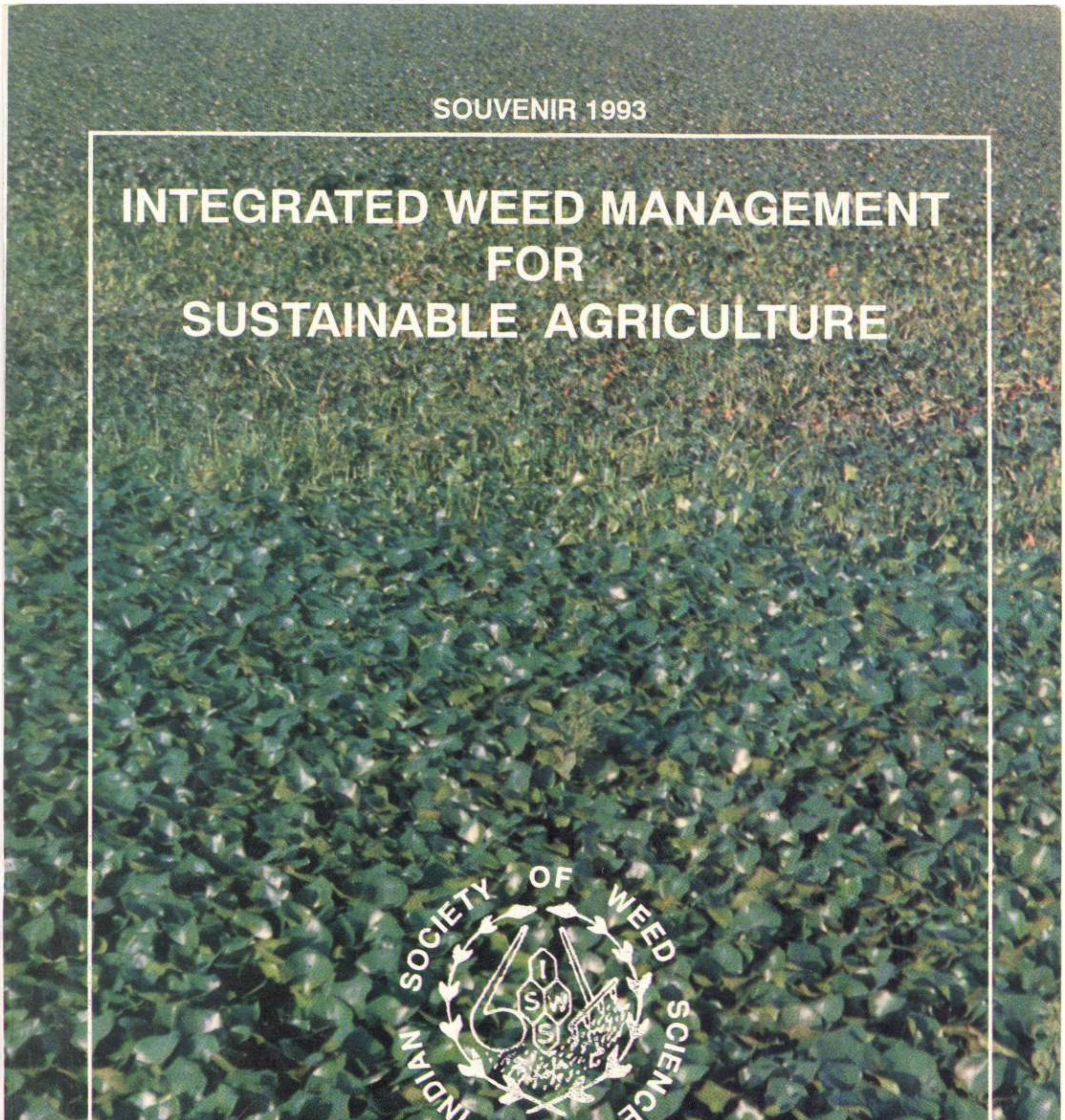
SOUVENIR 1993

INTEGRATED WEED MANAGEMENT FOR SUSTAINABLE AGRICULTURE



INDIAN SOCIETY OF WEED SCIENCE

1968

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INTEGRATED WEED MANAGEMENT FOR SUSTAINABLE AGRICULTURE

INDIAN SOCIETY OF WEED SCIENCE

1968

INTERNATIONAL SYMPOSIUM

18-20 November, 1993

Organised by :
Indian Society of Weed Science
at
Department of Agronomy
CCS Haryana Agricultural University
Hisar, Haryana, India

INDIAN SOCIETY OF WEED SCIENCE

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INDIAN SOCIETY OF WEED SCIENCE

K.S. Sandhu
Secretary Indian Society of Weed Science
Department of Agronomy, Punjab Agricultural University, Ludhiana

Indian Society of Weed Science was founded in 1968 under the able leadership of the late Dr. M.K. Moolani, then Professor and Head, Department of Agronomy, Punjab Agricultural University, Hisar (Now CCS Haryana Agricultural University). The objectives of the society were to promote knowledge of weed science and allied sciences; to encourage research in the scientific and practical aspects of different disciplines of weed science and to provide opportunity through periodical meetings for the research workers engaged in weed science. Initially the society had some problems but later on with dedicated efforts of its office bearers and cooperation of members, it has established its creditability in promoting the cause of weed science, for which purpose it was established. At present, it has a membership of about 480, of which 305 are life members.

The first number of journal of the society (Indian Journal of Weed Science) was published in 1969 from Hisar and thereafter being brought out regularly. Attempts were made twice to publish 'News Letter' of the society but due to certain unavoidable circumstances, it could not be continued. Efforts are on way to restart publication of the same. The ISWS, besides publishing journal has been holding Annual/Biennial Conferences from time to time at various places in the country to provide opportunities for the scientists to deliberate on various aspects of weed management and these were well attended.

The society has been playing a major role in highlighting the role of weed science in modern agriculture and welfare of the farmers. Realising the significance of Weed Science, All India Co-ordinated Research Programme on weed control was started by ICAR-PL. 480 in 1978-79 and National Research Centre for Weed Science by ICAR at Jabalpur (M. P.) in 1989.

At present the major bottleneck in prosperity of Society is that it has no permanent headquarters. In the past it has been operating from places like Hisar, Pantnagar, Hyderabad and Bangalore. It has now been decided to temporarily locate it at Hisar for two years (1994 and 1995) and then permanently shift it to Jabalpur (M. P.) where National Research Centre for Weed Science has been established and by that time it will start functioning at full swing.

This year in 1993, Indian Society of Weed Science is completing 25 years of its existence and commemorating its Silver Jubilee by holding an International Symposium on "Integrated Weed Management for Sustainable Agriculture" at CCSHAU, Hisar. The symposium will provide an opportunity to scientists from various countries to interact with one another. Besides, it will help the ISWS to develop links with other weed control societies especially American Society of Weed Science, European Weed Research Council, Asian Pacific Weed Science Society, Japan Weed Science Society, Australian Weed Science Society, Philippines Weed Science Society and Pakistan Weed Science Society.

I hope the ISWS will continue to prosper and serve the nation in increasing agricultural production.

MESSAGE

Bal Ram Jakhar

Agriculture Minister
Government of India,
New Delhi - 110 001

I am happy to learn that Indian Society of Weed Science is organising an International Silver Jubilee Symposium on "Integrated Weed Management for Sustainable Agriculture" at Chaudhary Charan Singh Haryana Agricultural University, Hisar from 18-20 November, 1993.

In the last 25 years, most work in weed science was concentrated on generating weed management recommendations for stabilising food production. Chemical weed control was readily accepted by farmers in wheat, rice and plantation crops, depending on the demand created by specific weed problem and nonavailibility of labour. The new objectives should be to enlarge the research base which could be done in five ways. First to generate new recommendations for dry land areas particularly with foliage absorbed herbicides so that moisture is not crucial for maximum efficiency. Second to strengthen weed science laboratories particularly in residue analysis, bio-chemical studies and weed management models. Third to foster new technologies including genetic engineering for herbicide resistance and parasitic weeds, bio-herbicides and their integration with other methods. Fourth to provide eco-friendly and cost effective weed recommendations after testing through extension means and fifth to strengthen teaching in weed science including short training courses. I would be happy to get feedback from the symposium.

I extend my best wishes for the success of this symposium.

November 5, 1993.

MESSAGE

M.S. Swaminathan

Centre for Research on Sustainable Agriculture and Rural Development
Madras, India

Long ago, the Roman Philosopher Seneca said "a hungry people listen not the reason nor cares for justice, nor is bent by prayers". Mahatma Gandhi expressed the same sentiment when he said "to the hungry, God is a loaf of bread". The television pictures we see daily now of starving children, women and men in Somalia testify the truth underlying the statements of Seneca and Gandhi. In 1964, Paul and William Paddock predicted a fate similar to "sheep going to a slaughter house" to the people of India by the year 1975. It may hence be appropriate to indicate the dimensions of India's accomplishments on the food security front.

The British colonial period began with drought and famine in Bengal in 1770, during which one-third of the population of the province perished. Just prior to the end of the colonial era, another great Bengal famine occurred during 1942-43, when about 3 million people died of hunger. Between 1770 and 1880, as many as 27 scarcities and famines were recorded. Twenty million lives were lost in about 20 famines during the period 1850 to 1900.

The population of the Indian sub-continent (including Pakistan and Bangladesh) was less than 300 million when great famines claimed numerous lives. The 1891 population figure of undivided India was 282 million. 10 million people died in a big famine in 1892. Today, the population of India is about 875 million and the population is growing by over 15 million each year. Yet, famines have been avoided since the country became independent in 1947. In 1965-66 food production was affected adversely by drought but there were no famines thanks to extensive food imports, largely under the PL 480 programme of the United States of America. Since the early seventies, the country prevented famines even during adverse weather conditions through a carefully designed food security system involving the maintenance of both substantial grain reserves and an extensive public distribution system. The food grain reserves were built largely from home grown wheat and rice, since from the late sixties, the rate of growth in food production generally exceeded the rate of growth of population. This was possible because of mutually reinforcing packages of technologies (developed by the national grid of research institutes, universities and grass root level training organisations), services and public policies which made it possible for farmers to make the country self-sufficient in food grains at current levels of purchasing power. But the challenge facing the country is not over. India has now nearly 100 million holding, 25% of the world's farmers are in India. Over 100 million ha of potential farm land has undergone varying degrees of degradation. No policy has yet been formulated to check the diversion of prime farm land for nonfarm use. This is true of groundwater resources which are often being exploited in an unsustainable manner. In intensively farmed areas, biotic and abiotic stresses are increasing. Unsustainable life styles and unacceptable poverty are both threatening the ecological security and social stability of our country and the planet as a whole. Therefore, the present challenge to scientific community is to impart a pro-environment and pro-poor bias in their scientific work.

I am happy that Indian Society of Weed Science is organising an International Symposium on "Integrated Weed Management for Sustainable Agriculture". I send my best wishes to all of you. I hope you will work out technologies for weed control which are ecologically, friendly and agriculturally sustainable.

MESSAGE

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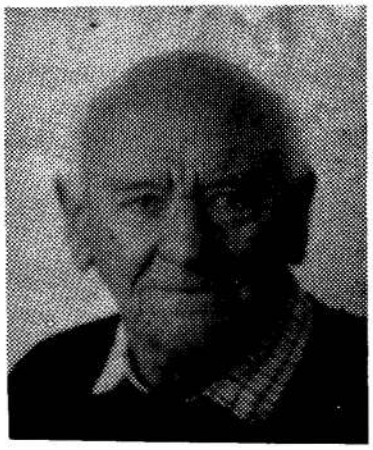

I first visited India in 1945 to take up an appointment as Area Officer of the Inter-services Stores Preservation Unit of the Indian Army. After a gap of 30 years I returned as Director of the Weed Research Organisation, Oxford to advise on the organisation of weed science in India and to encourage the formation of National Centre for Weed Science to serve the whole country. I am delighted by the progress that has been made in the recent years and am glad to have this opportunity to extend my very best wishes to the Indian Society of Weed Science and to the organisers of this International Symposium for the success of the Silver Jubilee, Symposium on Integrated Weed Management for Sustainable Agriculture being held at Chaudhary Charan Singh Haryana Agricultural University, Hisar, India from 18-20 November, 1993.

August 22nd, 1993

WEEDS AS MEDICINAL PLANTS

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Though the Himalayan yew, *Taxus wallichii*, may possibly be endangered, it's western American counterpart is considered a weed tree by western foresters, who had burned it in the past. Now, taxol from yew is the most promising new drug for cancer, especially ovarian cancer. It was apjproved by the U.S. Food and Drug Administration (FDA) Dec. 29, 1993. Taxol is predicted to become a billion-dollar drug by the year 2,000. Thus, the yew has replaced the weedy Madagascar periwinkle, *Catharanthus roseus*, once grown in India, now a pantropical ornamental, often becoming naturalized, especially in subtropical semi-arid pasture lands. Drugs from Catharanthus, vinblastine and vincristine, have commanded ca $100 million (US) a year for nearly thirty years, for the treatment of leukemia and other types of cancers. Podophyllotoxin from the Indian mayapple, *Podophyllum emodi*, has been modified a bit and converted into the drug vepeside, sales of which were $100 million, in 1990, the year when *P. emodi* was listed on the CITES endangered species list, $ 275 million in 1992. Will *Taxus wallichii* be close behind the Indian snakeroot and Indian mayapple as an endagered taxon? I do not imply that the Indian mayapple is a weed. But if it is endangered, Bristol Myers may be seeking alternative sources of podophyllotoxin, among them weedy species of *Hyptis* and *Juniperus*. These are plants at the forefront of the war against cincers, already developed. But these are for people who already have cancer.

Prevention may offer more hope than these toxic "cures". One of most promising phytochemicals for the prevention of cancer, especially breast and prostate cancer, is genistein. It prevents blood vessels from growing to newly develoing cancers, no more than 1 mm diameter, effectively checking their development into full blown tumors. Among the weeds reported to contain genistein are species of broom (*Cytisus, Genista*), chickweed, (*Stellaria*), clover (*Trifolium*), and kudzu (*Pueraria*). Vitamins A, C, and E, sometimes spoken of as the antioxidant aces in the hole against cancer, are well represented in our edible leafy weeds, like *Amaranthus*, *Chenopodium*, *Portulaca*, *Stellaria* and many other members of the Centrosperme. Probably the purslane, *Portulaca oleracea*, is best endowed in all three. Wild weedy members of the mustard family, so prevalent in India, may be equally endowed with A, C, and E plus the cancer-preventing indoles as well. However, phenolic antioxidant in the mint faimly seemed to have even more antioxidant activity than tocopherol or vitamin E, the premier antioxidant vitamin. Rosmarinic-acid, e.g., is very high in some of the weedy mint species, including *Prunella vulgaris*, the self-heal, considered a panacea by the Amerindian and Chinese as well.

On the AIDS frontier, compounds from the klamath weed, *Hypericum perforatum*, also known as St. John'swort, are in clinical trials in the US. Toxins from the African weed, the castorbean, *Ricinus communis*, and the American pokeweed. *Phytolacca americana*, can be affixed to monoclonal antibodies and targeted at the AIDS virus or tumors. The self-heal, mentioned above, is also in clinical trials for AIDS. Manyof the symptoms of AIDS can be attributed to oxidative damage. Recently heme was shown to be synergistic with AZT, the expensive antiviral drug used in the US. Nodules of the weed Hippophae are reported to contain as little as 0.3 ppm hemin (Weath of India), while some weedy legume nodules are reportedly "almost pure heme". Since I have found no reference to human consumption of legume nodules, other than my own, I cannto recommend experimenting with them. But there could be powerful medicine there including the genistein mentioned above.

