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PANEL DISCUSSION ON SOIL AND WATER CONSERVATION IN RED AND BLACK SOILS

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Central Soil and Water Conservation Research and Training Institute, Research Centre
Bellary 583 102
and
University of Agricultural Sciences
Bangalore 560 024

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Proceedings of the

Panel Discussion on Soil and Water Conservation in Red and Black Soils

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Foreword

Soil erosion is an age-old problem. However, its impact has been felt in the recent past due to enormous increase in population, deforestation and increased demand for food, fuel, fodder and fibre. Also after independence, number of multi-purpose reservoirs have been constructed for irrigation and power production. It was realised that these structures, constructed at enormous cost, were being silted up due to the high rate of erosion taking place in the catchment areas. Recognizing this, the Government of India started a chain of Soil Conservation Research Centres in the different agro-climatic regions in 1950s. Most of these Centres have now been in existence for the last 25 years and they have accumulated a lot of research information in soil and water conservation for different agro-climatic regions. Simultaneously, Government of India has also taken up execution of soil and water conservation programmes in farmers' fields and enormous funds have been expended in various Five Year Plans for this purpose. However, commensurate benefits have not been realized, the main reason being that sufficient advantage has not been taken of the research while planning soil and water conservation works. Apart from the different Soil and Water Conservation Centres, the several Agricultural Universities in the country have also contributed to build up research information on soil and moisture conservation. There was a long felt need for better coordination in this regard among the research scientists engaged in soil conservation and the development departments as well as the administrators and policy makers. It is a matter of gratification that the Central Soil and Water Conservation Research and Training Institute, Dehra Dun and Research Centre, Bellary have thought it fit to bring together all these concerned agencies on a common platform to take stock of things and arrive at suitable and agreed solutions for various problems faced in the farmers' fields with regard to soil and water conservation. The present panel discussion is a result of such a thinking and the deliberations are presented in the following pages. In this connection, I wish to congratulate the organizers for their timely action. I am sure that the contents of this publication be found useful by all concerned.

R. DWARAKINATH
Vice-Chancellor,
University of Agricultural Sciences

Bangalore,
August 28, 1981.

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Preface

Problems of soil erosion and low production in the Semi arid red and black soils continue to exist over vast tracts, eventhough we have with us the necessary technology to overcome them. Soil Conservation Research Centres at Bellary and Hyderabad have developed suitable technologies for arresting the menace of soil erosion and conserving moisture. Besides, a set of viable practices for improving the overall production is also available from the Agricultural Universities, Soil Conservation Research Centres and AICRP for Dryland Agriculture, Hyderabad. It was therefore felt very necessary to have a panel discussion among the scientists, extension workers and policy makers to identify suitable and mutually acceptable practices for efficient conservation and exploitation of the two valuable resources, namely soil and water.

Various technologists and economists from different institutions participated in the discussions. The recommendations that have emerged need careful consideration and implementation. This type of a panel discussion is first of its kind to develop technical manual for the State of Karnataka in the first instance and later on for adoption on all India basis. It is hoped that such kind of panel discussions will be regular and periodical to have better linkages between research and extension activities.

My thanks are due to Dr. M. S. Rama Mohan Rao and his colleagues and staff of Directorate of Research, UAS, Bangalore, for the interest they took in organizing this panel discussion. I express my grateful thanks to Dr. R. Dwarakinath, Vice-Chancellor, UAS, who was a guiding force in organizing the panel discussion.

K. KRISHNAMURTHY,
Director of Research
University of Agricultural Sciences

Bangalore
August 28, 1981

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Inaugural Session

Chairman : Dr. R. DWARAKINATH

Rapporteurs : SRI S. CHITTARANJAN

Dr. V. S. PATIL

Summary

THE session started with a welcome address by Dr. K. Krishnamurthy, Director of Research, University of Agricultural Sciences, Bangalore. While welcoming the gathering, Dr. Krishnamurthy pointed out the need for soil and water conservation measures for restoring the soil productivity and hence the importance for developing the package of practices enumerating proper land use in red as well as black soils under semi arid conditions.

Dr. D. M. Nanjundappa, Secretary (Planning), Govt. of Karrataka, inaugurated the panel discussion. In his inaugural address, he pointed out that due to ecological imbalances and lack of scientific management of catchments of major reservoirs, the soil and water conservation problems became severe. He further stated that soil and water which are our precious resources should be conserved and if they are allowed to be lost without proper check, the production levels would go down. Hence, research has to be continued to understand the implications of soil and water loss and also the benefits that accrue from their conservation. He further reiterated that apart from the technical results achieved, these have to be translated to the farmers' fields in a just and acceptable manner. In order to tide over the present crisis, planning is also essential. He opined that the problem has to be tackled in an integrated manner and the coordination between scientists, extension agencies and the planners is *sine-qua-non*. Alongwith proper soil and water conservation, provision should also be made for reclamation of unproductive soils. Lastly, he mentioned that presently there is certain lacuna in planning which is preventing us from reaching the goal.

Dr. R. Dwarakinath, Vice-Chancellor, University of Agricultural Sciences, Bangalore, released the bulletin on "25 years of research on soil and water conservation in semi arid deep black soils" published by Central Soil and Water Conservation Research and Training Institute, Dehra Dun, as monograph No. 1 of the research work carried out at the Soil Conservation Research Centre, Bellary, during the period 1954 to 1980.

While releasing the bulletin, Dr. Dwarakinath expressed his happiness for having chosen the occasion where scientists, extension workers and planners had gathered, as its distribution among the three groups would help in better understanding on the problems in soil and water management. He further pointed out that dependence on rainfall is very great in Karnataka and as such, greater attention should be paid on improving water harvesting technology and identifying methodology for its recycling in the event of failure of rains.

