board's pesticide and herbicide registration scheme was approved and only those agrochemicals that were fully tested in the research programme were eligible for registration for use on tobacco. The marketing company now has to supply a legal affidavit stating the full chemical details of the active ingredient as well as the wetting and filling substances in the commercial product.

Plant breeding

Plant breeding research has produced high-yielding disease-resistant cultivars and improved the styles of Zimbabwe tobacco. The first disease-resistant cultivar was released in 1968. It had resistance to powdery mildew (*Erysiphe cichoracearum*) which causes losses in yield and quality. Although epidemiological research and fungicide screening provided an effective way of controlling it, the new cultivars reduced input costs and overcame the problems of field sprays and residues. Over the years the genes for resistance to powdery mildew have been an integral part of nearly all breeding lines. Resistance to alternaria (*Alternaria alternata*), wildfire and angular leaf spot (*P. syringae* pv. *tabaci*), tobacco mosaic virus and root-knot nematodes were added to subsequent cultivars. The seven main hybrid cultivars on open release for the 2001/02 season have proven growth characteristics and have resistance to most of the pathogens that cause the major diseases, except race 2 of *P. syringae* pv. *tabaci*, frog-eye and sore shin.

The tobacco market is sensitive to small changes in the product and unusual colour or texture or other subjective assessments are regarded with suspicion. Experimental lines are tested in cooperative farm trials in several representative tobacco districts. Senior executives of the tobacco merchant companies assess the tobacco produced and subsequently the seed of promising cultivars is issued to selected farmers to widen the production base. If the tobacco is favourably received, more is grown and samples are provided for smoking and other tests to local and international companies. Representatives of the Tobacco Research Board, Tobacco Trade Association and Zimbabwe Tobacco Association meet each year to decide the maximum quantity of seed for release in the next season. All new released cultivars are hybrids which controls production because farmers cannot use their own seed.

Agricultural engineering

Curing, especially of flue-cured tobacco, requires special skills. Many innovations in barn adaptation and curing systems have originated from enterprising farmers. Agricultural engineering research has contributed to and improved curing techniques through, for example, the installation of fans in standard barns to improve throughput and leaf quality, continuous-flow tunnels and bulk and batch curers. The mechanization of seedbed sprayers (Hartill, 1971a, 1971b; Cole and Zvenyika, 1978; Deall and Cole, 1983) and field spraying with high-clearance tractors has added to the research on hand-held machines. Harvesting solar energy and storing it for curing smallholder and commercial farmers' tobacco presents a challenge that has been accepted by the agricultural engineering department and experimental units are being tested.

Information dissemination

As new information becomes available, results are formulated into recommendations to growers and incorporated into English and Shona versions of the *Handbook of recommendations.* Where techniques are too technical or costly for smallholders, they are simplified and made more realistic. More than 250 scientific papers have been published in appropriate books and scientific journals in Zimbabwe, the United Kingdom, the United States of America and Europe. Talks, broadcasts, field days and annual tours are formulated to disseminate research information. Popular articles on aspects of tobacco research and production are published regularly in local monthly tobacco magazines.

Response to market opportunities

Throughout the period 1950 to 2000, there was a steady output of research recommendations on how to increase the profitability of tobacco growing. At certain times the demand for immediate problem solving became intense, such as when new insects or diseases appeared, or when substitutes for banned agrochemicals were needed. In 1980 Zimbabwe tobacco once more appeared on world markets after 15 years absence and was subjected to comparison with tobacco from new competitors, particularly Brazil. Although some very good quality tobacco was on offer at the auction floors in Harare, international merchants were generally disappointed with the crop. Fortunately the problem had been anticipated and field trials at Kutsaga had already started on the effect of weather on leaf ripeness and curing schedules on tobacco quality. When these problems were solved (Garvin, 1985 and 1988), advice was provided to farmers and much more attention was paid to reaping ripe leaves and curing them according to parameters set by the weather during growth. Soon quality began to improve, especially in the highveld, and more mature and orange tobacco was produced. During the 1988 to 2000 seasons, high quality tobacco crops at country average yields of more than 2,250kg per hectare fetched good prices on the auction floors.

Stimulating smallholder production

Smallholders were growing oriental and burley tobacco during most of the colonial period. In 1979 the Rhodesia Tobacco Association started a scheme for training smallholders to grow flue-cured tobacco at Odar farm near Harare (then Salisbury) but it was not successful because 58 of the 60 participants had left the course by June 1980. Baxter (1981) attributed the failure of the scheme mainly to lack of adequate pre-planning, finance and participant selection. Training was restarted in 1985 at the Trelawney Training Centre, an institute funded by the government and managed by the Zimbabwe Tobacco Association. The students received an intensive three-month course. The training scheme was satisfactory but lacked appropriate follow-up. The subsequent inability of most trainees to realize the economic potential of the crop on their own farms emphasized the need for ongoing instruction and supervision.

In 1987 a committee composed of representatives of the Ministry of Lands, Agriculture and Rural Resettlement, the Tobacco Research Board, the Zimbabwe Tobacco Association, the Tobacco Trade Association and the Agricultural Finance Corporation was formed to provide guidelines on how to promote smallholder flue-cured tobacco production. Members visited smallholders in Zimbabwe and Malawi and the director of the Tobacco Research Board produced a paper based on their conclusions (Cousins, 1990). By then the committee had been expanded by representation from the Tobacco Marketing Board, the Department of Agriculture and Technical Services, the Department of Rural Development and the Forestry Commission. The committee reported that smallholder flue-cured tobacco production could be viable if candidates were supervised on their own holdings for several years after the completion of the training programme. Extension, finance and supervision were obvious prerequisites to success. Smallholders would benefit from central facilities, such as seedbeds and barns, so that certain tasks such as watering, harvesting and curing could be shared.