While not specifically proven against the AIDS virus, the weedy "sweet annie" *Artemisia annua*, a serious weed on my farm, contains at least five proven antiviral compounds. It is most famous, however, as a source of artemisinin, an endoperoxide, which has proved efficacious against chloroquine-resistant malaria. In my CRC Handbook of Edible Weeds (CRC Press, Boca Raton FL, 1992), I predicted that the malaria organism would quickly become resistant to artemisinin drugs. I'm told that such resistance has already evolved in Thailand.

New screens for xanthine-oxidase inhibitors (XOI) can indentify other mint species, like the weed, *Perilla frutescens*, which contain inhibitors as effective as the XOI, allopurinol, I currently take to prevent bouts of gout. Perhaps a tea made of the more active mint weeds could be as effective as the synthetic allopurinol, and a little bit easier on the stomach. Our laboratory recently submitted 60 American mints to Japanese scientists to see which are most promising as XOI's.

Perhaps the most promising drug for ulcers, may be even for depression, will come from the weedy species cultivated or harvested from the wild as licorice (*Glycyrrhiza* spp.). Licorice contains at least 5 monoamine-oxidase (MAO)-inhibitors, which may prove useful in depression, if not in migraine. Licorice root is the first thing I would try if I were suffering ulcers, low blood-pressure and/or hyperkalemia. One licorice species in the US is a serious weed. Wild relatives of crop species are often better endowed with allelochemic and pesticidal compounds than their cultivated relatives. In many cases, we borrow the compound to protect us from our pathogens that the plant has evolved to protect it from its pathogens and predators. More often than not, the plant has several closely related compounds, not just a single "silver bullet" compound to deter its enemies. Evolution would favor a synergy between these related compounds with similar objectives, and would disfavor antagonisms. It is not uncommon at all to find that a mixture of the pesticidal compounds from a given species is 2-5 times more effective than an equivalent dose of any one of the compounds. Synergy between allelochemical and pesticidal compounds, within a species, seems to be the rule rather than the exception.

The search for drugs for Alzheime's disease may be fruitful among the weedy mints as well. My weedy horsebalm, *Monarda* spp. like many weed mints, contains several compounds that can be absorbed transdermally, cross the blood-brain barrier, and which can, at least *in vitro*, if not in *cerebri*, prevent the breakdown of acetyl choline, a deficiency of which is a main indication of Alzheimer's. Parkinson's disease is also a manifestation of breakdown in cerebral circuitry. Various weedy species of *Mucuna* and *Vicia*, are good sources of 1-dopa, the drug of choice for certain types of Parkinsonism. Coincidentally, these, like most legumes are good dietary sources of lecithin and choline, some small percentage of which can recharge cerebral levels of choline and acetylcholine, possibly forestalling, though surely not preventing or curing Alzheimer's or Parkinson's.

Stinging nettles, weed of the genus *Urtica*, inject us with a little acetyl-choline and choline when they sting us. Some of us get this choline orally when we eat the weed as a potherb. Like beestings, flagellation with stinging nettles has evolved as a folk remedy for arthritis and rheumatism in nearly every big country where nettles occur. Like beestings, I would give nettle sting a try in another autoimmune disease, multiple sclerosis, for which the physicians offer little hope either.

Glaucoma has classically been treated with two phytochemicals, physostigmine from the African ordeal-bean, *Physostigma*, and pilocarpine from South America's jaborandi (*Pilocarpus* spp.) sometimes called "Indian hemp" (in some vernacular, meaning Amerindian hemp). Neither of these tropical species have been considered as weeds. But another so-called "Indian hemp", *Cannabis sativa*, has offered up a new compound, similar to its tetrahydro-cannabinol, which is proving very effective in glaucoma.

Mint-bidi's used to contain jimsonweed, *Datura stramonium*, sometimes smoked for asthma. The jimsonweed is also a good source of scopolamine, used for vertigo and seasickness, and atropine, antidote for nerve gas, and also used in ophthalmology and dentistry.

My country, America, is a constipated country, importing from India two purgatives, psyllium (*Plantago* spp) and senna (*Cassia* spp.), which though cultivated, can clearly be produced from weedy species as well. Still the US regularly imports millions of dollars worth of these weeds to maintain "regularity".

I estimate that more than half of drugs that come from plants could be sourced from weeds. I urge such sourcing, extracting the medicines from such weeds, conveting the residual biomass into mulch, leaf protein or power alcohol. Most of our weeds have already been identified and many studied chemically. There are still more medicinal species in the forests, awaiting discovery. Such forest species are more threatened and less studied biochemically. Utilizing weeds is economically and environmentally "greener" than spraying them with herbicides, which like 1, 8-cineole, could also be obtained from plants like the weedy Eucalyptus and Melaleuca.

I am overstaying my invitation here, but I should mention a few more of the more promising medicinal weeds with rather impressive folklore, aswagandha for arthritis, babchi for leukoderma, colocynth for constipation, cottonseed for contraception (male), dandelion, eclipta and milk thistle for hepatitis, gotu-kola for dermatitis, khella for angina, lemon-balm for herpes, methi and prickly pear for diabetes, tansy for migraine, and visnaga for asthma. A weed is only an unwanted plant. If all our plant species contain vitamins, minerals, amino acids, and phytomedicinals, are there really any weeds at all ? Not if we use them !

EXPERIMENTAL METHODS FOR CROP-WEED COMPETITION STUDIES.

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Abstract

A general and flexible conceptual approach to crop-weed systems and experimentation on them is outlined. This allows the assessment of weed effects on crop and crop effects on weed over a wide range of densities of both components. The implications for measuring the effect of weed infestation on crop yield and for the use of crop density as a tool in weed control are discussed. Several implications of the approach for experimental design are described. Other issues arising from the approach are briefly discussed.

Keywords : Competition, experimental design, weed

Introduction

Traditionally, experiments in weed research mainly concentrated on the effects of the weed(s) on crop yield. It may also be of interest to examine the impact of the crop and management practices on weed yield since this year's weed crop forms the basis for next year's weed challenge. This paper outlines a framework in which both these effects and the impact of management factors on them may be quantified and discusses the experimental designs required for crop-weed studies within this framework. For simplicity, the discussion is in terms of a two component system with one crop species and one weed species but the ideas generalise to more complex mixtures and are also relevant to intercropping between two or more crop species. This work is largely based on ideas developed (3).

Two design types have dominated experimentation in crop-weed research. The replacement series methodology (8) consists of a number of treatments in which the total density of crop and weed species combined is kept constant but the proportions of the two components vary. The additive series consists of a number of treatments in which increasing densities of the weed species are added to a fixed density of the crop. Recent work (1) has shown that the replacement series approach is not appropriate. The additive series method will allow assessment of the impact of the weed species on crop yield at the given crop density but results cannot be extrapolated to other crop densities. The use of a single crop density additive series design will not give adequate insight into the interaction between crop and weed as affected by the density of both species. In particular, the additive design at a single crop density gives a very incomplete basis for the assessment of the crop impact on weed yield.

Response Models for Crop-weed Systems

A new approach has evolved over the last ten years (2, 3, 4, 6) based on the idea that in a mixture of two species, the yield per individual of both components is strongly related to the densities of the two species. Various mathematical functions have been proposed to define this relationship, the most popular being the inverse linear model or generalisations of it (5, 7).

If the densities of the two species in a mixture are d^1 and d^2 respectively, the inverse linear model describes the relationship between the yield per individual for each species (w^1 and w^2 respectively) and the densities of the two species as

$$w_1^{-1} = a_{10} + a_{11}d_1 + a_{12}d_2$$

and

$$w_2^{-1} = a_{20} + a_{21}d_1 + a_{22}d_2$$

In this formulation a_{11} and a_{22} reflect the intraspecific effect of the crop and weed densities on themselves, while $a1_2$ and a_{21} reflect the interspecific effect of the species on each other.

Crop yield at any joint density is predicted as d1 w1 and similarly for total weed yield. Of course in crop-weed mixtures the crop yield is the economic output, whereas the weed yield in an indicator of problems stored up for the following year (in annual species as seeds added to the seed bank and for perennial weeds as rooting systems and growing points laid down for the following season). The model describes how crop yield will be affected by various levels of weed infestation and also how it will be affected by changes in crop density. Hence, it will be relatively simple to predict from the model a range of crop yield responses for varying crop densities and levels of weed infestation.

One thing that should emerge from this analysis is the extent to which the impact of a particular level of weeds on crop yield is reduced as the density of the crop component increases (because the weeds are individually smaller and hence less damaging to crop yield). The model also quantifies the impact of various crop densities on the weed yield. What should emerge here is that as crop density increases for a particular level of weed infestation the weed yield should decline and hence the problem posed by weeds in the next season should be reduced. Together these two points may show that an increase in crop density is economically justified in both reducing the impact of weeds on current crop yield and their impact in following years. Indeed if this effect is strong enough, it may be useful to compare the costs and benefits from increasing crop density with alternative (chemical and manual/mechanical) methods of weed control. One possible benefit would be that the selection pressure on weed genotypes arising from increased crop density might be expected to be much less focused than with chemical control, reducing difficulties with selection of resistant genotypes.

In additon to these direct interpretations of the parameters, it is possible to derive several indices (2) from the models which give insight into the interaction between species and whether the competition between them is ameliorated by synergistic effects. Such effects might be beneficial in reducing the impact of the weed species on crop yield but reciprocally may reduce the controlling role of the crop on the weed component.

Experimental Methods

There are several implications of this model based approach for experimental design. Firstly, and most importantly, there have to be sufficient and appropriately selected mixtures to allow the parameters of the models to be estimated. This could be achieved, for example, by selecting a fairly wide range of monoculture crop densities as the basis of monoculture treatments. For each such monoculture density generate a set of mixtures using a range of weed densities. Monoculture weed densities are not very relevant in this situation as opposed to intercropping where the monoculture yields for both species may be of interest. Optimal design methods have not yet been developed for these response models.

Management factors such as fertility and irrigation may modify the crop-weed interaction and this will reflect itself through changed values in the parameters. The experimental design would consist of a basic set of crop monocultures and crop-weed mixtures as described above, repeated at different levels of the management factors, with replication if desired. The analysis could be complex but would address questions as to how the management factor affected the parameters and various indices based on them. Several examples are given (3) where not all of the parameters would be expected to change with the level of management factor and this would lead to more closely specified models and more readily tested hypotheses. For example, in investigating the effect of relative emergence time of crop and weed, the parameters describing the monoculture crop response (a_{10} and a_{11}) should not be affected by v arying the weed emergence time which should only modify the weed effect parameter (a_{12}) of the crop response model. A similar argument applies for the parameters of the weed response model.

Other Considerations

Many crops are produced as part of a rotation and an analysis of the effects of the weed species on each of the crops in turn and vice versa would be required for a complete description of the effect of weeds on the crop and the weed dynamics of the system over time.

The dispersal pattern for the weed species is of importance in assessing the importance of immigration/emigration and of control of weed patches using either biological (as described above) or other methods.

The methods described above are in terms of a single crop and weed system and for annual plants but the ideas carry over readily to more complex systems with more than two species or perennial species. However, experimentation in these more complex systems would be more difficult and has not been widely attempted.

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POTENTIAL FOR BIOHERBICIDES IN TROPICAL COUNTRIES

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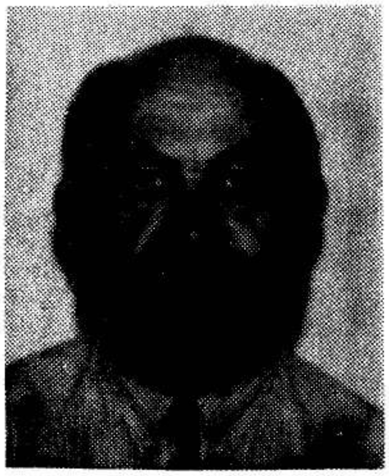
Introduction



Bioherbicides are biological herbicides in which the active ingredient is a micro-organism. So far, only microscopic fungal spores have been used in this technique and the products are sometimes also referred to as mycoherbicides (from the Greek *mykes* = mushroom). They are applied like conventional herbicides, usually as sprays. Up to this stage, bioherbicides have utilised indigenous or naturally occurring pathogens, although the use of exotic microorganisms is feasible, but requires adequate host range testing.

Three commercial bioherbicides Collego(R), Devine (R) and Biomal(R) are registered products in North America. Commercial products such as these are conveniently produced en masse by submerged culture fermentation then separation, drying and storage, but this requires high capital expenditure. The need for oxygen for sporulation of many fungi has often limited development of bioherbicides in submerged culture systems.

Ideally commercial products should have long shelf-life. Application sites may be considerable distances from place of manufacture and making a product at a time suitable to the manufacturer is desirable rather than in response to an urgent need by potential users of the product

Mycoherbicides generally have a requirement for dew or high humidity for satisfactory results. Collego(R) and Devine(R) are both used in irrigated agriculture and this is part of the reason for their success. Biomal(R) is used in situations where rainfall events are likely and can be confidently predicted in the mid-west wheat growing region of Canada.

A moisture requirement has hampered the development of several potential mycoherbicides in dryland agriculture in temperate regions. Thus, a great deal of research effort has recently been placed on the development of formulations to overcome this dew requirement.

The Tropics

The use of bioherbicides has been relatively neglected in tropical countries. However, recent interest has focussed on potential mycoherbicides in a number of countries, for example : *Rottboellia cochinchinensis* in Thailand.

Apart from the environmentally desirable aspects of using naturally occurring microorganisms over synthetic chemicals, the substitution of these products for imported herbicides would lead to valuable savings in foreign exchange.

Some of the factors which limit bioherbicide production and use in developed countries may not apply in tropical, developing countries :

Mass production. There is a tradition of food production by fermentation techniques in several tropical countries. Man of these fermentation systems use solid substrates and thus overcome the problem of oxygen limitation in submerged culture fermentation. Moreover, they do not require the same capital investment as fermenters and the media used in such systems may be derived from waste products of food production.

Shelf life. Because of the rapid multiplication rates of microorganisms in combination with the potential to produce them in local solid-state fermentation systems, the need for long shelf life diminishes. Products could be made in relatively small quantities locally to satisfy local needs.

Moisture requirements. In tropical regions humidity is high and rainfall relatively predictable. Moreover, many crops in tropical countries are also irrigated. Thus, the moisture limitations imposed on bioherbicides in dryland temperate agriculture often will not apply in developing countries.

Development of a biological program. The first step to be taken would be the nomination of the most important weed species, then the deliberate searching for pathogens, their isolation, identification, virulence testing and host-specificity testing. The steps to follow are then, defining optimal conditions for infection and disease development, mass production and field testing. Successful bioherbicide products require collaboration between plant pathologists, weed scientists and fermentation specialists.

Cooperative projects between scientists with experience in bioherbicide development and interested plant protection research group in developing countries should accelerate the adoption of bioherbicides as alternatives to conventional herbicides and manual weed control.