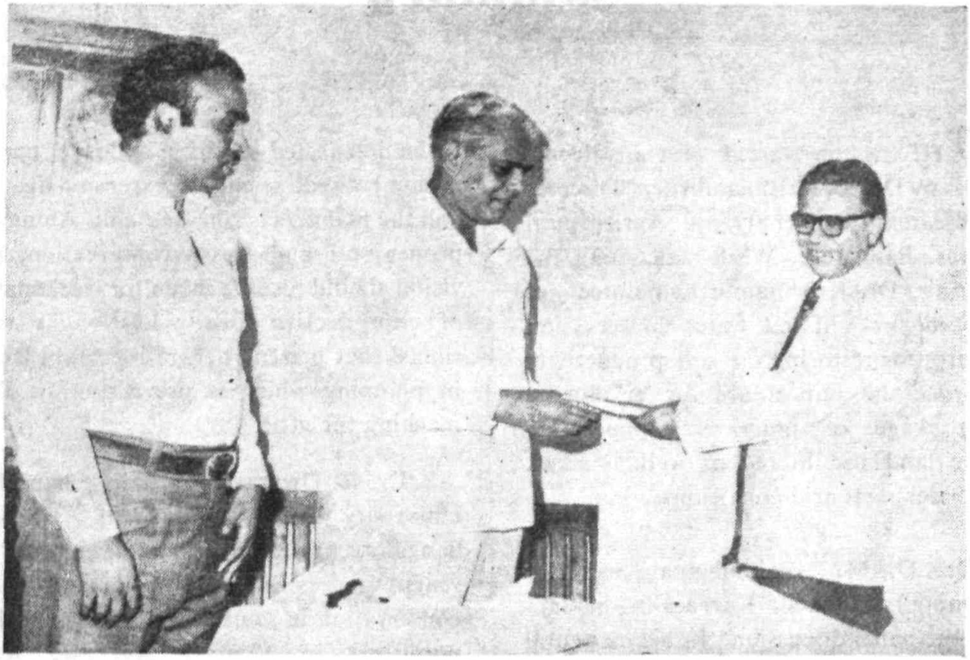

Fig. 1 Dr. R. Dwarakinath, Vice-Chancellor, U. A. S., releasing 25 years' Research bulletin.

He requested the participants to give importance to the following points :

translation of technology so that it may be useful to farmers ;

identification of further area of research that could be carried out at various research stations ; and

formulation of programmes for the post-graduate students to undertake research in this important field.

Mr. V. C. Katti, Director of Agriculture, Bangalore, presented the key note address on "Present status of soil and water conservation measures in black and red soils". In his address he very clearly brought out as to how the soil conservation measures that started on a small scale mainly as famine relief work has now attained the status of national importance.

It has been suggested that the present practice of contour *bunding* in black soils to some extent failed due to following strict contours, improper sections and inefficient waste weirs resulting in breaching of *bunds*. However, in case of red soils, he expressed that contour *bunding* has been successful. At the end, he suggested that the research needs to be continued in identifying proper soil and water conservation measures for deep black soils. In this connection, he appreciated the ongoing research work on conservation ditches at Soil Conservation Research Centre, Bellary.

Dr. K. G. Tejwani, Director, Central Soil and Water Conservation Research and Training Institute, Dehra Dun, presented a key note address on " Soil and Water Conservation measures in 1980s". He brought out the significant research achievements during the 1970s and identified 70s as a decade of build up of infrastructure and generating technology which has paved way for the 1980s to be a decade of watershed management. He pointed out that in 1980s we have to give more emphasis in organising research programmes with reference to soil and water conservation on all research farms as well as in transferring the technology.

The session ended with vote of thanks by Dr. M. S. Rama Mohan Rao, Officer-in-charge, Central Soil and Water Conservation Research and Training Institute, Research Centre, Bellary.

Inaugural Address

D. M. Nanjundappa *

I am happy to have the opportunity to inaugurate the "Panel Discussion on Soil and Water Conservation measures for different soils "

Soil erosion in India has been severe for centuries but its importance on national economy has been felt only in the recent past. The ever increasing demand for food has resulted in over-exploitation of the natural resources by extending agriculture into marginal and sub-marginal lands. In our anxiety to produce more of hydel power and promote forest based industries, we have allowed large scale denudation of forests. No compensatory forestry, in the real sense, has been attempted. This has not only reduced the forest areas but also accelerated the process of soil erosion. This, in turn, has resulted in soil losses to the extent of 12 to 43 tonnes / ha / annum in black soils. Similarly, soil losses to the tune of 4 to 10 tonnes / ha / annum seem to be taking place from red soils. Such high losses could be traced to adverse climatic conditions, rugged terrain, heavy land use and deforestation programmes. Absence of plant cover on the soil during major part of the year due to prevalence of dry climate in the semi arid region where black and red soils occur in large proportions, aids soil erosion. Crop yields from eroded lands are generally below the economic level of production even with heavy doses of chemical fertilizers. Research results have revealed that it takes considerable time and huge costs to restore the soil productivity in situations where top soil is removed.

There is no economical substitute for adequate soil and water conservation measures. Under such circumstances, realising that anything done on contour helps to conserve soil and retain rain water, contour *bunds* are recommended. The Government is spending huge amounts on contour *bunding* which has become synonymous with soil conservation. However, the benefits are not commensurate. Indeed doubts are being expressed by many experts about the suitability of present practice of *bunding* as the *bunds* are breaching quite often, creating fresh gullies either due to ineffective waste weirs and / or instability of *bunds*. It has now become more clear that it is not possible to retain or conserve all the rainfall where it falls and the excess runoff has to be taken out and stored in small tanks for reutilisation at a later stage or for charging the ground water. I understand that Central Soil &

* Secretary to Govt., Planning Department, Vidhana Soudha, Bangalore.

Water Conservation Research & Training Institute, Research Centre, Bellary; All India Co-ordinated Research Project for Dry land Agriculture, Hyderabad and University of Agricultural Sciences, Bangalore, have done considerable work in this direction and have come out with a recommendation that drainage type of terraces with grass waterways connected to farm ponds offer great scope in reducing soil erosion and sedimentation of reservoirs and help to stabilise agriculture, particularly in areas of subsistence farming. It may be recalled here that the World Bank, in its evaluation report, recommended graded *bunds* with waterways should be followed for soil and water conservation in deep black soils.

So far, our approach has been one of patch work type and it is high time we took a comprehensive approach. Soil conservation should be treated as the most important segment of re-establishing and maintaining the ecological balance between man and nature. It is to be reiterated that soil conservation starts and ends with good soil and farm management. The tendency to divorce soil conservation from farm management in conserving our natural resources should be eliminated, since this has resulted in expensive physical work without any regard to the integrated approach which could save large investments and bring larger benefits to the farmers. Co-operation and coordination between departments engaged in soil and water conservation is a *sine - qua - non* in any integrated system of soil management.

There cannot be a single solution to our problems of soil erosion. We have to identify solutions based on the socio-economic conditions and problems of soil erosion which are location specific. Therefore, continuous research in this field is essential. Towards this end, the extension agency should also give a feed back for the research. For this to happen, it is necessary to know the extent of the problem, the type of practices followed, whether what is done now is adequate, and what more needs to be done ? It is gratifying to note that the present panel discussion is covering all these issues and it is my hope that this workshop will spell out precisely what should be our future approach towards soil and water conservation.