The recommendations in the concept paper formed the basis of a Zimbabwe Tobacco Association pilot project for smallholders on flue-cured tobacco in 1990 on Ashenden, Nyamuary and other farms near Marondera which had been acquired by the government and designated for smallholder resettlement. A resident manager was appointed to supervise the project and provide advice on all aspects of production. There was an intake of 10 to 12 trainee farmers from the Trelawney Training Centre each year. Each was allocated 10 hectares of arable land on which to grow two hectares of tobacco and two hectares of maize or groundnuts. The rest was laid down to a nematode-resistant pasture in a tobacco rotation. Poultry, rabbit and vegetable production were also encouraged. There were communal grazing areas in a paddock system for four head of cattle each. Low-cost barns, a grading shed, a dwelling place and Blair toilet were part of the allocation and were rented by the trainee farmers.

Short-term and medium-term loans, granted by the Agricultural Finance Corporation and guaranteed by the Zimbabwe Tobacco Association, were available to each individual for current costs of production, cattle and capital items. After the first two seasons of successful production, the best farmers were encouraged to grow four hectares of tobacco and then eight hectares and ultimately they would qualify for the Zimbabwe Tobacco Association tenant farming scheme. By 1990 the first intake achieved an average yield similar to that of large-scale commercial farmers. They sold their crops and even after paying their loan commitments they made a considerable profit.

Groups of smallholders in other tobacco areas have been growing tobacco since 1983 with the assistance of extension provided by the Tobacco Trade Association, Zimbabwe Tobacco Association, Agricultural Finance Corporation, Tobacco Research Board and the Department of Agricultural and Technical Extension Services. Initially, few were viable because of the high cost of barn construction and the low yields. The techniques and material inputs for barn construction were simplified and tested at Trelawney Training Centre and the extension input was increased. Starting with only 12 growers in 1983, the number increased to 340 by 1990 and 6,700 registered in 2000. Although the average yield was well below that of large-scale commercial farmers, the smallholders were profitably growing flue-cured tobacco in the early 1990s and 500 additional farmers were attracted by the high prices in 1991 to grow the crop in 1992. In the next ten years, however, results did not fulfil expectations and the average yield in the 2000/01 season was less than 900kg per hectare and the average price was only 64 per cent of the auction floor average.

Research and development: future needs

Change is a constant feature of progress. Individual tobacco researchers have produced outstanding results under serious constraints. The Tobacco Research Board was initially able to recruit and retain high-calibre scientists but during the 1980s tobacco may not have received the full attention of government in keeping with its strategic role in the economy. The importance of research to tobacco growers and the tobacco industry needs to be reassessed. An integrated tobacco industry with its own research and development for all types of growers, both smallholders or large-scale, would seem to be a desirable goal.

The three types of tobacco form the core of the tobacco industry in Zimbabwe. They provide rural employment and generate much-needed foreign exchange earnings. Small-scale commercial and communal farmers have gained from producing a high-value cash crop that complements production on the poor soils. Moreover, oriental tobacco often provided a cash return to communal farmers in drought years when maize and millet failed on sandy soils.

Turning to research priorities, there is world pressure to reduce the amount of agricultural chemicals used, for toxicological and environmental reasons, by as much as 50 per cent in the next decade. Tolerance limits for pesticide residues on tobacco are generally low and strictly adhered to. There are obvious advantages from using alternative methods of pest and disease control. A local isolate of *Trichoderma harzianum*, a soil inhabiting fungus, is currently patented for the control of a transplant disease caused by two phytopathogenic fungi, *Rhizoctonia solani* and *Fusarium solani*, and it can also stimulate plant growth (Cole and Zvenyika, 1988). A commercial company marketing agricultural chemicals is producing it locally and its potential for the control of other diseases in the float system of seedling production is being investigated. Biotechnology is seen as a line of research with tremendous potential in plant breeding and disease and insect control, although financial resources, availability of foreign exchange and biosafety regulations may determine the degree of complexity of the techniques employed. Biomolecular techniques for the identification and detection of plant viruses, bacteria and fungi also have great practical value. An innovative idea whereby tobacco premises could be used as factories to produce pharmaceutical and industrial chemicals much more cheaply than current industrial techniques has been considered by researchers. The wider application of plant propagation and tissue culture also gives scope for the commercial exploitation of research facilities and expertise. The new techniques could expand the grower base because much of the skilled part of tobacco production, such as curing, handling and marketing, would not be necessary. The ability to keep pace with advanced technology remains one of the key factors to success in the future.

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ZIMBABWE'S AGRICULTURAL REVOLUTION REVISITED

Since the publication of the first edition of the *Zimbabwe Agricultural Revolution* ten years ago, the country's agricultural sector has undergone fundamental changes. This book raises issues on the direction and pace of Zimbabwe's agricultural revolution.

Zimbabwe's agrarian history is unusual in African development experience in that the country used its own resources to craft an agricultural science base that fuelled the first and second agricultural revolutions. However, the policy environment and prime movers have been seriously eroded and that raises a question on whether the country is capable of generating a third revolution. The unfavourable macroeconomic environment, deterioration of the core rural institutions in the 1990s, a contested land reform programme, economic and political 'isolation' and recurrent droughts have all worked against agricultural recovery.

This book attempts to raise issues of importance for agricultural development. A common theme throughout the book is the need tackle challenges and prompt serious discussions that could lead to the recovery of the country's agricultural sector.

The book is targeted at students, academics, practitioners, policy makers, citizens interested in the agricultural development of Zimbabwe.

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