An International Bioherbicide Group (I. B. G.) has been established to foster communication and cooperative projects on bioherbicides and assist transfer of technology that will assure availability of bioherbicides. Anyone interested in receiving the I. B. G. Newsletter should contact the author at the address above.

FATE OF PESTICIDES IN AGRO-ECOSYSTEMS

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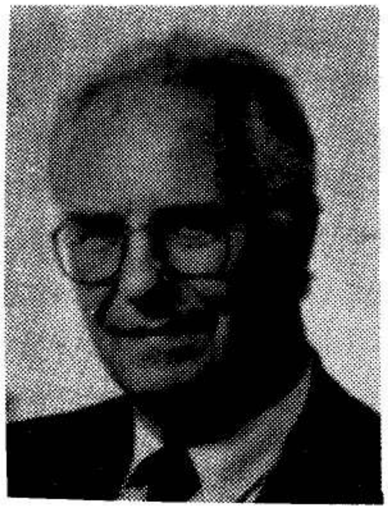

Depending on the method of application between 30 and 100% of the pesticide directly reaches the soil, thus for example pre-emergence herbicide spraying onto the soil ready for sowing or post-emergence spraying onto the developing vegetation which does not yet cover the soil. The arable soil is thus in the final instance the great sink for all specifically applied pesticide active ingredients. Only labelling of the active ingredients with the radioactive carbon isotope ^{14}C enables, apart from an extreme reduction of the detection limits, the analysis of total residues in various soil layers, and above all the quantification of the residues persisting in the soil in a bound form, not extractable and therefore not analytically detectable (1).

Precisely the processes of degradation, mineralization, fixation and binding, as well as translocation, taking place in the soil are dependent on a number of parameters, namely climatic parameters such as temperature, moisture, aeration, also the soil's own parameters such as texture, clay minerals, humic substances, pH value and nutrient situation, as well as biological parameters such as microbial biomass, the species of which this is composed, and finally the plant residues as a source of energy of microbial populations. Terrestrial ecosystems are characterized by a variable daily change in temperature and moisture, high contents of reactive surfaces, as well as an extremely wide range of species and also population fluctuations of the microorganisms. It, thus, becomes clear that a prediction of the long-term behaviour of pesticides in arable soils is only possible to a limited extent with the aid of results from standardized degradation, leaching and bioactivity studies.

The Lysimeter Station

The Institute of Radioagronomy has profited from its special siting advantages at the Research Centre, Julich since 1971 by carrying out practice-related experiments with 14C-labelled pesticides under field conditions. Major emphasis is placed on experiments in lysimeters i.e. sections of the agricultural ecosystem.

Since 1983 undisturbed soil blocks with a profile depth of 110 cm, removed from the soil with the aid of stainless steel cylinders, have been available in absolutely tight stainless steel containers firmly embedded in the soil. The lysimeters with a cultivated area of 0.5 or 1 m^2 are surrounded by control areas cultivated with the same crop. The experiment with radioactively labelled pesticides is thus embedded in an agricultural plot with the same crop and treated with the same cultivation methods.

All measures for fertilization and complementary plant protection are closely coordinated with agricultural practice.

Fifty lysimeters (20 of 0.5 and 30 of 1m2 cultivated area) located on openair grounds of about 2500 m^2 distributed between 10 experimental beds of 5 lysimeters each are available for research investigations into the long-term behaviour of pesticides. The soils used represent the soil types orthic luvisol and gleyic cambisol predominanth used for agriculture throughout Germany.

Results

In these lysimeter experiments, which permit an analysis of pesticide active ingredients and metabolites in soils, plants and drainage water over several vegetation periods, realistic data are obtained on the residues situation since the lysimeter results are in good agreement with results from field experiments carried out in parallel. On the basis of results from lysimeter experiments, complementary and specifically designed standardized laboratory experiments make an essential contribution towards clarifying individual processes such as adsorption, degradation/mineralization, bioavailability and translocation, thus permitting an interpretation of the lysimeter results and providing indications of key processes in the soil so that important impulses can be obtained for the appropriate practical application of pesticides (1, 2).

On the basis of results of extensive experiments with ^{14}C-labelled pesticides combining microecosystem, pot and lysimeter and field experiments the following conclusion can be drawn (3) : the soil generally constitutes the main sink for all pesticides applied. Generally pesticides and their metabolites lose their bioactivity, and in many cases also their identity due to processes of degradation, sorption, fixation and binding. This leads to varying residence times of the carbon from the molecular structure of pesticides, especially as a function of the soil carbon structures and the bond interactions. During the continuous turnover of the soil carbon non-extractable, bound residues may be released and undergo further transformation, but mere ageing of the residues in soil leads already to a considerable reduction in their biological availability to plant roots.

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MAXIMISING RATIONALITY IN HERBICIDE DESIGN

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Introduction

It has to be admitted that herbicides design is not a wholly rational process. Mos industry sources would quote a ratio of about one herbicide, fungicide or insecticide commercialised for every 20-25,000 compounds synthesised. Nevertheless, the whole innovative process can be made as effcient as possible by being rational at each step, although such attempts to be rational are often hampered by the general lack of knowledge of the scientific processes which are involved. Even so, something can be done about designing a potent inhibitory molecule and tailoring its structure to give it favourable properties in relation to uptake, movement within the plant, metabolism and safety. Our approach in this short article will be to take the reader through the various aspects of herbicide invention, with an emhpasis on the extent to which rationality can be applied at each stage.

Lead Finding

During the discovery process, leads come from four main areas : (i) new synthetic chemistry; (ii) analogue chemistry; (iii) natural products; and (iv) biochemical design.

In the first approach, the chemist will have been inspired only by the chemical aspects of the proposed synthesis; no attention will have been paid to biological activity in the first instance. In contrast, in approaches (ii) and (iii) the starting point will have a molecule known to have interesting biological activity, either from the chemist's or the company's own knowledge base, or from a publication, e.g. a competitor's patent. Frequently, a combination of inspirations is involved; chemists plan their new synthesis on the basis of a combination of their own skills and experience coupled with available information about the structural features associated with the biological activity under examination. Approach (iv) is significantly different in that the biochemically inspired attempts at pesticide discovery start with an understanding of the biochemical capabilities of the target organism and make no reference to known structures with *in vivo* biological activity.

Whatever the inspiration for the synthesis, all compounds would be evaluated in an *in vivo* biological screen, carefully designed to ensure that molecules with desirable attributes

* This short article is based on a longer version by the same authors written in a volume published by Elsevier, Amsterdam (see Wright *et al.*, 1991).

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will be detected. Within practical limits, most companies would screen all synthesised molecules for all types of biological activity, reflecting the inherent serendipity involved in this work.

***In Vivo* Evaluation**

The design of screens is a large topic in itself (Giles, 1989). The ultimate aim of the screen is to find a herbicide able to control a desirable spectrum of weeds, either selectively in a crop or for total vegetation control, economically and reliably under a wide range of conditions in the field without adverse environmental effects. Such demanding criteria are met by very few compounds, with the consequence that an industrial screen must be capable of high throughput to accommodate the number of compounds required to give a reasonable chance of finding the rare success. Rationality is crucial in the choice of species in the initial screen, rates of application and criteria for progression to the next stage, but there is also room for debate, particularly as it takes around 7-10 years to bring a compound to market and the commercial targets and performance requirements 10 years in the future have therefore to be estimated.

Choices also have to be made concerning soil type, formulation, conditions under which treated plants are kept and the timing of assessments after treatment. Observation of the development of the symptoms exhibited by the test species with time is also important as an indicator of the possible mode of action of the compound.

Mode of Action Studies

While it is possible to develop a successful product in the absence of this information, knowledge of the biochemical site of action can significantly influence the rational development of a series of compounds by :

- providing an *in vitro*, cell-free test that can rapidly eliminate inactive compounds and generate data for use in structure and activity correlations;
- revealing biochemically active compounds that are inactive *in vivo* due to unfavourable uptake, transport or metabolism properties;
- allowing lateral development of the lead inhibitor through knowledge of the biochemical target.

However, mode of action studies must not be regarded as obligatory, since they can often require the input of many thousands of man-hours and cannot be certain of success. To be of maximum use in helping to influence the direction of synthesis, the mode of action clearly has to be available relatively early in the development of a new series of compounds.

Once a possible mode of action has been identified it is then important to establish cause and effect. The best way to demonstrate that the proposed target is indeed the primary and only site of action is through mutation and/or molecular biological studies. The goal here is to isolate a resistant mutant that can be shown to be insensitive due to a change in the target enzyme that renders it insensitive to the compound.

Good supplies of pure target protein, which are increasingly becoming available through the techniques of molecular biology, can pave that way for more detailed analysis of the molecular mechanisms by which the compounds exert their action. Kinetic studies can provide information about how a compound binds to the enzyme in relation to both the substrate(s) and other ligands; photoaffinity labels based on the lead compound can be useful in identifying the amino acids around the binding site; and site directed mutagenesis can identify the amino acid involved in binding. In addition, crystallisation of the enzyme and subsequent X-ray analysis has the potential to provide a full three-dimensional picture of the inhibitor binding site and, perhaps more importantly, to identify other, nearby binding regions which might also be exploited.

Biochemical Design

At a Chesterford Park we have some considerable experience of the approach to herbicide discovery that starts with the rational selection of a novel target site. Such a site must have an essential function and offer potential for inhibitor design and synthesis. Selection of an essential process is the first step, and this draws on the disciplines of biochemistry, physiology and molecular biology. Once a particular pathway has been chosen, the question of whether all the enzymes in the pathway are equally good targets must be addressed. If mutants are available and the lesion has been characterised, then the answer is obvious. In other cases the choice can be more difficult but may take into account such factors as the flux control of a pathway and the possible accumulation of a toxic intermediate. Last, the biochemical accessibility of the target enzyme also has to be considered. The biochemist's goal should be to provide a suitable, cell-free test system, ideally using a homogeneous enzyme preparation from the target organism but compromises over purity and/or enzyme source may well be acceptable in many cases.

A major consideration which influences the decision concerning which of the many potential targets to work on is the perceived potential for the chemist to design and synthesis inhibitors. There is often considerable debate about the 'ideal' type of inhibitor for a herbicide, but as the literature contains herbicidally active examples of most types of inhibitors, it would be imprudent to rule out any possibility.

Research into biochemical design goes back to the mid-sixties in our laboratories and we have, for example, attempted to design inhibitors of choline acetyltransferase(Baillie *et al.*, 1975), indole-3-acetic acid oxidase (Wright *et al.*, 1973) and uncouplers of photosynthetic phosphorylation (Wright *et al.*, 1980). In addition, we attempted to design inhibitors of shikimate dehydrogenase in the aromatic amino acid biosynthesis pathway (Baillie *et al.*, 1972); as it happens this turned out later to be the pathway in which glyphosate exerts its effect

(Amrhein *et al.*, 1980). More recent work in-house has been concerned with pyruvate dehydrogenase (Baillie *et al.*, 1988) and glutamine synthetase (Wright *et al.*, 1991). These examples, and those from other laboratories (eg Aulabaugh and Schloss, 1990), provide good evidence for the potential of the approach but, for the moment, we still await the first commercial herbicide dicovered from first principles.

Maximisation of Activity

Whatever the source of the lead inhibitor, the objectives of the biochemist are to help the chemist to arrive at the most potent biochemical inhibitor as quickly as possible and at the same time to build up a picture or model of the binding site(s) involved. Ofcourse, it is a fact that the most active biochemical inhibitor does not often equate with the most biologically potent compound. An important part of the maximisation process is to establish what is and what is not allowed within the binding site so that the chemist can subsequently make changes to modify the uptake, transport, metabolic stability and selectivity properties of the compound in a manner that will not compromise the requirements for activity at the target site. At this stage information from the biological screen and the biochemistry laboratory is combined with physicochemical considerations and results from specialised tests such as soil leaching, soil persistence and plant systemicity in an attempt to improve the biological activity of the lead compound by optimising all the factors thought to contribute to activity.

Physicochemical Considerations and Movement within the Plant

Physicochemical properties of herbicides, such as solubility, partition coefficient and volatility are of crucial relevance to *in vivo* activity since they control transfer of the chemical to the plant and uptake and redistribution within the plant, and thus net accumulation at the target site. These physical properties can be readily measured or calculated from the chemical structure so that their potential influence on *in vivo* activity can be assessed. Compounds with a particular type of biological activity tend to relatively narrow ranges of properties which can be a guide to optimising activity.

Uptake by roots of neutral compounds is relatively simple, passive, partitioning process between the solution of chemical and the roots (Briggs *et al.*, 1982). On the other hand, root accumulation of acidic compounds depends on a combination of the penetration of the unionised form of the acid and ion-trapping within the root, properties which are themselves determined by the lipophilicity and dissociation constant of the compound as well as the pH external to the root (Briggs *et al.*, 1987). Uptake is passive, but since it relies on the pH difference between the root cells and the external medium, it can be affected by metabolic inhibitors (and could therefore be wrongly classified as an active process). The root uptake of organic cations is not well understood at present. Foliar uptake is a very complex process. Current indications are taht it depends largely on physical properties. Low melting compounds which are not too lipophilic tend to be taken up rapidly. High melting compound tend to crystallise on the leaf surface as the spray dries and becomes virtually unavailable.

Measurements of translocation of chemicals from an external solution through the roots of plants to the upper parts indicate that there is an optimum lipophilicity for passive transport, the Casparian strip in the roots acting as the barrier to highly polar or highly lipophilic compounds. Thus, despite high concentrations accumulated in the roots, chemicals with log K_{ow} (octanol/water partition coefficient) greater than 4 move very slowly to the stem and leaves. Highly polar compounds are also not well translocated from root to shoot because they do not penetrate the Casparian strip. The optimum log K_{ow} for transport is about 2-3 and it is in this region that virtually all commercial pre-emergence herbicides acting as inhibitors of photosystem II are found. Chemicals entering the transpiration stream via the stem or leaves do not appear to meet similar barriers to those entering via the roots so that more polar compounds move readily to the leaf margins.

Since sucrose is a highly polar molecule incapable of passing through membranes without a carrier, emphasis on phloem transport research has been on the question of how molecules enter the phloem. However, for most xenobiotics, which are generally moderately lipophilic neutral or weakly acidic molecules, membrane permeability is rapid and retention in the phloem is the key phloem mobility rather than entry. For weak acids, ion trapping in the phloem (pH about 8) after movement of the unionised form from the xylem (pH about 6) provides and adequate explanation of their phloem mobility in terms of the pK_a and log K_{ow} of the compounds (Bromilow and Chamberlain, 1989).

Plant Metabolism

The principal selectivity mechanism for herbicides is plant metabolism with little evidence for differential uptake being an influential factor and only one example of active site differences being responsible. Considerable information is available about the metabolism of specific compounds but we will need much more before it becomes possible to rationally design specific selectivities into candidate herbicides.

Concluding Remarks

As the reader will have deduced from the above, the process of herbicide discovery by screening, selection and optimisation is a well tried and tested procedure. However, as registration requirements grow and the whole process becomes more expensive, it becomes of ever greater importance to inject rationality wherever possible. Every time a rational approach allows better compounds to be reached more quickly, money is saved and there is an increase in efficiency. There seems little doubt, therefore, that - as in the pharmaceutical industry - companies will contine to invest in approaches which enable them to increase their efficiency as they gain confidence in them through their successful application.