It may be of interest to know that in a State like Karnataka, measures have been initiated for implementing a programme of compensatory forestry in areas which have undergone large scale denudation of forest wealth, resulting in creating ecological imbalance apart from heavy soil erosion. Perhaps, special attention is needed to ensure that all catchment areas are covered by afforestation programme to keep soil erosion under check.

In our package programme, land and soil management practices for resource development for realising better yields have not found a place. The present panel discussion with focus on this aspect seems to be first of its kind and I, therefore, congratulate the organisers for the lead they have taken.

I wish the deliberations every success.

Present status of Soil and Water Conservation measures in Black and Red Soils *

V. C. Katti

THOUGH the concept of soil and water conservation is relatively recent in the west, it was well understood and found as a regular practice in Indian agriculture since time immemorial. This is evidenced by *bunds* constructed of stones and / or soil across the steep slopes in Konkan region of Western Ghats. Also to support the fact that soil conservation measures are not new to Indian agriculture, reference is made to the literary work of a Lingayat saint of the 18th century. Nagabushana Ghanamathada Arya Shivayogi of Bijapur wrote a volume named, " Krishidhyana Pradeepike ", in the year 1879. This book detailed the soil conservation measures that were in vogue at that time. Most of the techniques and practices advocated in this work, hold good even today. Another startling revelation is that the loss of top soil, if the land is left unprotected, has been meticulously estimated and expressed in number of cartloads. If this is converted, it is very close to the loss of soil by erosion expressed in tons by research at a much later date.

The first involvement of the Government, in undertaking scientific measures for soil conservation and in the improvement of fertility and productivity of the soil in India can be traced back to the year 1907, when Sir Edward Buck, K C S I Ltd., submitted his report on " The control and utilisation of rivers and drainage for fertilisation of land and mitigation of Malaria ".

This report was considered by the Government of India at the Agriculture Conference held at Kanpur in 1907 and necessary action was taken in informing all provincial (State) Governors, of the recommendations made by Sir Edward Buck in his report. He suggested the flooding of land, drainage and silt arresting for improving fertility of the soil in plains and by arresting silt in hilly regions. This system was termed as, " Bonificazione " the name of the same technique adopted in Italy at that time.

Mr. J. P. Orr, Collector of Ahmednagar district, was the first to take action in the implementation of field work on the " Bonificazione System ". He also stressed that entire catchment should be treated from ridge to valley. So, this proves that the concept of " Watershed Treatment " was well understood as early

* Key note address delivered by the Director of Agriculture, Dept. of Agriculture, Bangalore.

as in 1907 though the actual measures were still in the rudimentary form. Another important factor was that soil conservation and land improvement works were even then recognised as famine relief works. However, the interest on soil and water conservation abated suddenly after the Government undertook some major irrigation works in Ahmednagar district.

Between 1910–20, Mr. G. F. Keatings, Director of Agriculture of the erstwhile state of Bombay undertook experiments on contour *bunding* on the experimental farms at Poona, Dharwad and Gadag. In the year 1921, Mr. T. Gilbert, Deputy Director of Agriculture (Southern Division) Bombay state published a pamphlet entitled "Field embankments". He recommended low broad *bunds* or terraces to be constructed on contour, so that crops could be grown on them. In August 1922, a post of Embankment Officer was created specially for the Southern Division whose job included preparation of plans and estimates for field embankments and generally advise farmers for land improvement. The farmers had to construct the embankments from their own resources or raise money on "*tagavi* loans". With the creation of post of the Embankment Officer, the first phase of *bunding* work on a large scale began. At the end of 1925, Mr. C. O. Lowsley, a Superintending Engineer was entrusted with the investigation of minor irrigation works as a means for combating and protecting agriculture against famine. Mr. Lowsley, in addition to preparing plans for minor irrigation works, prepared plans for land improvement works on considerably large scale and proposed them to Government and Co-operative organisations for implementation, where the capital would be raised from Government in the form of *tagavi* loans. The Government of Bombay created two more posts of *Bunding* Officers in 1927 to prepare plans for land improvement which included, terracing and construction of field embankments costing between Rs. 100/- and Rs. 5000/- and advise agriculturists in undertaking these works from their own resources.

Though the Government was involved in the preparation of Land Improvement Schemes and advising agriculturists, in general, there was no financial involvement on the part of Government. The first strong plea for financial involvement of the Government was made by Dr. Mann, Director of Agriculture, Bombay State to the Royal Commission on Agriculture in India in 1927. He argued that land improvement schemes, not only benefitted the land owners but conserved the rich top soil which was an important national resource. He strongly recommended that the Government ought to take up definite financial responsibility and pay a definite part of the cost of land improvement works. Mr. V. H. Naik, Collector of Bijapur supported Dr. Mann's recommendation stating that a series of *Wads* (field embankments) properly constructed, not only aid in the retention of rain water but also prevent loss of top soil due to erosion. He said that this would ensure at least some crop yields in years of deficit rainfall and definite increase in yields during seasons of good rainfall.

Rao Bahadur S. S. Salimath, Deputy Director of Agriculture(Southern Division), Bombay State in his replies to the questionnaire of the Royal Commission, supported Dr. Mann's recommendation. He suggested extended technical advice and long term loans to achieve this goal. He also estimated that *bunding* increases yields up to 20%.

Mr. V. H. Naik, in addition to crusading for land improvement works, was also instrumental in establishing the "Wilson Anti Famine Institute" at Bijapur, which turned out a lot of valuable work in the field of *bunding* in Bijapur district.

At this juncture it was felt necessary to educate cultivators and sons of farmers' regarding the benefits of *bunding* and to accord training in the field. With this in view the first "*Bunding* Training Class" was opened in 1929 at Barsi. Constant experiments on contour *bunding* were also taken up at the Dry Farming Research Stations at Sholapur and Bijapur from 1930 and at the same time the American type of broad base terraces were constructed at Marewad, Annigeri and Bijapur on an experimental basis. Also, broad base terraces were constructed by cater-pillar tractors under the aegis of the Burma-Shell Company at Mundargi in Dharwad district.

Bunding activities were intensified from 1935 and the need for trained hands became acute. To meet this need for trained personnel, the Agricultural Engineering Section of the Agricultural College, Poona, started offering training classes on *bunding*. With the formation of the first popular Ministry in 1937, *bunding* received great impetus and was intensified on the field with the result *Bunding* Training Classes were opened all over the province of Bombay at selected centres.

In 1939, the Government decided, that, as *bunding* constituted an integral part of Rural Development, to transfer all *bunding* and land improvement schemes from the Department of Agriculture to the Rural Development Department. This change can be treated as the beginning of the second phase in the history of large scale *bunding*. As we will see later, the second phase can also be treated as one of the most formative phases which aided in the sophistication of contour *bunding* technique.

By the end of 1940, a scheme for *Bunding* and Dry Farming Survey and Development was sanctioned with the objective of taking up *bunding* and dissemination of dry farming techniques. The major difference was that emphasis was placed on taking up *bunding* work on *bunding* units i. e., small watershedsi catchments and sub-catchments in their, entirity. Small projects covering 200 acres and more of entire sub-catchments were termed as "Block *Bunding* Projects" and projects covering more than 500 acres were called as "Village Development Projects". The field implementation came into effect during later half of 1941.

At the end of 1941, Mr. R. P. Dalley and Mr. V. A. N. Sansman, Officers of the Forest Department and Messrs. M. S. V. Rama Rao and M. K. Shirole of the Agriculture Department were deputed to Punjab to study the Soil Conservation measures practiced in the foot hills of the Himalayas. Mr. R. P. Dalley furnished a report on his return which was considered at a conference of the Commissioners. It was concluded that the problems of soil erosion were of such magnitude that it was felt necessary to streamline the executive staff into a soil conservation service on the same lines as in United States of America. As a result of economic stringency due to second World War, the proposal of creating a Soil Conservation Service could not be considered on its merit. As an alternative the Commissioner to the Government of Bombay recommended that a departmental board consisting of Divisional Commissioners, Director of Agriculture, Chief Conservator of Forests and Superintending Engineer of the Irrigation Circle (Deccan) should meet periodically and review the work done on Soil Conservation and plan the future course of action.

When *bunding* is taken up on catchment basis, problem of non-cooperation from some of the *ryots* whose lands were included was met with. To overcome this obstacle the Land Improvement Schemes Act of 1942 was enacted. This Act provided that execution of Soil Conservation measures could be taken up if two thirds of the *ryots* involved gave their voluntary consent. It also provided for recovery of the cost of works and for maintenance and repairs subsequently. This Act, we can mention was a precursor to the Karnataka Land Improvement Act of 1961.

With the expansion of *bunding* activity the departmental infrastructure kept growing in proportion and a post of Deputy Director of Agriculture was created for Land Development.

At the same time there occurred a development of great significance. A sum of Rs. 7 lakhs was donated by Sir Cusrow Wadia with stipulation that the interest accrued upon the same should be utilised for rural development works viz., sinking of wells, minor irrigation projects, soil conservation, adoption of scientific dry farming, soil management and establishment of demonstration centres. The Government of Bombay added a sum of Rs. 5 lakhs to this deposit and instituted the Sir Cusrow Wadia Trust Fund to serve the above mentioned purpose and to take up village Development Projects. As contour *bunding* fell within the purview of the Trust's objective, the land owners involved in *bunding* projects started getting subsidies ranging from Rs. 3/- to Rs. 5/- per acre. This development indicated that awareness began to creep into the Government, towards its financial responsibility and recognition of the need to subsidise Land Improvement Projects.

In the later part of 1942, a severe famine occured due to total failure of monsoon in the districts of Bijapur, parts of Dharwad and Belgaum. *Bunding* work was resorted to as an important famine relief measure besides other works *viz.*, road work, metal breaking *etc.* Though the Collectors recommended that *bunding* works were to be totally financed by Government as famine relief, the Government refused to undertake total financial responsibility but compromised by accepting to subsidise a sum of Rs. 14/– per acre, provided that this sum would be reduced by like amount if any subsidies from Sir Cusrow Wadia Fund or from the Wilson Anti Famine Institute, Bijapur, were received.

Famine relief works were continued upto end of 1944 though officially famine ended in late 1943. However, the speed of *bunding* was not reduced even later as the ex-servicemen had to be provided civilian employment after the cessation of war. During 1944–45 to 1946–47 lot of *bunding* work was done, especially in 1946 when famine re-occurred. *Bunding* was then so much expanded that work was being taken up without advance planning. Staff had also increased to such an extent that it was felt necessary to create a post of Director of Land Improvement and a temporary post of Additional Director of Land Improvement.

The study of the techniques adopted during 1942 and 1946 indicates that *bunding* was taken up on "strict contours", without advance planning and work was taken up by direct contouring. A combination of these factors resulted in the *bunds* being extremely sinuous which caused severe inconvenience to agricultural operations. In spite of adherence to permissible deviations, errors in levelling could not be eliminated. These deviations and errors caused breaches in the *bunds* and gully formation in the lower regions and scouring of *bunds* laterally. Another important lacuna in the technique was the failure to provide waste weirs to dispose off excess runoff in the zeal to conserve all the rain water, indicating lack of consideration of rainfall intensities. Further, the *bund* sections adopted were not backed up by sufficient research data for different locations.

All these short comings contributed in creating an uproar amongst the *ryots* and complaints from all quarters started pouring in to the Government and a strong anti-*bunding* feeling was generated. All this upheaval culminated in the institution of a Land Improvement Inquiry Committee in August 1946 consisting of :

- Mr. V. S. Bhioa, Commissioner S. D. as Chairman;
- Dr. N. V. Kanitkar, Retd. Chief Investigator, Dry Farming Research Scheme, Sholapur;
- R. B. Bidari, Chief Minister of Andhra State ;
- Rao Saheb V. C. Pavate, D.D.A.(SD), Dharwad ; and
- Mr. W. X. Mascernhas, Jt. Secretary to Government, Reconstruction Department as Secretary.

The Inquiry Committee examined the matter in detail and interim reports were furnished from time to time and suitable action was taken by the Government on these reports. The final report of the Committee was submitted to Government in April 1947 after much careful study of the evidence and cross examination of witnesses.

It recommended the design and inclusion of waste weirs for surplussing excess runoff and preventing water stagnation. Smaller section *bunds* (*i. e.* 8–10 sq. ft.) were suggested for coarse and gravelly soils and larger section *bunds* (*i. e.* 10–16 sq. ft.) for medium deep black soils. For deep black soils, broad base terraces of 24 sq. ft. section were recommended with gentle slope on the upstream to facilitate cultivation on the slope of the *bund*.

With regard to alignment of *bunds*, strict contour *bunding* could be avoided to eliminate the sinuosity of *bunds*. Contours could be eased and made as straight as possible with permissible deviations. *Bunds* are to be strengthened at the points of deviation in gully so as to maintain the top level. The committee also recommended that each *bunding* project was to be treated on its own merits and the *bund* alignment planned before hand, after sufficient consultations with the *ryots* involved. Dry farming practices *viz.*, contour cultivation, strip cropping, land levelling in the inter terraced area between *bunds* etc., were to be disseminated amongst the farmers so as to accrue the fullest benefits of contour *bunding*. Further, some amendments to the Land Improvement Schemes Act, 1942 were suggested to make it more streamlined and advised the Government to wind up the Land Improvement Department and rename the *bunding* section as the Soil Conservation section under the administrative control of the Department of Agriculture.