The industry will not only progress through its own efforts but will also be highly dependent on advances in our fundamental understanding of plant biochemistry and biophysic, much of which work must go on outside the industry in research institutes and universities. The process can become more rational and there is every reason to expect that it will.

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MANUFACTURE OF HERBICIDES IN INDIA

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I. Introduction

India has emerged as the second largest basic pesticides manufacturer in Asia after Japan. Even though the overall performance of the industry has been satisfactory, it suffers from poor capacity utilization - around 60%. While pesticides consumption has grown from 2000 tonnes in 1955 to 60,000 tonnes in 1989-90, the per capita consumption is a meagre 400 g/ha - one of the lowest in the world compared to Japan which is 11,000 g/ha. The pesticides market is placed at Rs. 1500 crores with an installed capacity of 1.16 lakh tonnes.

Pesticides can be classified into the following categories : Insecticides, Fungicides, Herbicides, Rodenticides and Fumigants, etc.

Herbicides

Any plant growing alongwith a planted crop and competing for nutrients and water is defined as a weed. These unwanted plants are controlled by certain chemicals classified as herbicides. Herbicides are chemicals that check or eliminate weeds. They are further grouped as selective and non-selective. Selective herbicides are those which would kill only certain types of plants without adversely affecting the crop e.g. isoproturon in wheat and butachlor in rice. Non-selective herbicides are those which are used for general weed control and would kill most vegetation e.g. glyphosate.

II. The pattern of demand and consumption for the period 1988-89 to 1992-93 provides a fair glimpse of the herbicides usage/trends in India.

Demand consumption pattern of herbicides M/T

	Actual cons	Est dem	Actual cons	Est dem	Actual cons	Est dem	Actual cons	Est dem
	1988-89	1989-90	1989-90	1990-91	1990-91	1991-92	1991-92	1992-93
1	2	3	4	5	6	7	8	9
2-4, D (97)	1100	1200	1200	1200	1200	1200	1200	1200
Anilophos	-	200	-	200	100	300	400	650
Atrazine/Semazine (80/92)	120	125	100	100	150	200	200	200
Benthiocarb (93)	160	200	200	200	100	125	125	125
Butachlor (85)	1400	1500	1600	1700	1600	1500	1100	1100
Dalapon (85/90)	90	100	50	60	25	25	20	20
Diuron (95)	10	12	50	50	50	50	50	50

Contd.

1	2	3	4	5	6	7	8	9
Fluchlroalin (65)	50	60	60	60	60	65	45	45
Glyphosate (95)	65	70	70	80	65	75	75	80
Isoproturon (95)	1200	1500	1400	1500	1500	1650	1600	1900
Oxyflourfen (70)	-	5	-	-	12	15	12	20
Paraquat	325	340	-	-	300	320	320	350
New herbicides	-	-	-	-	-	-	-	30
Total herbicides	4100	4900	4730	5150	5162	5555	5367	5790

III. List of herbicides registered on regular basis under section 9(3) of the Insecticides Act, 1968

1. Alachlor 2. Anilophos 3. Atrazine 4. Benthiocarb 5. Dalapon 6. Diuron 7. 2, 4-Dichlorophenoxyacetic Acid 8. Fluchloralin 9. Glyphosate 10. Isoproturon 11. Methyl clorophenoxyacetic acid 12. Methabenzthiazuron 13. Metoxuron 14. m-Sodium methane arsenate 15. Nitrofen 16. Oxyfluorfen 17. Pendimethalin 18. Propanil 19. Simazine 20. Triallate 21. Trichloro acitic acid

IV. Herbicides formulations

Most active ingredient cannot applied as such in the field; they have to be made up into a form suitable for application, the formulation with the aid of auxiliary agents which can comprise inert carriers, solvents, surfactants and some times further components such as dye stuffs antifoaming agents, stickers or stabilizers.

Further more the formulation is a product with a fixed content of active ingredient. These active ingredients can be formulated in the various different ways. The most important types are -

1. Wettable powders (WP) 2. Emulsifiable concentrates (EC) 3. Water soluble powders (SP) 4. Water soluble concentrates (SCW) 5. Oil soluble concentrates (SCO) 6. Flowables with an aqueous (FW) or oily (FO) base.

V. Herbicides : emulsifiable concentrates

Many herbicides like butachlor, anilophos and pendamethalin are available in the form of emulsifirable concentrates. These formulations require suitable blends of emulifiers, aromatic solvents like xylene, kerosene, aromax, etc. and stabilizers. Emulsifiable concentrates have to be tested for various parameters to be effective. Emulsions become unstable due to following reasons : 1. Wrong emulsifier 2. Incompatibility 3. Electrolytes 4. Unidentified type 5. Improper manufacturing 6. Excessive dispersion 7. Inadequate dispersion 8. Temperature 9. Insufficient viscosity 10. Decomposition of emulsifier 11. Improper storage

Quality control in herbicide manufacture

Quality control embraces all aspects of procurement, production and application of herbicides. All raw materials used for manufacturing and formulation have to be tested for chemical and physical properties to ensure proper yields, quality and shelf life. Some broad guidelines for quality assurance for different formulations are given below :

(a) Emulsifiable concentrates

Phytotoxicity, Cold stability, Volatility of emulsion, Emulsion stability, Heat stability, Acidity/alkalinity, Active ingredient, Shelf life, Colour and physical appearance.

(b) Wettable powder formulation

Physical appearance, Active ingredient, Particle size, Suspensability, Wettability, Bulk density, Storage stability

(c) Granular formulations

Absorptive capacity, Particle size, Flowability, Bulk density, Dustability, Abrasiveness, Carrier compatibility, Flowability

Management of laboratory practices, training of technical personnel and adherence to systems are basic requirements of quality control in herbicides manufacture.

VI. Wettable water dispersable concentrates

Wettable water dispersible concentrates or water dispersable powders is a mixture of one or more toxicants, one or more carriers, or inerts to form a dry, free flowing powder and surface activity agent, and can be diluted to field strength to form stable, homogenous, sprayable suspension. A successful formulation should have desired flowability, wettability, dispersibility, suspensibility, low foaming, and storage stability (physical and chemical). Satisfactory wettability, dispersibility and suspensibility will depend on the following factors:

1. Characteristics of the toxicant and carrier - density and surface irregularities.
2. Particle size distribution range - for adequate suspensibility. This should be between 1 to 3 U.
3. Proper choice and concentration of wetting and dispersing agents.

When organic liquid toxicants are impregnated on the inert carriers, the normally hydrophilic surface of the inert carrier is changed to a hydrophobic one. With solid or semi-solid toxicants, the carrier acts more like a conditioning agent to keep the solid particles from agglomerating and it is the hydrophobic properties of the toxicants which strongly influence the wettability of the concentrate.

Certain precautions regarding use of surfactants for formulating wettable powders

1. Dispersant should be chosen after the proper wetting agent has been found out, as the suitability of a dispersing agent will depend upon the nature of the wetting agent.

2. Solid wetting and dispersing agents that have high water solubility should be preferred to the liquid ones, because of the following reasons :

   (a). There would be less liquid load on the carrier.

   (b) There would be better distribution of the surfactant.

   (c) A liquid surfactant will get tightly absorbed in the carrier and will not get entirely released when the W.D.P. is dispersed in water.

   (d) No spraying equipment is necessary.

   (e) Solid surfactant can be chemically absorbed on both the carrier and toxicant surfaces.

3. Surfactants, that are normally liquids, but marketed as dry powders impregnate with liquid surfactant should be avoided, for the following reasons :

   (a) Surfactant carriers may be incompatible with the toxicant.

   (b) Surfactant may be held tightly on its carriers.

4. The surfactant should be added after the toxicant and carrier are blended together. If the toxicant is liquid, it will first be absorbed into the inner pores of the carrier, and if followed by a liquid surfactant, the surfactant will be more readily accessible to the particle surface where it must function. If the toxicant is a solid, the liquid surfactant will have a chance to coat the toxicant surface alongwith the carrier.

VII. Formulation process

Any solid herbicide formulation process includes the following three steps :

(i) Pre-grinding of ingredients jointly or individually

(ii) Blending of the ingredients

(iii) Fine grinding or final grinding and mixing to achieve required quality

For scaling up of the above steps the following properties of the batch ingredients are to be studied thoroughly.

(a) Particle size distribution
(b) Bulk density
(c) True density of the ingredients
(d) Particle shape
(e) Surface characteristics
(f) Flow characteristics
(g) Friability
(h) State of agglomeration

(i) Moisture content
(j) Density viscosity and surface tenson of the liquid ingredients if used.
(k) Temperature limitations of the ingredients

Particle size distribution

This indicates the percentage of the material in different size ranges. With this data the ratio "ratio of reduction" can be predicted. Ratio of reduction = Feed size/Product size.

Bulk density

Bulk density data is useful in scaling up the volume past to be handled in the equipment and conveyor system.

True density

This information helps in designing the feed hoppers, etc. if the feed product is in a lump form.

Particle shape

Shape of the particle palys an important role in scale up procedure with reference to screens, feeder and charging devices. The common shapes are pellets, egg shaped, block spheres, flakes chips, rods filaments, crystals or irregular shapes.

Surface characteristics

This includes surface area and tendency to hold static charge. Particularly in designing blender blades the knowledge of this characteristic is useful.

Flow characteristics

Angle of repose and flowability of the ingredients is the deciding factor for designing material handling and feeding equipment. Steeper the angle of repose lesser the flowability of the powder. Some times "Lubricity" term is used for solid particles to correspond to viscosity of a fluid.

Friability

This is the tendency of the material to break into smaller size in the course of handling. Abrasiveness of one ingredient upon another should also be considered. Knowledge of these data will be useful in designing the blender, etc.

State of agglomeration

During blending operation it should be studied whether the particles exist independently or adhere to one another in clusters. If the agglomeration takes place, some additional energy or device will have to allow proper particle dispersion.

Moisture

Presence of more moisture in the batch may affect the blending and grinding operations. So before designing for scale up this aspect should be taken care of. Some times a little water is added to minimise the dust particles which becomes a source of pullution leakage of dust contributes loss of the material as well.

Density, viscosity and surface tension of the liquid ingredients

When any liquid ingredient is added in the solid formulation the density, viscosity and surface tension of formulation at the operating temperature must be known so that load on the blender agitator can be made available i.e. power requirements.

Temperature limitations of the ingredients

The knowledge of the effect of temperature on the ingredient is very important in scaling up of the mill and as well as blender. Heating or cooling provision can be designed accordingly. The rough study of the above characteristics of the formulation developed in the laboratory will be the guidelines for scale up to the production size.

VIII. Herbicides : Granular formulations

The granular formulations of herbicides have sprung into the lime light of herbicides application in the last two decades. The advantage of granular formulations is in the use as emergence soil herbicides and the possible long time effect.

Advantages of granular formulation

Simple and safe handling during processing and application.
Practically no dusting during processing and application.
No drifting during application.
Easy to transport and good storage properties.
Reduced volume due to high bulk density.
Possible combination with fertilizers.
Good flow and dosing properties

Requirements of granular formulation

Homogenous distribution of the chemical within granules.
Proper release of active ingredient for good results.
Grain size distribution to lie within a narrow range.
Attrition resistance with regard to and friction must meet high requirements.
Economically viable in comparison with other type of formulations.
Necessity for appropriate application devices.

IX. Herbicides : flowable formulations

A flowable formulation is a stabilised concentrated emulsion or suspension in water or oil, which will be diluted with water. It has to be pumpable, and in the event of phase separation it should be easily reconstituted without caking.

Flowable formulations are prepared using emulsifier and wetting agents/ dispersants, along with gums or clays to modify viscosity and prevent recrystallisation. During milling addition of anti foam may be necessary. It is also necessary to add another defoamer at the end of the operation to release the incorporated air and improve packing characteristics.

Some flowables are formulated as triple-phase systems of a solid suspension in oil emulsified in a water phase e.g. triple-phase system of water, on emulsified oil (corroil) and atrazine 80% wettable powder.

X. Role of surfactants in herbicides formulations

Most herbicides are sold to the consumer in the form of concentrates that are diluted by the user in water or oil and then sprayed over large areas. The concentrate is formulated by blending the herbicide with such ingredients as may ensure ease of handling and maximum controlled activity of the herbicide. The formulated concentrate may be in one of the following forms :

(1) Emulsifiable oncentrates
(2) Water oluble oncentrates.
(3) Wettable water dispersible concentrates.
(4) Flowable formulations.
(5) Triple-phase systems.
(6) Dusts.
(7) Granular products.

Surfactants are a very important group of components of the above formulations, as they serve as tool in the hands of paint formulator to achieve most effective and balanced formulation. Presence of surfactant in the formulation will influence one or more of the following :

(1) The dispersibility and stability of the concentrate in water.
(2) The physical characteristics of the spray solution.
(3) The activity of the toxicant toward the pest.

For getting a successful balanced herbicide formulation, it is very necessary to know the physical and chemical properties of the herbicides and vehicles on one hand and those of the surfactants on the other hand for a proper selection.

XI. Role of surfactants in spray solutions

The presence of surfactant in spray solution will have influence on its following properties :

1. Wetting and penetrating.
2. Particle size distribution.
3. Bouncing off.
4. Retention.
5. Even distribution
6. Foaming.

XII. New herbicides

1. Tribenuron 2. Chlorimuron 3. Sulphonyl Urea 4. Metsulfuron 5. Trifluralin 6. Trifiuralin 7. Clopyralid 8. Imazethapyr 9. Haloxyfop-methyl 10. Fluazifop-p-butyl 11. Metolachlor 12. Cyclocydim 13. Phenoxapropethyl 14. Bentazon 15. Naproanilide 16. Oxyfluorfen 17. Fluroxypyr 18. Pertilachlor 19. Tralkoxydim-A 20. Fluazipop-p-butyl 21. Fluazifop-butyl 22. Cinamethylin

XIII. Herbicides manufacture : Safety

Safety is of prime importance for manufacture of agrochemicals. This is a vast subject and includes the following :

A. Safety in the plant

Explosion hazard-especially in solid formulations in such plants like ball mill, hammer mill or ring roller mill which achieve high grinding temperature, have to be provided with Explosion Arrestors. In view of these hazards the design engineer has to carry out various tests such as ignition test, dust explosion test, accumulation test, etc.

Earthing of equipment.
Electrical safety
Standard operating procedures.
Safety training.
Safety equipment and apparel.
Fire fighting equipment, measures and training.
Disaster management and emergency plans.
Periodical safety audits.

B. Safety during storage

This involves safety precautions in the plant warehouse, storage at the distributor/dealer level and precautions while displaying and selling herbicides in the dealer shop. This also involves precautions while storing herbicides by the farmers. Standard literature on these subjects is available with various government departments and with agrochemical manufacturers.

C. Safety during transportation

Various precautions have to be observed while transporting the herbicdies from one place to another to minimise hazards in case of accident, or during loading and unloading, as well as in other situations.

D. Safety during application of herbicides

This involves precautions to be taken during handling and mixing, while applying herbicides in the field and precautions to be taken after application. Detailed instructions are available on instruction leaflets attached to individual herbicides containers and these instructions should be followed carefully.

E. Decontamination

Procedure for decontamination of equipment.
Procedure for decontamination of spills.
Procedure for decontamination application equipment.
Procedure for decontamination spray personnel.
Procedure for decontamination and disposal of used of leaky containers.