It was with the publication of the Land Improvement Inquiry committee report that streamlining of soil conservation followed and more emphasis was placed on the role of both the Government and the individual land owner in conserving the man's most valuable resource, SOIL.

After Independence, soil conservation slowly but steadily grew in importance and a number of training centres imparting training in Soil Conservation to different strata of field functionaries and executives, sprang up all over the country. A number of Central Soil Conservation Research, Demonstration and Training Centres were established by the Government of India in different regions for taking up research on soil conservation measures suitable to the areas *i. e.*, red soils, hilly region and high rainfall tracts, scanty rainfall tracts, black soils *etc.*, and valuable research work is being done at these centres.

Soil conservation started getting the attention of the Planning Commission. With recognition for maintaining the ecological balance and thereby achieve flood retardation, soil conservation came into limelight. In addition to the establishment of various research centres, considerable large budget allotments were made both at the Centre and States to take up soil conservation measures on a large scale.

In the late 1950s and the early 80s, siltation of multipurpose reservoirs resulting in reduction of their storage capacity, necessitated the Government in taking up catchment protection work on war footing. Soil conservation measures and afforestation works were taken up in the catchments of river valley projects on large scale and the infrastructure along with budget provisions grew proportionately. This work is continuing today at a much accelerated pace in all the catchments of major irrigation projects all over the country, with a major share of financial responsibility by the Government of India.

Further, the frequent incidence of floods and the resultant havoc focussed the attention of the planners on the magnitude of the problem of soil erosion. The concept of watershed management was reviewed and brought under implementation with some modifications. The accent now is on integrating all the activities of various developmental departments *viz.*, Soil Conservation, Agriculture, Forest, Public Works Horticulture, Animal Husbandry, Sericulture, Fisheries *etc.*, for all round development of the region on watershed basis.

With the proliferation of soil conservation works all over the country, the various soil conservation measures have undergone modifications and improvements to suit the conditions of soils, slope groups, rainfall *etc.*, in different regions. Most of the techniques such as contour *bunding*, terracing, arresting of runoff and silt by construction of farm ponds, gully plugs *etc.*, have been modified over the years to suit local conditions.

Graded *bunding* was another technique evolved over the years and proved successful in some regions. However, it could not get wider application due to obstacles such as, the need for common drainage for surplussing runoff, the problems of small holdings and proprietary *bunds* interfering with the planning and execution of *bunds* on grade.

However, the experience over the years indicates that red soils due to their inherent characteristics have proved responsive to almost all techniques of soil conservation measures. Contour *bunding*, land development by Contour *Bunding* Scheme, terracing, graded *bunds*, check dams *etc.*, were found suitable in red soil tracts. The myth that red soils are not suitable for farm ponds to collect runoff water is proved wrong as number of farm ponds constructed in the red soils of Kolar district are functioning well.

Major obstacles faced in the adoption of soil conservation measures in red soil tracts are of administrative and legal nature such as small and fragmented holdings, proprietary boundaries not conforming to contours as per plans of soil conservation measures, rather than lack of techniques. Even in such cases, check *bunding* or field *bunding* followed by general smoothening of the land against the *bunds* have proved to be effective in reducing soil losses.

The black soils, however, are different altogether. Due to high content of clay, high erodibility and poor infiltration, these soils have always proved to be problematic and non-responsive to different soil conservation measures. Shallow and medium black soils have responded comparatively better than deep black soils to measures like contour *bunding*, graded *bunding* etc., with a *bund* section of 12 to 16 sq. ft. Though the problem of settling of *bunds* could be overcome, the problem of stagnation of water against the *bunds* could not be altogether eliminated inspite of provision of waste weirs.

In deep black soils the problem of cracking and settling nature of soils was overcome by adoption of *bunds* of very large section *i. e.,* upto 24 sq. ft. However, the problem of water stagnation could not be totally eliminated. As such, the problem of evolving a suitable measure for soil conservation in deep black soils is being studied assiduously at various research centres.

However, I am happy to say that there is a gleam of hope on the horizon for a solution to this problem in the near future as Mr. U. S. Patnaik, an Agricultural Engineer, has been conducting research on 'conservation ditches' at the Central Soil and Water Conservation Research and Training Institute, Research Centre, Bellary. These ditches can be described as inverted *bunds* and are spaced in a staggered manner along the contours. The response of these ditches has shown encouraging results and its large scale application on the farmers' fields is to be tried out and may apparently find a niche for itself in the field of Soil Conservation especially in black soils after undergoing suitable modification for adoption on large scale, if necessary.

Hence, in conclusion it can be stated that soil conservation programme which started on a small scale mainly as famine relief work has now attained the status of national importance and thousands of trained personnel and hundreds of research scientists are striving to conserve nature's most important gift to mankind, THE SOIL.

*Soil and Water Conservation in 1980s**

K. G. Tejwani

THE beginning and the end of a decade is an important landmark in the life of individuals as well as institutions. The beginning of a decade looks ahead to the promises it holds and the end of the decade calls for a review whether those promises were kept and achieved. It speaks volumes about the foresight of the scientists and planners that in the first Five Year Plan of India, they provided for the long range benefit development programme of soil and water conservation. While planning for soil and water conservation development programme, it was easy for the planners to catalogue the problems and also some traditional solutions of these problems based on scientific research and investigations. Keeping the situation in view, a chain of Soil and Water Conservation Research and Training Centres was established late in the first Five Year Plan and early in the second Five Year Plan of India.

As the soil and water conservation programme was being initiated during the early 50s, these centres received very great support in terms of man power, materials, money and other facilities, so as to lay a sound and strong base for research and training. This happy situation continued upto the end of second Five Year Plan in 1962 and these centres made very good progress not only in establishing themselves but also by coming up with many solutions to various problems in a short period of time. During the third Five Year Plan though the development programme of soil and water conservation continued to grow, for inexplicable reasons the soil and water conservation research programme was taken out of the plan and it became a non–plan activity. This situation continued during the third Five Year Plan and also during the three annual plan years (1966-67, 1967–68 and 1968–69).

During these 8 years (1962 to 1969), as the cost of man power and materials progressively increased, the progress achieved by fixed non-plan outlay was less.

By 1968–69 a situation had arisen when it became necessary to curtail the field activities to the extent that agricultural land at research farms had to be taken out of cultivation. Thus, a very healthy seedling which was planted in the 50s and nurtured well during the first 10 years of its life, received a shock during the next 8 years of its life and suffered from stunted and retarded growth. It was at this stage that the 70s started. Fortunately, in the meanwhile, a parallel healthy development had taken place. It was during the year 1965–66 that a decision was executed at national level that Agricultural Research and Education in India should be transferred to Indian Council of Agricultural Research (ICAR). In the first phase of this reorganisation, the chain of the Soil

* Key note address delivered by Director, Central Soil & Water Conservation Research & Training Institute, Dehra Dun.

and Water Conservation Research Centres which was in Ministry of Food and Agriculture was not transferred to ICAR. However, after reconsideration and review, it was decided to transfer these centres to ICAR on October 1, 1967. With the transfer of these centres to ICAR, which was charged with the responsibility of promoting and strengthening research, it immediately took note of the situation that these centres which had been given a very good start and had made good contributions, somehow or other had not been able to expand their research activities according to their charter due to their being relegated to non-plan programme. This situation was rectified with the start of the fourth Five Year Plan in 1969-70. It was at this stage that the decade of the 70s started and these centres once again could look forward to an era of growth and better opportunities for research. 70s saw increased budget outlays, increased man power, initiation of new projects like Dryland Agriculture and ICAR Agricultural Research Complex with emphasis on research, coordination and building up of infrastructure.

SIGNIFICANT RESEARCH ACHIEVEMENTS IN THE 70s.

Water harvesting and recycling ;

runoff/water yield under different land uses ;

intercropping and double cropping under rainfed conditions ;

management/rehabilitation of degraded/ denuded habitats not only to protect them but to produce from them. Data was generated to quantify the effects of closure to biotic interference, yield potential of different trees and grass spp. and fodder-fuel plantations;

beginning was made to develop values for some of the parameters of USLE specially R, K, C & P;

information on intensity - duration - frequency of rainfall for design of structures was made available ;

evaluation of soil and water conservation measures undertaken during the past two decades was initiated; and

the concept of ORP was developed and taken up.

One can say that the 70s were a decade of building up the infrastructure, laying down foundations and generating technology for the watershed management. The 1980s will be a decade of Watershed Management.

SOIL AND WATER CONSERVATION DEVELOPMENT PROGRAMME

While at present all of us agree that there is need to treat the land-water-plant systems on watershed basis, this concept has been developed over the past 25 years. The history of agricultural development programmes since 1952 is as under :

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Name of the programme	Year	Remarks
CD programme	1952	
IADP, IAAP and NDP	1960–61	Lead to increased production when combined with HYVP.
HYVP	1966	
SFDA, MFAL	1969	Had focus on development of specific groups of people.
DPAP, ITADP	1974	Had focus on regional development and employment.
IRDP	1977	Had focus on regional development and employment.

A closer scrutiny of the contents of these programmes reveals that emphasis on watershed management was placed since 1974 with the start of Drought Prone Area Programme.

During the sixth Five Year Plan not only the entire Soil and Water Conservation Programme, but also the agricultural development programmes are firmly grounded on the concept of watershed. This is a very encouraging sign for management of land–water–plant systems on their natural units of treatment *i. e.*, on watershed basis.

The achievements and projections of soil and water conservation development programmes are given in Table 1.

It can be seen from the above projections that if the cost of development is kept fixed (at the sixth plan prices) and we provide for an increasing target of 3.5 m ha in every plan, we will be able to treat 90 m ha of land (the area which needs to be treated on priority basis) by the end of the tenth Five Year Plan in the year 2004 A. D. By then we would have spent Rs. 6674 crores on this programme. The above projects do not take into account the cost of maintenance of works and also redoing them as their life is estimated to be 15 years under field conditions.

SOIL AND WATER CONSERVATION RESEARCH IN THE 80s

Research in transfer of technology

The concept of ORP must be pushed vigorously to transfer the technology and identify the constraints in soil & water conservation and rainfed agriculture. This is essential as considerable data have been generated and technological packages are available.

Techniques must be developed for project identification, planning, implementation and evaluation on watershed management basis must be developed and transferred as a package.

Intensification of research

The concept of water harvesting and recycling must be refined with respect to

Table 1 : Achievements and projections of Soil and Water Conservation Development Programmes.

Period	Area (m ha)	Expenditure (Rs. in Crores)	Remarks
Upto the end of 4th year (1977-78) of fifth five Year Plan (Actuals)	21.8	510.7	
Last year (1978-79) of fifth Five Year Plan	1.2	88.4	Proposed
Total upto end of fifth Plan	23.0	599.1	
Projection of Development Programme			
Sixth Plan (1979-84)	6.3	585.0	First proposal of the working group on Soil & Water Conservation for Sixth Plan.
Seventh Plan (1984-89)	10.0	900.0	At the price level proposed in the sixth Five Year Plan.
Eighth Plan (1989-94)	13.5	1215.0	— ,, —
Nineth Plan (1994-99)	17.0	1530.0	— ,, —
Tenth Plan (1999-2004)	20.5	1845 0	— ,, —
Total	90.3	6674.1	— ,, —

quantifying water yield, reducing seepage and evaporation and recycling it. In case water is to be harvested for non-agricultural watersheds, the relationship between the vegetative cover and water yield needs to be quantified and criteria developed to manipulate the vegetation *vis-a-vis* water yield.

Now we have considerable data on runoff / soil loss from runoff plots all over the country. It is time that a beginning is made to quantify the various factors of USLE specially for R, K, C and P. With respect to LS factor, data need to be generated.

Land capability classification rating tables need to be developed for different soil, agro - climatic and socio - economic conditions of the country.

Some selected sub-watersheds may be taken up in different soil, agro-climatic zones of the country and monitored for soil and water loss, yield of crops and other plantations, such as grasses, horticultural plants, trees *etc.*, before treating the land. Integrated land use plan may be prepared depending upon the land capability and suitable soil conservation measures and monitored for soil, water loss and yield components. Cost benefit analysis may be made. Tangible and intangible benefits may also be considered.

For estimating sediment yield from watersheds where hydrological information is lacking, simulated mathematical models that characterize the time-space progression of sediment from its original source need to be developed.

The magnitude of erosion caused by roads, buildings and other construction works should be estimated.

Standard methodology for evaluating socio-economic benefits of soil and water conservation projects be developed, so that the programmes taken up by various organisations / agencies in different regions may be assessed using the same yardstick.

The social scientists should quantify the scope for group action in watershed to identify an optimum blend of technology.

Objective specific suitability criteria should be developed for selecting priority watersheds for different programmes.

Watershed data retrieval and data bank be set up at the Central Soil and Water Conservation Research and Training Institute, Dehra Dun.

Research on shifting cultivation areas needs to be intensified and strengthened in the 80s.