F. Accident management

Action in the event of fire in the plant or warehouse.
Action in the case of accidental poisoning. Poisoning by herbicides is very unlikely unless there has been a gross negligent exposure or purposeful ingestion. In case of over exposure apply routine first and measures as suggested. In case of ingestion gastric lavage may be indicated. Treatment is symptomatic.

XIV. Status of herbicides in India

India is emerging as a major producer of herbicides. Herbicides constitute approximately 12% fungicides, 13% insecticides, 75% of the total market. Isoproturon on wheat constitutes a major chemical with production of 2000 MT per annum of active ingredient. Major producers are Gharda Chemicals Ltd., Hoechst India Ltd., Montari Inds. Ltd., etc. The product is also exported. Products like metaxuron and methabenzthiazuron are no longer in use due to adverse costs, but research scientists are advocating use of additional chemicals aother than isoproturon for use on wheat. 2, 4-D ester constitutes another major product at 1200 MT active ingredient per annum.

In rice which is grown in 40 million hectares in India, butachlor has remained a dominant product at 1600 MT consumption of active ingredient per annum. Since 1990 anilophos is being produced by Gharda Chemicals Ltd., and Hoechst India Ltd. and is increasingly finding its own status amongst rice cultivators. Butachlor is manufactured by GNFC, Montari Inds. Ltd., Searle India Ltd. and Siris India Ltd. amongst other producers.

Products like pendimethalin which is mainly a pre-emergence herbicide for various crops is increasingly in use on onions, cumin, groundnut, etc. Glyphosate manufactured by Excel India Ltd., is growing in different applications. Metribuzin is also being tried commercially on sugarcane.

Paraquat manufactured by ICI India Ltd., with total consumption of approximately 300 MT is a popular herbicide for many years. The herbicides market is growing fast and various Companies are experimenting with new products in different stages of trial, registration and commercialisation. With products finding increasing use on oilseeds, fruit and vegetables, cotton, sugarcane, plantation crops, herbicide manufacture in India is likely to expand manifold in the years to come.

TESTING BLACK-GRASS (*Alepocursus myosuroides* Huds.) FOR RESISTANCE TO CHLOROTOLURON IN THE GLASS HOUSE

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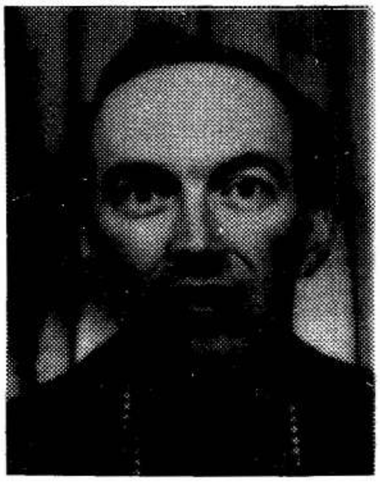

Herbicide resistance in black-grass is a continuing problem and is associated with the repeated use of herbicides. Use of herbicides is likely to remain an important component in any overall control strategy but cultural aspects will also play a crucial role. Herbicide resistance is the inherited ability of a weed to survive a rate of herbicide which would normally give effective control. This inherited ability contrasts with poor herbicide activity resulting from incorrect application or adverse environmental conditions.

Any weed population may contain a small proportion of plants resistant to a specific herbicide. Repeated use of this herbicide, or herbicides with the same mode of action, remove susceptible plants, allowing the resistant plants to survive and multiply. Thus the resistant individuals eventually dominate the population. Herbicide resistant weeds are an increasing problem. By 1991, herbicide resistance had evolved in 84 weed species in 31 countries world-wide, including nine species with resistance to one or more herbicides in the UK. Black-grass populations resistant to substituted-urea herbicides, such as chlorotoluron and isoproturon, were first detected in 1982 and now been found on over 60 farms in 19 counties of England. Since 1990, an increasing number of populations showing resistance to the aryloxyphenoxypropionate herbicides ('fops') have been identified. Resistance has mainly been associated with continuous or near continuous winter cereal cropping, non-ploughin cultivation system, straw burning and regular use of herbicides to control black-grass-on an average 1.7 applications per year for at least 10 years which has resulted in evolving cross resistance to 22 other herbicides.

Resistance is not absolute and it has been necessary to devise a rating system based on response of plants in glass house screening tests. Resistance rating range from S (Susceptible-no evidence of resistance), 1* (marginally less sensitive than susceptible standards and having a marginal effect on field performance of herbicides), 2* (clearly detectable in tests and having some effect on field performance, through 3* and 4* to 5* (where field performance is severely impaired). Populations are only described as resistant if they gain at least a 2* rating.

The main mechanism of resistance, at least in the substituted-urea herbicides chlorotoluron and isoproturon, is an enhanced ability of resistant plants to metabolise and detoxify the herbicides. Resistance to fenoxaprop-ethyl appears to be due, at least partly, to the presence of other biochemical mechanisms. The severity of resistance to substituted-urea herbicides tends to increase quite slowly in UK from one year to the next. However, there is increasing evidence that resistance development is more rapid to herbicides of the aryloxyphenoxypropionate and cyclohexanedione groups ('fops' and 'dims'). This type of cross resistance to the herbicides with different modes of action is a cause of serious concern. To devise an effective control strategy we will have to integrate some cultural measures like deep ploughing, crop rotation, spring cropping. delayed autumn drilling. stubble hygiene, raising of competitive crops & cultivars and inter-row cultivations with herbicides mixtures and herbicide rotations. To aschieve this objective it is imperative to have a thorough study of resistance problem in details to have a sound contol practices for recommendation to farmers field.

Experimental Details

1. **Seed collection** : collect ripe seeds in the field by shaking and gently rubbing heads over a tray. Direct collection of heads or stripping off will have some inviable seeds. Seeds collected should be stored in a dry shaded, well ventilated place for proper drying.

2. **Cleaniung** : remove empty seeds by winnowing. Cleaning can improve the proportion of viable seeds in the sample considerably. A good indication of the propotion of viable seeds in a sample is obtained by counting and weighing sub-samles of 100 seeds, and calculating numbers of seeds/g: 500 seeds/g = 70% viability - good; 700 seeds/g = 45% viability - fair; 900 seeds/g = 20% viability - poor.

3. **Glasshouse test** : most black-grass seeds have a relatively short period of dormancy of 2-3 months. For using the freshly colleted seeds the dormancy need to be broken either by using KNO_3 of by pricking (rubbing) the seeds.

(a) **Germination** - in petri-dishes.

For each seed stock, place approx 50 seeds in each of 10 nine cm petri-dishes containing 3 cellulose filter papers (Whatman No. 1) covered with a glass fibre filter paper (glass fibre paper limits fungal growth and also make it easier to pick out germinated seeds, as roots don't grow into the paper so easily). Thus, approx. 500 seeds for each seed stock are needed. Add 7 ml of KNO_3 (2g KNO_3/lt water) to each dish for breaking dormancy. Stack dishes in polythene bags in a contolled environment cabinet or incubator, set at 18°C 14 hour day/12°C 10 hour night). (Temperature is not critical but avoid temperatures over 25°C; some light is also essential for germination). Radicles should be visible after 6-7 days.

(b) **Transfer of gerrminated seeds to pots**

Ideal time for tansfer is when radicles are just visible, but coleoptiles have not emerged, usually 6-7 days after placing seeds in perti-dishes. Beware of leaving seeds too long in petri-dishes befoe trransfering to pots. Once coleoptiles emerge, tansfer is much more fiddly. Place 10 germinated seeds on each of sieved loam soil (organic matter ideally 2-5%) in each 3.5" pot. Prepare 12 pots for each seed stock. Cover seeds with a standard quantity of soil so that seeds are coverred by about 1 cm depth of soil. Label the pots.

(c) **Thinning and selection**

Thin out emerging plants at the one leaf stage to leave 6 plants/pot. Select the 10 most even pots per stock and discard the remaining pots.

(d) **Spraying**

Apply herbicide at the two leaf stage (usually 2-3 weeks after sowing germinated seeds) to five replicated pots of each stock. (At LARS we use a single nozzle laboratory sprayer, applying herbicide in the equivalent of 300 lt water/ha, at 210 kPa through a 'Spraying System' 8001 Teejet nozzle set at 45 cm above the pots).

(e) **Pot maintenance**

Randomise all treated pots within each of five replicates in the glasshouse. Water from above. Lighting should be maximum possible, if the test is carried out during autumn/winter. (Urea herbicides are photosynthetic inhibitors, and activity can be poor at low light levels).

(f) **Assessment**

Determine fresh weight of foliage/pot when herbicidal effects are obvious, usually 3-4 weeks after spraying. Calculate % reduction in foliage weights for each stack. Providing any differences between replicates is small, relate the treated fresh weight values for each replicate to the mean of the five replicate values, for untreated pots of the same stock. Plants are also classified into 4 categories according to vigour. The four classes are (a) healthy-similar to untreated with no or only slight symptoms, (b) showing clear symptoms of damage from herbicide, but likely to recover, (c) showing major symptoms, plants alive but growth severely affected and (d) dead-no (or virtually no) green leaf.

	Replicate 1	2	3	4	5	mean
Stock A Foliage weight in untreated pots (mg)	3400	2400	3100	3600	2500	3000
" " " " " treated pots (mg)	500	700	250	450	600	500
" % reduction	83	77	92	85	85	83%

(g) **Analysis**

Statistical analysis may not be needed if differences between stocks are very large. Otherwise the most appropriate analysis should be made after taking statistical advice. An analysis of variance using an arcsin transformation of the % reduction data has often been appropriate.

(h) **Interpretation**

Herbicide resistance in black-grass does not give total immunity to plants. Partial rresistance is more common, and relating results from a pot screening experiment to field performance is difficult.

The inclusion of standard stocks is useful. especially if the degree of resistance in the field has been assessed. At LARS we always include Peldon (resistant), Faringdon (partially resistant) and Rothamsted (susceptible) as standards. Faringdon is a useful marker for resistance, as we know from outdoor experiments that reduced performance of chlorotoluron can occur at field recommended rates. Other stocks are only termed 'resistant' if they show greater resistance than the Faringdon stocks. All stocks more susceptible to chlorotoluron than Faringdon are termed 'susceptible'.

Finally, it is important to recognise that, although this test identifies resistance to chlorotoluron, it is likely that there will be cross resistance to many other herbicides.
In England most, but not all, of the stocks showing resistance to chlorotoluron have shown cross-resistance to pendimethalin, diclofop-methyl and many other herbicides. Thus any stocks identified as being resistant to chlorololuron, need to be tested further for cross-resistance, before authoritative recommendations on herbicide use can be made.

INTEGRATED WEED MANAGEMENT IN TROPICAL AGRICULTURE

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The agriculture practiced by small-scale farmers in the tropics is diverse, complex, frequently resource poor, and lacks the research base of temperate agriculture. Many of the farmers are deficient in formal education but are wise in the ways of their systems that are often characterized by small size and reliance on human or animal power and local information. These farmers need improved weed management techniques and systems that are integrated, as most farmers do. Some of the weed management techniques now used in these farming systems may seem primitive and inefficient but before they are rejected and changed one must ask How do they work ? and What can be learned from them? The management techniques are aften agronomically wise because they consider local conditions and plant requirements. Therfore, a major point of this short paper is that traditional methods must be understood before they are replaced by what others may think is modern or more efficient (3). This paper will also discuss the importance of problem definition and research objectives and conclude with a brief outline of research objectives that could be considered for many tropical areas.

Moody (1) cited Reed *et al.* (2) and posed the imprtant questions that should be considered by anyone who wants to develop weed management systems in the tropics regardless of the present cropping system. The questions are applicable whether one is considering modifications to a developed or developing system. The first thing one needs to know is what is known. There is a tendency among weed scientists to assume that weed are harmful to crop yields in all situations. That may be true but it does not follow that the cost of control will be recovered in yield gain. It is also true that weeds are already managed in many tropical cropping systems so yield losses are minimized. Secondly, one must determine what is already known. This is not the first question in another form. The first question demands problem identification and is logically followed by determining if existing knowledge is sufficient to address the problem. That knowledge may be available in local information, the source of knowledge in traditional farming systems, or in other places (eg. the weed science literature) that may not be available locally. When it is determined that what is known is not sufficient to solve the problem indentified then one proceeds to ask what must be done to slove the problem. Another way to state the same question is to ask what experiments should be done to address the problem?

When the appropriate experiments and procedures have been identified it is obligatory to consider if the work can be done within the limitations of time, money, facilities, and help available. These necessary resources will determine what can be done. Moody (1) also suggests that the farmer is central to the research. The acceptance of weeds varies among cropping systems and farmers. A farmer who depends on weeds for forage or livestock feed will have a different tolerance of weed competition than a farmer without livestock. Improved weed management techniques must be accepeted by farmers who might reject them on the basis of cost or because of alternative and more favoured used for money, labor, or time. Some farmers are willing and able to pay more for improved yields for better weed management and others are not. One should not assume that systems are rejected for irrational reasons.

It many cropping systems it may be necessary to convince farmers and those who control funds that weeds are deterimental to yield. Local competition experiments may be required to provide the evidence. Therefore, competition experiments may be part of necessary local work that must be done to gain recognition and local support for development of weed management systems. Most weed scientists know the damage weeds do no longer needs to be documented but others may have to be convinced. Thus, part of problem definition may have to include convincing others of the importance of weed competition. If this type of work does not have to be done, then weed scientists in the tropics can select from a range of problems, the solution of which will contribute to progress in the development of weed management system. A few of the more imoprtant problems follow.

Many weed scientists consider the unavailability of funds to be the most important barrier to the development of weed management research. Without funds little can be done but I suggest that lack of good ideas and innovative approaches to problems may be a more serious barrier than funds. When weed scientists understand the most imorotant problems and have crafted objectives that address them, money may not be the most important obstacle. Worthy research objectives must come first. The balance of this paper will suggest some research objectives that should be considered by those who develop weed management programs for the tropics.

A paramount objective for any practical weed research program in the tropics, or anywhere else, is that it must yield economically and socially feasible weed management strategies. Any strategy will be evaluated by potential users and should be evaluated by developers with four imperactives : markets, resources, information, and ecology. The market imperative includes consideration of cost-benefit analyses that show whether the technology's benefits outweigh its costs. These analyses should include country constraints on a technology and the influence of government policy, especially subsidies for a crop or a technological intiative. Resource questions include the availability of the proposed technology and its cost to the user and the nation or region. Users of weed management systems need information about the system that must come from somewhere. Researchers are not always competent to extend the information users require. An extension service or an equally competent and unbiased source of information must be available or developed for good technology transfer. Potential users know they need information and may reject a technology if they feel avenues of information are absent. Finally, weed scientists have to recognize the ecological imperative. If a weed management system is not ecologically wise it may be rejected by users or the public. Ecological accountability is required for all weed scientists.

The second essential step in development of a good weed management program is to define the specific weed problem for the crop or cropping system. This should be followed by a determination of the role of weeds in the whole agroecosystem rather than emphasizing a way to control weeds in a crop or year. Weed science does not have good record here. It has been very successful at controlling weeds in almost any situation but not at defining the role of weeds in entire agroecosystems. This is a part of the ecological imperative.