With respect to rehabilitation and utilization of degraded non-agricultural lands, it will be essential to

- evaluate non - traditional plant spp. and minor hardy fruit plants of economic utility ;
- intensify research on agroforestry/ silvi-pastoral system ; and
- integrate land - water - plant -animal system.

Economic evaluation of all soil and water conservation practices must be made an essential part of the research programme.

Education and training

It will be necessary to develop mass awareness of the need of soil and water conservation at all levels of strata and groups of the society. For this purpose, it will be necessary to develop popular literature.

It will be necessary to include subjects/ courses of soil and water conservation in schools/colleges/universities.

It will be necessary to train man power for the projected development programme in a systematic and planned manner. The projections of trained man power in Soil and Water Conservation upto the year 2004 are given in Table 2.

Table 2 : Projections of need of trained man power

Period	Officers	Asst.	Sub-Asst	Remarks
Total man power trained upto end of fourth Five Year Plan	783	3042*	—**	*Asst. trained at Kota, Ootacamund, Bellary & Hazaribagh centres only are reported
Upto end of 4th year (1977-78) of fifth Five Year Plan	1060	455	—	**Information not available
Last year (1978-79) of of fifth Plan	60	240	—	Assistants trained by State Govts. are not reported.
Total upto end of fifth Plan	1125	3497	—	
Projection of training needs				
Sixth Plan (1979-84)	1290	6440	32180	
Seventh Plan (1984-89)	1980	9900	49500	
Eighth Plan (1989-94)	2675	13370	66830	
Nineth Plan (1994-99)	3370	16830	84150	
Tenth Plan (1999-2004)	4060	20300	101480	

Considerable research data are available on various aspects of soil conservation and water management, rainfall intensity-duration - return equations, prediction of runoff and soil loss, conservation cropping *etc*. These data should be compiled region-wise in simple language in the form of manuals which can be used by extension workers for direct use in the field, while planning soil and water conservation programmes.

CONCLUSION

In conclusion, it may be said that in a country like India where there is acute land hunger and great pressure on land-water-plant systems, it is essential we clearly understand that we cannot sell " Erosion Control " programme. The programme will have to be oriented to " conservation-*cum*-production" from all land uses and types of land. To that extent, all our research should be oriented accordingly. The research should be problem solving rather than merely doing " research for publication ". The danger of scientists doing research to satisfy their need for knowledge was foreseen by Father of the nation, Mahatma Gandhiji as early as in 1927 when he wrote :

To the scientists of India :

" I would like you to be men, who stand up before the world, firm in your convictions. Let your zeal for the dumb millions be not stifled in the search for wealth. I tell you, you can devise a far greater wireless instrument which does not require external research but internal – and all research will be useless, if it is not allied to internal research – which can link your hearts with those of the millions Unless all the discoveries that you make have the welfare of the poor as the end in view, all your workshops will be really no better than Satan's workshops ".

—Gandhiji
13–7–1927

Session II

Soil Conservation Measures

Chairman : SRI D. C. DAS

Rapporteurs : Dr. M. S. RAMA MOHAN RAO

Dr. B. R. HEGDE

Summary

In this session five papers were presented two from black soil and three from red soil areas.

BLACK SOILS

Mr. Chittaranjan and Prof. Ramaiah presented their papers. Mr. Patnaik explained the concept of conservation ditch. After discussion, the following recommendations were adopted:

Graded *bunds* with suitable waterways stabilized with vegetation may be tried on the farmers' fields on a large scale ;

Breaches of *bunds* are mainly due to accumulation of water near the *bunds*. Land grading and smoothening in between *bunds* is necessary to lead water to the waste weir and to avoid stagnation of water in depressions. This aids introduction of inter terrace treatments for moisture conservation ; and

Broad base terraces are also suitable for black soils provided they are executed and maintained properly.

Items for further research

Conservation ditch technique developed at Bellary should be tried at other research stations, Operational Research Projects and seed farms ; and

The feasibility of conservation bench terraces and/or inter plot water harvest technology sh ould be tested.

RED SOILS

Three papers were contributed by Dr. B. R. Hegde, Mr. V. Kameswara Rao and Dr. G. Venkatanadhachary. The following recommendations were adopted:

Graded as well as contour *bunds* are suitable for red soils. But the decision depends upon whether a disposal or a conservation system is needed depending on soil depth and rainfall in a given location. When disposal is needed either contour *bunds* with open ends or graded *bunds* are to be adopted ;

Graded border strips are adaptable in high as well as low rainfall regions for higher moisture conservation ;

Inter terrace management such as, sowing on a gradient of 0.2 to 0.3% and ridging later helps to control runoff and improve crop yields ;

Graded furrows at an interval of 3 m may be followed for disposing excess water;

To conserve moisture, shallow or deep tillage after the harvest of crop and incorporation of crop residues with tillage early in the season may be followed ; and

Stabilization of waterways is better achieved by *Lotononis bainesii* than some of the tall growing grasses.

Soil Conservation Measures in Black Soils

S. Chittaranjan and U. S. Patnaik *

THE problems of soil and water conservation in black soils are quite different from those of red soils. Whereas red soils are shallow and light, black soils, generally, are deep and heavy. These differences in soil properties call for an entirely different approach for soil and water conservation in black soils. While in red soils, level terraces or contour *bunds* are reported functioning satisfactorily, these are found not suitable in case of black soils. This is borne out by experience of different research organisations and the extension work already carried out in farmers' fields. Contour *bunding* in black soils was found be associated with the following drawbacks :

- prolonged water stagnation and consequent loss of area for crop production ;
- breaches in *bunds* due to soil cracking and pressure of water ;
- instability of masonry waste weirs ;
- man made breaches consequent to water stagnation ; and
- extensive rill erosion and gullying due to concentrated flow in series of waste weirs located one below the other.

Studies conducted at Central Soil and Water Conservation Research and Training Institute, Research Centre, Bellary have conclusively proved that contour *bunds* are not suitable to these soils. This is also the finding of ICRISAT, Hyderabad and to some extent that of Agricultural Research Station, (UAS) Bijapur. They have all recommended that in case of black soils both the inter terrace treatments as well as terrace level structures should be on grade. The grades recommended vary from 0.2 to 0.6%. Swindale, (1981) rightly observed that in soils of poor infiltration the solution lies in developing technologies that make use of the natural topography and drainage patterns implying drainage type of terraces and waterways.

Other incidental advantages of the recommended drainage type of terraces over conventional contour *bunds* are : reduced cost per ha due to reduced section of *bund* and elimination of waste weirs ; practically no breaches due to absence of direct hydrostatic pressure on the *bund* ; and the practice of water harvesting and farm ponds which has come to stay in

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drought prone areas fits well into the new system and it is easy to construct a farm pond for every 8 to 10 ha at the end of a waterway.