Considering the four imperatives defined above and identifying the weeds for each cropping situation are necessary preliminary steps but may not solve the farmer's immediate weed control problem. They are essential to development of long-range, successful weed management programs.

Worthy specific research objectives for the tropics could include a wide range pf research problems. There is an enormous need to study parasitic weeds from the *Striga* and *Orobanche* genera. Species from these genera cause large losses on small farms and there are no good control or management techniques available for small-sacale tropical farmers. Years of basic biological study may be required to develop effective management for parasitic weeds.

Little is known about the dynamics of the tropical soil weed seed bank; the source of the weed problem in most annual crops. Available temperate data may provide leads on ecperimental method but precise knowledge on seed hebaviour in the tropics awaits local research. Neither the rate of addition nor the rate of depletion of weed species is known for tropical soils.

Research on minimal and no-tillage weed management systems is well underway in the temperate zones and work is needed for the tropics. Researchers may find that traditional systems of soil management are appropriate and help manage weeds or that new systems are needed. Research to modify tillage systems is a good example of where one must consider the resource, information, and ecological imperatives mentioned above.

The world's population is growing exponentially and will continue for several decades. Majority of those added to the world will live in tropical countries and be reliant on tropical agriculture for their food. Improved weed management systems are not sufficient to solve all the problems of feeding an ever growing population but they are necessary. Tropical farmers and the world need the research weed scientists in the tropics will do.

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AGRICULTURAL SYMPOSIUM ON INTEGRATED WEED MANAGEMENT FOR SUSTAINABLE AGRICULTURE

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The theme of the symposium 'Integrated Weed Management for Sustainable Agriculture' and venue to hold this International meet at CCS Haryana Agricultural University, Hisar has been most appropriately chosen. This Agricultural University has the distinction of having high level academic and research programme in weed science as evident from the fact that this is the only Agricultural University at National level having the Professor's post in Weed Science.

For sustainable agriculture, maintaining sustained productivity of the cropped land is a must. This may be achieved primarily through the adoption of crop cultivars having sustained high yield potential and being suitable to the agro-climatic region linked with effective production management.

The resilience of weed population under intensive herbicide use, build-up of weed species tolerant to the control methods used and increasing public concern about indiscriminate pesticide use and its effect on environment and human health have led to widespread appreciation of the integrated weed management concept which is the rational use of direct and indirect methods to provide cost effective weed control.

The essential factor in any integrated weed management programme is the number of indirect and direct methods that can be combined economically in a given situation. The commonly suggested indirect methods are land preparation including stalseedbed technique, water management, plant spacing, seed rate, crop cultivar use, and fertilizer applications. Direct methods include hand weeding, use of mechanical weeder, mulching and use of herbicides.

Farmers are interested in net benefit and in protecting themselves against risk. A critical assessment of indirect weed control methods suggested for use in integrated weed management, their cost-benefit ratio and their relative contribution to long and short-term weed control – should be provided to put the integrated weed management concept in perspective. However, the researchers often do not provide an economic assessment of these indirect methods.

It is a known fact that among many factors responsible for poor yield of crops, weeds are recognized as one of the major ones. In Indian agriculture, weeds cause nearly 33% loss in crop yield which exceeds the total loss by pathogens (16%) and insects (12%). Weeds have long been considered as major constraint in enhancing the agricultural production. At the national level, still hand weeding goes as a major effort of weed control which however gets handicapped due to high cost and timely non-availability of man power and sometimes difficulty in manoeuvrability of mechanised operation which limit the effective control of weeds in cropped fields.

Nevertheless now there are chemicals which are expected to meet the situation to a certain extent. To find out this as an alternative, researches have been directed to exploit the chemicals to achieve the said objective. However as said, the use of chemicals (herbicides) poses polution problem. Therefore, to reduce the environmental pollution and sometime food poisioning (with the use of chemical pesticides) the use of natural agents in weed control is considered to be of immense importance.

Natural or biological weed control agents are those of biological origin, which suppress or kill the weeds without significantly affecting the desirable plants. They include insects, animals, fish (like chinese carp menatal), birds (like duck), microbes (fungi, bacteria, viruses, nematodes, etc.), their toxic products, and plants (parasite plants, competing plants) or their products. In general, bioherbicide means anything of biological origin used to suppress or kill the weeds. But in modern literature the term bioherbicide refers to microbial plant pathogen which are applied as sprays that uniformly kill or suppress the growth of weeds. The fields of biotechnology and genetic engineering offer great scope for development of bioherbicides as well as resistant crop plants to selected herbicide. Farmers everywhere search for ways to widen the narrow margin of profits between production costs and crop returns. Cost effective methods of controlling weeds could help preserve profits and increase yields.

Introduction of short duration high yielding crop varieties has opened many avenues to augment agricultural production in the country. A new strategy of cropping system is gaining prominence in farmers fields. Some of the profitable intercropping systems for dry lands are reported to be fllowed in many areas which however, when infested with specific weed species suffer severely due to soil moisture availability in competition with weeds. The post emergence control of the weeds using chemical herbicides is limited in presence of the crops of different nature under intercropping system, under such situation integrated weed management and use of bioherbicide would prove to be prospective.

Research for each problem area need now to be oriented on the basis of climates, soil, irrigation potential and most suitable crops. The coordinated effort under All India

Coordinated Research Programme on Weed Control of ICAR has paid a rich dividend to the above effect. Nevertheless our coordinated effort would further provide success in exploiting our resources to the best advances and achievement which would not only raise the standard of living of our people but also the prestige of our country in the ittee of nations. There is a notable conceptual advance and the scientists of agriculture are bound together for boosting crop production and productivity on which lies the country's prosperity. The scientists of the region need to bring in agrarian prosperity by encouraging participation of rural community of the region in their endeavour for introducing the cost effective weed control technology.

For the International Weed Scientist to come closer and exchange their understanding about the control of weeds for the benefit of each other's nations, there is the occasion for strentheinig the favourable situation. Now there are computer codes available which are useful for universal identification in bibliographies and data bases.

An aproved computer code is a five letter abbreviation based on the scientific name of each plant. In general the first three letters refer to the genus and the last two denote to species, the sub species or the variety. For example the code for *Echinochloa colona* is ECHCO, for Ecinochloa crusgalli ECHCG.

The national objectives for scientists and so the weed scientists include developing and maintaining competence to do good scientific work that should yield valid and reliable results to contribute to the socio-economic development, that is the need of the country

DEVELOPING A NATIONAL WEEDS STRATEGY FOR AUSTRALIA

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Abstract

The draft National Weeds Strategy (NWS) for Australia outlines the extent, the economic and ecological impact, and potential of weed problems in Australia. It discusses the main issues of weeds, which confront governments, landholders, weed scientists and the general public today. Recommendations are made for improving the effort devoted to weeds in Australia within the context of the principles of ecologically sustainable development and the conservation of biological diversity.

Keywords : Weeds strategy, weeds policy

Introduction

Weeds cost Australia an estimated $3 billion each year. They are a major problem for primary producers and a serious threat to the natural environment. Native plants and animals are increasingly being displaced by weeds. In additon, weeds can affect the health of people with allergy and asthma problems. Both weeds themselves and some of the methods used to control them are major causes of land degradation. Weeds reduce biological diversity and reduce prospects for sustainable agriculture decline. Weed invasion is a process with impacts that are not fully understood or appreciated by the majority of people.

Recognising the importance of the issue, the Commonwealth, States and Territories of Australia agreed in 1991 to jointly develop a National Weeds Strategy outlining necessary action by governments, individual and the community to minimise the future environmental, economic and social impact of weeds. The draft Strategy recommends action in the areas of legislative and institutional arrangements, awareness and education, research and development and implementation of weed management strategies.

Basis for a National Weeds Strategy

The NWS takes its format from a consideration of the principles of weed management appropriate to an island continent, where despite naturalisation of many plant species now viewed as weeds, government action has succeeded in keeping out many other unwanted species and containment programs have been enacted against some of those species

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now naturalised here. Acknowledgement of success and failure with these efforts and evidence that a better integration of effort is needed is the stimulus for the Strategy.

Also with national and international concerns for the state of the environment resulting in publication of the World Conservation Strategy in 1980, the National Conservation Strategy for Australia in 1984, and the draft National Strategy for the Conservation of Australia's Biological Diversity in 1992, action against weeds must be considered within the principles of (i)ecologically sustainable development and (ii) conservation of biological diversity.

Basis of Recommendations

The NWS is a response to scientific and community concerns about the consequences of weed encroachment. It recognises that :

* weeds impose a major and increasing environmental, economic and social burden on Australia :
* sound weed management is integral to sustainable land use practices;
* exotic plants species are among the most serious threats to the conservation of native plants and habitats;
* many of the current legal, institutional and social mechanisms for handling weed problems are outdated; and
* increased public appreciation of the environment, economic and social implications of current weed invasions patterns are required to formulate effective, intergrated weed management strategies.

The Strategy is seen as an important step in moving beyond the traditional focus on weed control in agriculture towards recognition of the need for improved management across all ecosystems. It recognises that while successful weed control outcomes depend on action by landusers and the community, a realignment of legislation and institutional effort is necessary. It also reflects a growing awareness that long-term management of Australia's productivity and biodiversity is best served by an integrated approach to weed management. Weed control is not an end in itself. It is disturbance of ecosystems which creates environments for weed invasion. These causes need as much attention as weed consequences, if rehabilitation of ecosystems is to be achieved.

The NWS is a sequence of recommendations developed from consideration of the process of weed invasion and community response to it. The essence of the strategy is weed exclusion, early warning systems (of external threats and action to detect early colonisation by exotic species), of priorities for containment of weed species, education and training (which includes research and development) commensurate with the problem and an administrative basis for action.

The recommendations are based on the following premises :

1. The range of species not already present in Australia and which pose a weed threat if they gain entry justifies a continuation of reliance on quarantine procedures and scrutiny of

current legislation to ensure that it is appropriate in intent and effective in practice, for the exclusion of invasive species.

2. The basis for importation of any species apart from those on a prohibited list requires more attention to possible impacts in ecosystems other than the one for which it is intended. There have been sufficient examples of agricultural species obtaining weed status to merit extreme caution with future imports.

3. There are anomalies between States and Territories in legislation on weed issues which relate to landholder responsibilities, sale of plants and transport of grain and fodder.

4. Responsibilities for ensuring control of noxious weeds at the local level are often honoured more in the breach than in strict observation, because of uncertainties about "fairness" and local sensitivities.

5. In many cases Aboriginal communities are faced with weed problems caused by the policies of white Australia.

6. Tertiary training in environmental and weeds science, and training of weed control operators is assessed as inadequate for the scope of the problem which faces the next generation.

7. The scale of the continent and the diversity of its ecosystems demands that specialist effort focus on segments of the environment to provide the detail required for setting priorities in research, education and training and the planning of public awareness programs.

8. The appointment of a national manager or co-ordinator and a National Co-ordination Committee is the administrative structure proposed to assume responsibility for organisation of the Strategy and the action against specific weed issues.

Vision Statement

The vision of the NWS for Australia is to enhance environmental management for ecological sustainability and species diversity by minimising the impact of weed populations.

Goals

The proposed goals of the NWS are to :

* protect Australia's productive capability, the ecological sustainability of natural ecosystems and human welfare from the deleterious effects of weeds,
* prevent the introduction and establishment of new weeds,
* identify and eradicate potential weeds promptly,
* manage existing weeds populations appropriately,
* increase community awareness, involvement and action on weed issues.

Reference

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INTEGRATED WEED MANAGEMENT IN CEREAL CROPS

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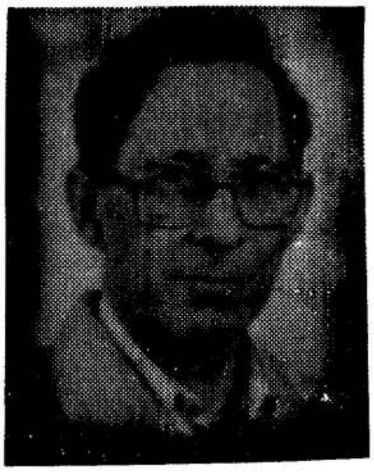
Introduction



Weed are plants growing where they are not wanted. In a cereal field, plants other than the crop are weeds mainly because they compete with the crop for water, nutrients, space and occacionally light, causing small, shurnken grains and reduced quantity as well as quality of the yield. Some weeds are even poisonous. Additionally, weeds may hamper the harvest operation, add water, foreign plant parts and dust to the produce, thus increasing the costs needed for drying and cleaning the crop. Consequently, weeds can cause damage from an early stage of the cereal plants to well after the crop is harvested.

The farmer's concern in respect of the weed problem is too often limited to the field and the specific crop which he is currently growing, simply because it is there he most easily recognizes the weed problems. That such problems frequently are closely linked to conditions for weed growth at other times of the year, is unfortunately often overlooked. In an integrated approach of weed control the whole period of the year during which the weeds are able to develop, must be taken into consideration, i.e. also the periods between the crops. In the present paper, therefore, I want to discuss weed management in cereals on the basis of this comprehensive view, starting with a newly harvested field.

The Fallow Period

After harvest, the field is often left open to the weeds. New plants may emerge, and weeds which did not reach maturity while the crop still occupied the field, are now allowed to grow freely and unhampered producing large amounts of weeds, which may germinate and create problems in future crops.

Perennial weeds, such as *Elytrigia repens* (L.) Nevski and *Cirsium arvense* (L.) Scop., normally take even more advantage of an undisturbed fallow period than annuals do. During the fallow time such weeds can strengthen their propagation capacity substantially, especially the vegetative one. In this way, the weeds increase their damaging potential, which will express itself in the following crops.

Therefore, during the interval between two crops, it is vitally important to prevent the weeds from building up the infestation. Instead the farmer should use this period to his advantage. Regarding perennial species, this is especially important, because such weeds often are difficult to control in the crop itself.

Unless the soil is vulnerable to erosion, the stubble field should be harrowed to stop the growth of the existing weeds soon after harvest. A second pass with the harrow, or perhaps plowing, before new annuals have produced mature seeds or perennials have reached ca 20 cm of height, will increase the effect.

On soils liable to erosion, a herbicide e.g. Roundup may be used as an alternative. To achieve good results, the time of application is crucial. Perennial grasses ought to have 4-5 leaves, and dicotyledonary species should have a well developed rosette of leaves or 15-20 cm long stems at the time of spraying.

Sowing

A well established cereal field is a strong competitor to weeds. Consequently, it is of great importance to prepare the growth conditions in such a way that the crop emerges rapidly and grows vigorously. Thus, it is vital to use healthy and clean seed, especially free from weed species that are difficult to control in the crop. The seed bed must be smooth, and the seeds planted deep denough to ensure sufficient supply of water, but not so deep that the emergence is delayed. A balanced fertilization will assure even and rapid growth after emergence.

It is well known that great differences in competitive ability may exist between different cereal species and cultivars. Therefore, it is important to choose a species/cultivars which covers the soil surface as rapidly and completely as possible. Of the barley, oat and wheat, oat generally shows the highest and wheat the lowest competitiveness. In this relation the amount of seed sown also needs to be mentioned. A small quantity will give a field with low competitive power against weeds.

Weed Control in the Field

The preventive and cultural measures mentioned above will reduce the need for direct weed control in the field itself. Most often, however, some measures will still be necessary, but they can be less extensive and so having smaller impact on the crop. The direct stepscan principally be of two different kinds.

Mechanical measures by which the weeds are destroyed usually by means of a spring-tine harrow with long tines. This is an old method, but during the last 40-50 years it has largely been out of use. In resent years, however, the method has got some kind of a renaissance.

It is very important to do the harrowing while the weeds are small; preferably at the cotyledonary stage. This means that the first shallow harrowing has to be done at the time of emergence of the crop. At such an early stage, the cereal plants tolerate the disturbance fairly good, and the harrow can be moved in as well as perpendicularly to the sowing direction. If the weeds should recover it may be necessary to repeat the harrowing when the cereal plants have developed 2-3 leaves. At this stage the movement of the harrow can only be parallel to the sowing direction.

Even if the use of harrow may seem simple, it is by no means easy to practice this method safely in the field. To achieve good control of the weeds and at the same time avoid unacceptable damage to the crop, the job must be done carefully.

Harrowing is most effective on small weeds. After the cotyledonary stage the resistance to harrowing increases rapidly, and against vegetatively propagated perennials, harrowing is nearly useless.

Chemical measures (herbicides) play worldwide the major role in weed control in cereals. In this crop the use of herbicides has become almost a routine measure, in fact too much so. The problem, however, has been and to some extent still is to find a reliable and user-friendly criterion for deciding when application of a herbicide is necessary or not. In the absance of such a criterion spraying is carried out " for the sake of security". That this "security" not always is that positive, has been clearly demonstrated in a Norwegian study, where 35-40 % of the acreage sprayed with hebicides, hardly paid the application costs.

Use of herbicides is an easy and generally effective way of removing weeds. On the other hand, this method requires a fair amount of knowledge about the chemicals, the weeds and the crop.

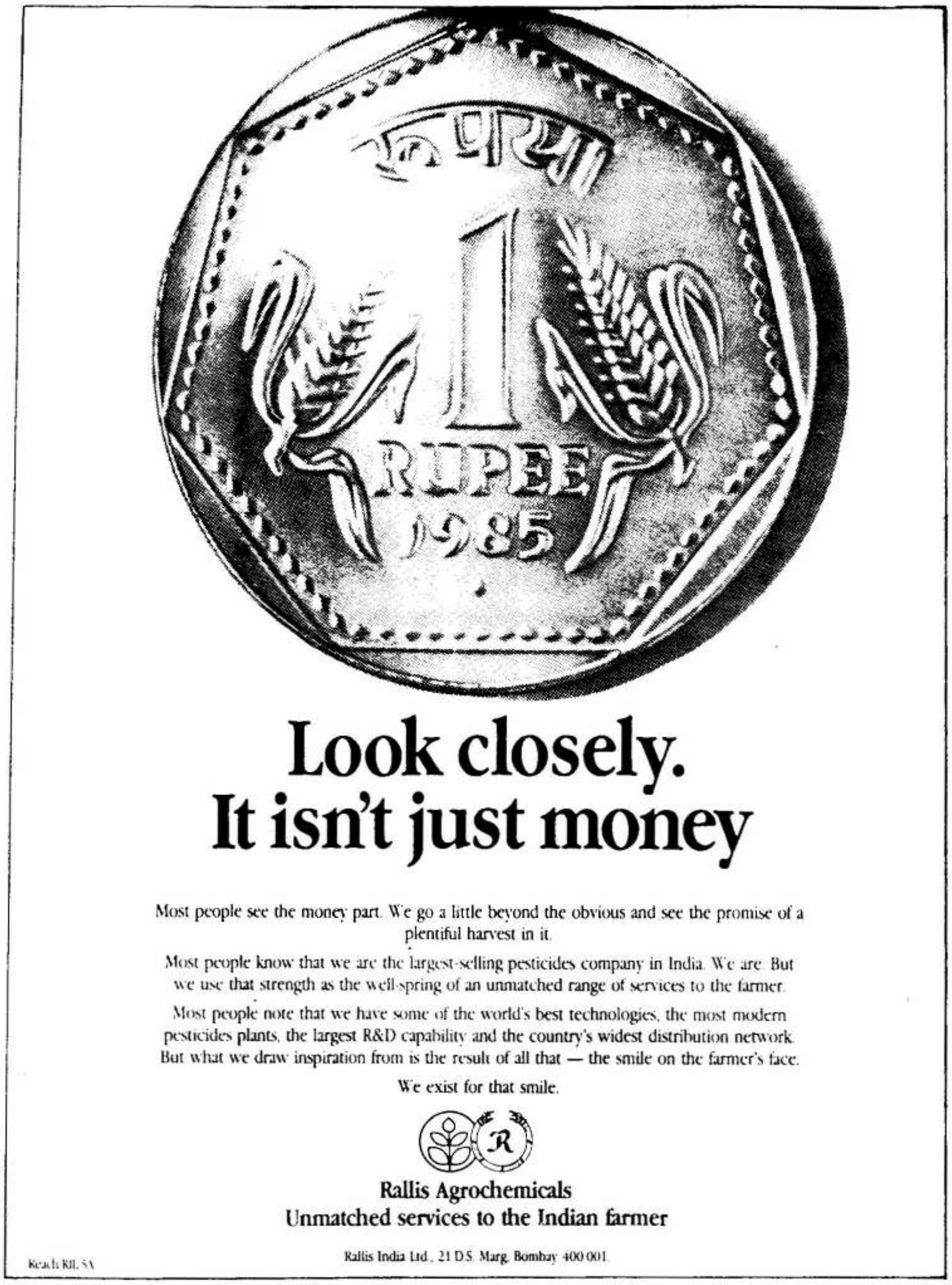
As a herbicide is intended to kill or at least retard the growth of some plants (the weeds) while leaving the creal plants unharmed, it is very important to choose a compound which is tolerant to the crop. Further, as the weed population may differ quite a lot from one field to another, and different herbicides by no means are equally effective against all types of weeds, it is obligatory to take the weed community of each field into consideration. Thus it is quite common that different herbicides have to be used on the same farm.

If the weed flora is not taken sufficiently into account, the weed control will not be as good as expected in the first place. Secondly, in a longer perspective, this can lead to a shift in the seed community towards species which the chosen herbicide does not control or controls onle slightly, thus increasing the weed problem. Further, it shall not be forgotton that species which may be of minor importance at the beginning, simply because they are few in number, eventually, due to an unfortunate selection of herbicides, may develop into major problem weeds.

It is good agricultural practice, therefore, not to use the same herbicide on the same field every year. A change of herbicide prevents also the evolution of resistant strains within an otherwise susceptible weed species.

Conclusion

Integrated weed management is a strategy relying on a number of different control measures. The fundamental principle is to deprive the weeds of the possibilities of developing their strong points. The practical steps taken in the field, whether in the growing crop or in the fallow period between the crops, should be adjusted to the actual situation to obtain optimal effect on the **weeds to the benefit of the crop with a minimum of risk to the farmer as well as the environment.**



WEED MANAGEMENT STRATEGY FOR PARASITIC WEEDS

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Introduction

In India, as elsewhere, parasitic weeds continue to create special difficulties for farmers and are tending to increase in importance. All the main groups of parasitic weed are represented in India.

In *Scrophulariaceae*, the witchweeds, *Striga* species, are hemi-parasitic root parasites, so-called because they have normal chlorophyll and green colour, enabling them to photosynthesise some, but only part, of their carbohydrate requirement. Starting from minute seeds less than 0.5 mm long, they rely on host root exudates to stimulate their germination. Once the seedlings are attached, they depend very largely on their host for carbohydrate, minerals and water. In addition, most *Striga* species cause serious physiological disturbance of their host, resulting in a change of root : shoot balance and severe stunting of the shoot system. In India, several species of *Striga*, especially *S.asiatica* cause serious losses in yield of sorghum, other millets and sugar cane. Crop yields can be severely reduced, often to the point of total crop failure. Problems for farmers are increased by the fact that they tend to emerge after the main weeding time and require special weeding effort. They also produce vast numbers of seed which have great longevity in the soil.

In *Orobanchaceae*, the broomrapes, *Orobanche* species, are holo-parasitic root parasites, having no chlorophyll and being wholly dependent on their hosts for all carbohydrate. Like *Striga*, they also have minute seeds which are stimulated to germinate by host root exudates. *Orobanche* species damage their hosts mainly by upsetting water balance and are therefore especially damaging during drought stress. In India, the most extensive problem is from *Orobanche cernua*, affecting about 50% of the tobacco crop in Andhra Pradesh and reducing yield by 25% or more. This and other species also cause more local losses of tomato, brinjal, etc.

In *Convolvulaceae*, the dodders, *Cuscuta* species, are almost holo-parasitic stem parasites, containing only traces of chlorophyll. They consist mainly of yellow stringy stems which twine around the host shoots and apparently strangle them. The haustoria which are sunk into the host stems and foliage act as very powerful physiological sinks attracting most of the carbohydrate away from the host flowers and fruits, often causing total failure of affected crop plants. The commonest species in India is *Cuscuta reflexa* which attacks many fruit and shrub plants but *C.campestris* is also locally serious on some vegetable crops and niger seed.

In *Loranthaceae* and *Viscaceae*, the mistletoes are all woody hemi-parasitic stem parasites, with varying chlorophyll content. They depend on their hosts mainly for water, and under wet conditions may do little harm. Under drought stress, however, they often cause death of infected branches. In India a wide range of species occur, of which *Dendrophthoe falcata* is perhaps the commonest, damaging many fruit, ornamental and forest tree species.

Control of Parasitic Weeds

Mistletoes

Starting with the easiest and progressing to the more difficult, mistletoes are not necessarily easy to control, but it could be said that they are easily managed as they can generally be ignored ! Although often conspicuous, the damage they cause is not usually sufficient to justify any control measure. Where they are present in large numbers and associated with weak tree growth, it is most likely that the weakness of the host tree is the cause rather than the results of the mistletoe infestation. Mistletoes rely on their own photosynthesis to a far greater extent than other parasitic weeds and therefore need plenty of light to thrive. A slowly growing host three allows vigorous growth whereas a fast-growing tree suppresses parasite growth. If mistletoes are thought to be causing unacceptable damage the first consideration is that the trees are growing as vigorously as possible. Weeding, irrigation and fertilization should be attended to, and in certain crops such as tea, coffee and cocoa, the presence or absence of shade trees can be critical, the presence of the shade being generally benefical. However, if the shade trees are themselves infested (or other surrounding vegetation), they can be a source of infestation (via birds) and felling or pruing of these sources may be desirable. Direct control on the infested crop trees can be achieved to some extent by pruning infected branches back to well below the attachment point or by directed spot-spraying of diesel oil or paraquat but this is rarely completely safe. An interesting method developed in Kerala for large forest trees involves trunk injection of dilute herbicide (metribuzin).

Research effort on mistletoes is very little world-wide. The need is not great and the prospects of improved control are not good, but effort could be devoted to further study of trunk-injection techniques, especially in citrus.

***Cuscuta* species**

The first principle in dodder control is prevention. A common source of a *Cuscuta* problem is contaminated crop seed, especially in lucerne and niger seed, whose seeds are comparable in size to those of the *Cuscuta* and are not easily cleaned. If in doubt seed should be obtained from a reputable, uncontaimated source. Farmyard manure must also be uncontaminated. Where fields are already contaminted, rotation into any grass or cereal crop, or certain non-susceptible broad-leaved crops such as cotton will be helpful. Susceptible broad-leaved weeds must, however, be controlled. As *Cuscuta* germinates relatively shallowly in the soil, it can be controlled by pre-emergence herbicides and selective compounds are available for use in number of crops, e.g. chlorpropham and propyzamide in lucerne, chickpea, sugarbeet, niger seed and onion; also pendimethalin and fluchloralin in potato, green gram, black gram, moth bean and kenaf. Once allowed to establish, control by chemicals is much more difficult, though diquat and paraquat can be used for spot spraying and glyphosate has been used selectively at low doses sprayed over lucerne and citrus. Most recently the new herbicide imazaquin has shown promise in soyabean. Other control methods for *Cuscuta* include hand-pulling or fire to destroy localised patches and mixed cropping with cluster bean.

Research effort should yield further useful herbicide treatments but combinations of the available possibilities should be adequate for most infestations.

***Orobanche* species**

The ideal means of controlling *Orobanche* (and *Striga*) problems is generally felt to be the use of resistant varieties, and the first crop to be bred specially for this purpose was sunflower for resistance to *O. cernua*. Although new races of this parasite keep occurring, it is still possible to avoid serious loss of sunflower yields by this means. In other crops, such as tobacco and tomato, it has not yet proved possible to find high levels of resistance though partial resistance to *O. crenata* is being exploited in faba bean. With modern techniques of genetic engineering it is possible that a resistance gene may be isolated and introduced to some of these crops but there is no prospect in the near future. Meanwhile an almost equally existing prospect is the development of herbicide-resistant crop varieties in which perfect selective control should be possible. This has already been confirmed experimentally with chlorsulfuron against *O. aegyptiaca* on genetically engineered tobacco. Other crops such as tomato are also likely to be developed with resistance to this or other sulphonyl ureas, imidazolinones, or glyphosate. Where crop value justifies such herbicide use this is likely to be a very important control method. Meanwhile low doses of herbicide provide moderate to good selective control in some legume crops; glyphosate post-emergence on faba bean and lentil and the newer herbicides imazaquin and imazethapyr pre- or post-emergence on these same crops plus pea, tobacco and sunflower. A simple but more labour-intensive method developed in India is the use of vegetable oils dripped or wiped onto the emerged parasites. Among other methods, fumigation and solarisation offer very high degree of control but are too expensive for all but the highest value crops. Crop rotation is theoretically helpful but has to be practiced over many years before the reservoir of seeds in the soil is exhausted. Hand-pulling does not prevent all the damage and again has to be repeated over many years to achieve long-term reduction but is suitable for low infestations and may be vital to prevent seeding. Flooding for at least 2-3 months has been reported effective and deserves more trial. Good biological control by the fly *Phytomyza oryobanchia* has been reported from eastern Europe but success is not easy to achieve. More promising is the possibility of mycoherbicides based on cultures of *Fusarium* or other pathogens.

Research effort, other than the long-term development of herbicide-resistant varieties, can usefully be devoted to evaluation of the newer herbicides; also to the development of mycoherbicides.

***Striga* species**

As for *Orobanche*, resistant varieties have so far failed to provide a complete answer to the *Striga* problem. Only in cowpea has immunity (to *S. gesnerioides*) been found and this is now being incorporated into new varieties for release in affected areas of West Africa. In the case of sorghum, decades of work by plant breeders in India, most recently at ICRISAT (International Crops Research Institute for the Semi-arid Tropics) have yielded so-called SAR (*Striga asiatica*-resistant) varieties with a very high level of resistance to *S. asiatica* and this resistance should soon be incorporated into new hybrid varieties, Equivalent high-level resistance has not yet been developed in maize or millets, nor in sorghum for the African *S. hermonthica*. Whether the *Striga asiatica* resistance will prove durable over time has yet to be seen. There is some danger that more virulent races of the *Striga* will develop with repeated growing of the resistant varieties. This makes it important that other methods, including hand-pulling, are used to prevent seeding of any surviving parasite. As hand-pulling is a labour-intensive and unpopular task, it is rarely suitable for any but light infestations, but it may be essential for complete prevention of *Striga* seeding, and should not be dismissed as impossible. Rather, the aim must be to reduce *Striga* numbers by every other means possible, and then finish the job with a minimum of manual effort. Among the other available methods, rotation with non-host crops is recommended wherever possible to prevent further parasite seed production and allow time for the resevoir of seeds in the soil to decline. Some rotational crops, known as trap crops, may be better than from their roots which trigger suicidal germination, but even then several years of these crops may be necessary to greatly reduce the problem.

Time of planting can be critical for the success by continuous wetness. Hence, early or later planting can be beneficial, depending on the rainfall pattern. Soil fertility is also critical for the success or failure of *Striga* and fortunately what is good for the crop, especially high nitrogen, is bad for *Striga*, which thrives on low soil fertility. This makes nitrogen one of the most important weapons available for its control. The optimum dose, form or timing of nitrogen fertilizer is still not well defined, but as it works mainly through reducing host stimulant exudation it should be applied in a way that is expected to be most beneficial to the crop. As nitrogen fertlizer is rapidly leached and depleted during the growing season its effect does not always last through to havest but it should greatly delay *Striga* development, improve yields, and reduce the cost of supplementary methods such as hand-pulling. If soil fertility can be improved in a longer-term manner, by growth of green manure crops, alley-cropping, etc. this is likely to be even more beneficial than the application of fertilizer. Intercropping with any leafy crop is now known to suppress *Striga*. The mechanism is not fully understood but the intercrop needs to be within the row rather than planted as alternate rows. No herbicide has been found which will prevent attack altogether, but 2, 4-D and some others can be'used to kill the emerged parasite, as an alternative to had-pulling. A further chemical approach, used very successfully on light soils in U.S.A. has been the injection of ethylene gas into the soil to stimulate suicidal germination of the *Striga* seeds. This can be applied by relatively simple knapsack injectors but yet to be exploited outside U.S.A. Biocontrol has not yet proved feasible for *Striga* but, as for *Orobanche*, there are possibilities for the development of mycoherbicides.

Research effort in the past has often been too short-term and has given disappointing results because few if any of these techniques give a high level of *striga* control in a single season. New research, especially on crop resistance, may yet provide improved solutions but in the meantime it is certain that much better results could bne obtained by proper use of the available techniques. 'Proper use' entails firstly the integration of all those methods - rotation, use of the most resistant (or least susceptible) crop variety, optimum planting time, soil fertility improvement, intercropping, herbicide- as most appropriate to the level of infestation and farming system involved, and with hand-pulling as necessary to make sure no seeds are produced. Secondly, such procedures need to be repeated with determination over a period of years. The cumulative benefit from such sustained effort has rarely been demonstrated but should be the main objective of field-based *Striga* research in affected areas.

Conclusion

Control of parasitic weeds is difficult but not impossible. May all workers in India find success in their work!

ROLE OF NATIONAL BANK FOR AGRICULTURE AND RURAL DEVELOPMENT (NABARD) IN SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT

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I. Genesis of NABARD

The Committee to review arrangements for Institutional Credit for Agriculture and Rural Development (CRAFICARD) set up by the Reserve Bank of India (RBI) under the Chairmanship of Shri V. Sivaraman conceived and recommended the establishment of National Bank for Agriculture and Rural Development (NABARD). The Parliament through the Act 61 of 1981 approved its setting up and the National Bank for Agriculture and Rural Development came into existence on 12 July 1982. NABARD took over the functions of the erstwhile Agricultural Credit Department (ACD) and Rural Planning and Credit Cell (RPCC) of RBI and Agricultural Refinance and Development Corporation (ARDC). NABARD is an apex institution accredited with all matters concerning policy, planning and operations in the field of credit for agriculture and other economic activities in rural areas. NABARD operates throughout the country through its Head Office at Bombay, 17 Regional Offices located in the capitals of all major States and 9 Sub-Offices.

The Board of Directors of NABARD comprises the Chairman, two experts in Rural Economics and Rural Development activities, two persons with experience in the working of cooperative banks, one with experience in the working of commercial banks, three representatives each from Government of India and RBI, two from State Governments and a Managing Director.

II. Credit Facilities Available from NABARD

Since NABARD is a refinancing agency, it has to act through other banks in providing ground level credit. NABARD under its statute, has been entrusted with the responsibility of providing credit through banks not only for sustainable agriculture development but also for the entire gamut of economic activities of rural areas inclusive of small indsustrial activities with a view to securing prosperity of rural areas. NABARD provides refinance to eligible institutions viz., State Land Development Banks (SLDBs), State Cooperative Banks (SCBs), Commercial Banks (CBs) and Regional Rural Banks (RRBs) or Gramin Banks for different purposes covering both investment and production credit. The credit facilities covered a wide range of activities both in the farm and non-farm sector.

The major objectives which guide refinance support for different activities through the eligible institutions by NABARD are

(i) To support national policies for increasing agricultural production and rural employment through efficient use of national resources on sustainable basis;

(ii) Reduction of regional imbalances;

(iii) Equitable distribution of growth, ensuring credit support to the weaker sections of the society through special programmes like the Integrated Rural Development Programme (IRDP);

(iv) Increasing the credit absorptive capacity of the credit delivery system by improving the health of the agencies involved in credit dispensation; and

(v) Improving quality of lending through proper coantrol of technical and financial parameters and propagation of the repayment ethics.

III. Strategy and role of NABARD in promoting enviroment friendly projects

NABARD, with the mandate for the promotion of agriculture and rural development through credit, has endeavoured, since its inception, to devise development strategies consistent with its mandate and in line with the national objectives and priorties.

The Eighth Five Year Plan document has indicated that the thrust areas for which institutional finance is to be directed are :

(i) minor irrigation,

(ii) animal husbandry, dairy and fisheries development,

(iii) livestock improvement,

(iv) soil and water consevation measures, reclamation of water logged, saline, fallow lands, etc.

(v) agro-processing,

(vi) promotion of high yielding plantation crops in traditional and non-traditional areas and

(vii) provision of financial and technical support to the non-farm sector and encouraging rural artisans and small rural enterprises.

NABARD has estimated that the ground level disbursement of investment credit by all agencies during the Eighth Plan period is likely to be of the order of Rs. 44,014 crores of which the refinance availability may be of the order of Rs. 16,700 crores. Considering the past growth trend of 15 per cent per annum, the estimated amount of investment credit during the current Plan works out to Rs. 42,300 crores which is close to the Agriculture Credit Review Committee of Reserve Bank of estimate of Rs. 42,881 crores. These estimates were, however, lower than that estimated at Rs. 52,241 crores by the Working Group on Credit for the Eighth Plan. The production credit requirement, as estimated by NABARD is likely to grow to a level of Rs. 21,647 crores during the terminal year of the Eighth Five Year Plan from a level of Rs. 10,820 crores in 1990-91, calling for an annual compound growth rate of a little over 12 per cent. NABARD's estimates of amount outstanding in respect of production credit are very close to the estimates of ACRC and the Working Group on Credit for the Eighth Plan.

1. Increase in Green Cover

Increase in green cover to arrest green house effect through projects like Horticulture, Plantation, multistoreyed and multiple cropping and high density of planting, discouraging shifting cultivation, agro-forestry, social forestry, increased irrigation through groundwater and surface water development, silvipastoral schemes, recycling livestock and poultry refuse for agriculture and aquaculture and popularising stall fed animal schemes.

2. Preservation of Coastal Belts

Preservation of coastal zones through controlled groundwater development to arrest sea water ingression, plantation and forestry projects along the coast, social forestry, tree plantation to minimise cyclone and storm devastation. Removal of sandcast, pisciculture project play an important role in coastal ecosystem including estuary, mangrove, swamps, coral reefs are highly productive fisheries habitat and play important protective roles against waves, high tides, flooding and sedimentation.

3. Protecting Biodiversity through special projects to conserve endangered species - tissue culture, plantation of medicinal aromatic flora, pureline poultry project mixing of local breed with exotic breed and germ plasm.

4. Watershed, Wasteland and Wet Land Development

Reclamation of wasteland and wet land for agricultural production through multi-disciplinary approach, reclamation of water logged, saline affected and ravine lands adopting latest technologies. Watershed Development also assists in maintaining hydrologic cycle through intersectoral linkages.

5. Recycling and Reuse of Industrial Effluents, Sewerage, etc.

Promoting lift irrigation schemes on treated industrial effluents for agricultural production, at the same time, meeting the basic raw material needs of mother industries.

Aquaculture projects in diluted and/or treated effluents and sewerage. Using treated effluents for pisciculture of *hybrid tilapia*. Sectoral integration of poultry, piggery-cum-fisheries projects.

6. Arresting Desertification

Low, uncertain rainfall and wind erosion coupled with forest degradation has created a situation for gradual desertification of agricultural lands. Prevention measures like aforestation and cultivation of drought resistant crops like groundnut (wide root variety) has been proved successful in the reclamation of sand dunes and prevention of desertification in the affected states of Rajasthan and Andhra Pradesh.

IV. Future Thrust Areas

India with its natural physical and climatic diversity is no exception to global phenomena of environmental degradation. It is a country endowed with rich land but poor people. The unsustainable life style and consumption pattern often lead to environmental stress. A new model of growth is needed to be developed which would incorporate such programme for ecological regeneration as to create employment for the rural community in degraded areas and alleviate poverty. The present technologies fall short of meeting these future demands. The following thrust areas would therefore form part of National Bnak's future policies on environment.

1. Developing an Information Net Work for collection of wasteland data on environmental assessment for each sector on the lines of Environmental Information Systems (ENVIS) by the Government of India.
2. Evolving an environmental design criteria and pollution standards under intensive agricultural production projects.
3. Blending of indigenous technology with frontier technology for a sustainable agricultural growth suitable for environmental conditions.
4. Commercialisation of bio-technology developed by the Universities, Research Institutions, Industries, etc. and ensuring its accessibility to community/individual farmers.
5. Guidelines on Planning and Management of coastal lines, ocean resources including coral reefs, mangroves and wasteland.
6. Recycling of industrial effluents, sewerages, etc. for irrigation and pisciculture development.
7. Promotion of aquaculture for improving the water quality or river systems particularly under Ganges Action Plan.
8. Planned management of groundwater and surface water resources with modern irrigation

technologies especially in scarce water areas.

9. Conjuctive use of surface and groundwater in command areas of irrigation projects to arrest water logging and effective utilisation of water resources.

10. Promoting bio-technology projects particularly in forestry such as clonal multiplication, tissue culture in Eucalyptus, Bamboos and Salvadora (Pilodi).

11. Development of tissue culture labs on regional basis.

12. Development of Agro-forestry in Arid and Semi-Arid area.

V. NABARD's Contribution in Technology Adoption and Upgradation in Farm and Non-farm Sectors

(a) Farm Sector

The credit support extended by the banks as well as by NABARD has played catalytic role in the upgradation of technology and its adoption more particularly in the farm sector. Wherever extension support from the State Government agencies has gone hand in hand with credit support extended by the banks, the results have been encouraging and the returns on these investments have been sizeable. The efforts made by the NABARD as well as the credit institutions in this regard can be classified in the following categories :

(i) Providing adequate production credit support to the farmers to take to modern technologies and cultural practices for improving their productivity and production.

(ii) Technological upgradation through the provision of term credit to encourage private investment by the farmers for adopting different technologies evolved. For this purpose, the NABARD has been testing the bankability of such technologies and framing suitable guidelines for formulation of projects by banks for which refinance support is being extended.

(iii.) NABARD has set up a Research and Development Fund through which it has been supporting projects for technology upgradation and evolution of new technologies and projects for technology transfer and dissemination of information.

(iv.) NABARD has also extended support for infrastructural linkages, both forward and backward, for making the private investment fructuous.

(v.) NABARD also organise seminars wherever schemes involving improved technologies are to be propagated with the credit support.

(vi.) NABARD formulates/sanctions pilot projects to facilitate field trials of new technologies developed to promote wider adoption through demonstration. Full refinance support is extended to some of these projects viz. development of rainfed areas on watershed basis, wasteland development, etc. so that the banks are induced to grant loans to a large number of beneficiaries. In this endeavour, the support and ivolvement of voluntary agencies for motivating the farmers and transfer of technology is given due emphasis.

VI. Initiatives Taken by NABARD for Flow of Credit for Sustainable Agriculture and Rural Development

1. Linking banks with Self-Help Groups (SHGs)

Despite the vast expansion of formal credit system, the dependence of rural poor on money lender still continues in some areas especially for meeting emergent credit requirements. Such dependence is pronounced in the case of marginal farmers, landless labourers, petty traders and rural artisans belonging to the socially and economically backward classes and tribal population, particularly in the resource poor areas. Some of the major causes for the flow of credit to such people lie in the difficulties in dealing effectively and economically with a large number of small borrowers who require credit frequently and in small quantities. Under the circumstances an non-formal agency of credit supply to the poor in the form of "Self-Help Group" of the poor could emerge as a promising partner of the formal credit agencies. Such SHGs have been formed generally around specific issues confronting the poor or specific production activities and often they have mobilised savings among their members and use such resources to meet the emergent credit needs of the members of the group. With an object to evolve supplementary credit strategies for meeting the credit needs of the poor by combining the flexibility, sensitivity and responsiveness of the informal credit system with the strength of technical and administrative capabilities and financial resources of the formal credit institutions, NABARD initiated a pilot project for linking banks with Self-Help Groups. A recognition by the formal credit structure of the self-management capabilities of the poor through the SHGs and a link up between the two is expected to result in a specific advantages to both the systems. For the groups, the advantages lie in the access to a larger quantum of resources as compared to their meagre sources generated throughh thrift, access to better technology and skill upgradation through different schemes of the banking sector and general improvement in the nature and scale of operation that would accelerate economic development. The advantage to the banks would be externalistation of a part of the work items such as assessment of credit needs, appraisal, disbursal, supervision and repayment. Improvement in recoveries would lead to a wider coverage of target groups. After consultation with banks and voluntary agencies (Non-Government Organisations NGOs), the **NABARD** has finalised the guidelines and propose to link 500 Self-Help Groups with banks.

2. Vikas Volunteer Vauhini (VVV)

NABARD recognised the need for enlightening the borrowers in rural areas on how to make efficient use of credit, a scarce resource, to raise their output and income and to repay the loans from incremental income. The Bank therefore constituted Vikas Volunteer Vahini (VVV) as an extension service for disseminating the five principles of "Development through Credit" namely :

(i). Credit must be used in accordance with the suitable methods of science and technology.

(ii.) The terms and conditions of credit (techno-economic parameters) must be fully respected.

(iii.) Work must be carried out with the desired skills so as to realise optimum productivity and income.

(iv). A part of the additional income created by using credit must be saved.

(v.) Loan instalment must be repaid in time and regularly to facilitate recycling of credit.

The VVV consists essentially of small farmers, rural artisans and other persons of small means who have successfully put into practice the five principles referred above. The volunteers chosen are assisted by specialists or technocrats and representatives of NABARD and other financing banks. The VVV provides an organic link between the farmers/artisans in the village on the one hand and banks/Government agencies on the other.

References

1. Annual Report of National Bank for Agriculture and Rural Development of 1982-83 to 1991-92.

2. A booklet on the "Role of National Bank in the Sphere of Rural Credit" published by National Bank for Agriculture and Rural Development, 1987.