As regards the practical difficulties often mentioned, it may be said that they are more hypothetical than real, for, the system has not been given any serious trial except in isolated blocks like Tidagundi village in Bijapur district and Integrated Dryland Agricultural Development Project, Hadagalli. As regards establishment of grasses in waterways, one may begin with bare channels protected with dry stone checks. As on today there does not seem to be any alternative to waterways in black soils.

It may not be out of place to mention here an interesting experiment conducted by Central Soil & Water Conservation Research & Training Institute, Research Centre, Bellary, in Haraginadona village, Bellary dist., where in a sub–watershed of about 18.75 hectares, the terraces and waterways were first aligned and land redistributed among ten small farmers, in newly allotted lands. It is understood that a similar project was executed more or less simultaneously in Satara district as reported by Mr. Zafar Futehally *vide* his article " Meeting Conservation Challenges " published in The Indian Express dated 28–4–1980. This is not to suggest that such things are possible everywhere, but to point out - where there is a will, there is a way.

REFERENCES

1 Chittaranjan, S., Rama Mohan Rao, M. S., and Ramanath, B., 1980, " Mechanical structures for Soil Conservation in deep black soils " . Ext. Bull. No. 1, CS&WCR&TI., Research Centre, Bellary.

2 Swindale, L. D., 1981, "The agricultural potential of land in semi arid tropics ". Paper presented at the Seminar on "Land use potentials in Karnataka State" held at Regional Research Station, Raichur, on 5th & 6th February, 1981.

Soil Conservation Measures in Black Soils of Karnataka

R. Ramaiah *

SOIL and water are the most important natural resources for crop production and the conservation of these vital resources implies optimum utilization so as to make high production levels possible, which can be continued indefinitely. Soil and moisture conservation can be accomplished by any of the following measures *viz.*, contour *bunding*, broad base terraces, zingg-conservation terraces and bench terraces with appropriate out-lets and waterways. At present, trapezoidal shaped contour *bunds* of different sections are adopted in black soils occurring predominantly in the districts of Chitradurga, Bellary, Dharwad, Belgaum, Bijapur, Raichur, Gulbarga and Bidar. These contour *bunds* have certain disadvantages, as scientific hydrological considerations are not followed while executing these in different agro-climatic zones. Breaching of *bunds* resulting in more damage is a rule rather than an exception. When there are no breaches, water stagnation for prolonged periods near the *bunds* makes cultivation difficult. Floods created by breaching of *bunds* wash away the out-lets in the lower *bunds* leading to formation of fresh gullies, almost in the middle of the field. The improper position of out-lets and concentration of runoff water during heavy rains, leads to accelerated erosion and permanent gullies. Most noticeable feature is that all runoff water does not smoothly reach the waste weir because of the undulations in the inter-*bunded* area. This results in concentration of runoff in few pockets along the *bund* leading to saturation and breaching, even though, the main reason for breaching of bunds is recognised as transverse cracking during summer.

The studies conducted at Central Soil and Water Conservation Research and Training Institute, Research Centre, Bellary, since 1957 clearly indicate that broad base terraces and graded *bunds* perform better than contour *bunds* resulting in higher yields. The details of the information regarding performance of these structures are presented in Tables1-3.

In some places, attempts have been made to adopt broad base terraces to off set the effect of cracking of *bunds* in black soils. They are found to perform better than ordinary contour *bunds* even after 15 years. The major advantages of these are: no loss of area for cultivation and reduction in soil loss.

As is evident from the above results, the climatic conditions and physical pro-

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Table 1 : Yields of different crops from contour *bunded* and un*bunded* areas (Kg/ha)

Year/Season	Annual Rainfall (mm)	*Jowar* grain		*Jowar* Straw		Seed Cotton		Safflower	
		Contour *bunded*	un*bunded*	Contour *bunded*	un*bunded*	Contour *bunded*	un*bunded*	Contour *bunded*	un*bunded*
1959–60	356.7	54.8	100 8	209.3	337.7	43.9	124.6	48.0	56.6
60–61	436.9	116.6	78.1	512 6	546.4	100.2	115.7	120.8	191 0
61–62	330.0	5 4	16.8	13 8	54.4	No crop		No crop	
62–63	710.9	92.6	209.9	869.0	988.3	107.3	117.2	114 3	150.3
63–64	419.0	332.8	390.5	816.2	767.6	77.5	110.6	185.9	185.3
64–65	564.6	311.5	471.8	554.7	667.9	172 4	228.4	No crop	
65–66	336.3	184.0	238.8	370.0	74.2	100.9	328.0	No crop	
66–67	687.3	371.7	452.1	532.0	614.7	70.4	113 5	No crop	
Mean	480.2	183.7	244.8	479.4	543.4	92.3	130.1	117.2	145.8
S.Em ±		15 25		14 83		6.5		12.30	
C D at 5%		51.00		49.59		34.07(1%)		55.34	
Average increase over *bunded* area (%)		33.3		13 1		41.0		24.4	

(Source : Chittaranjan *et al.*, 1980)

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Table 2 : Constructional and performance features of different mechanical structures

	Contour *bund*	Broad base terrace	Graded *bund*
Type	Retention	Drainage	Drainage
Bund section (m^2)	$\frac{(3.66+0.61)\times 0.76}{2}$ = 1.61	$\frac{(6.10+0.61)\times 0.37}{2}$ = 1.56	$\frac{(3.05+0.61)\times 0.46}{2}$ = 0.87
Bund spacing			
Horizontal distance	90 m	75 m	75 m
Vertical interval	0.91 m	0.61–0.76 m	0.61–0.76 m
Deviations	15 cm in ridge 30 cm in valley	Negligible	Negligible
Level/gradient	Level	Uniformly or variably graded (0.1–0.2%)	Unformly or variably graded (0.1–0.2%)
Water stagnation	Yes	No	No
Bund breaches	Yes	No	No
Area occupied by the *bund* (%)	5	8–10	3.5
Area lost from cultivation due to water stagnation (%)	10–15	Nil	Nil
Surplussing arrangement	Pipe outlet waste weir	Grass waterway	Grass waterway
Bund stability	Stable	Liable to be damaged since it permits crossing over of carts, implements etc.	Stable
Maintenance	Rs. 1.07/ha/yr when laid out with permissible deviation	Channel grade needs to be maintained under technical guidance	Channel grade needs to be maintained under technical guidance
Effect on crop yields	Reduced yields compared to un*bunded* area	Increased yields	Increased yields

(Source : Chittaranjan *et al.*, 1980)

Table 3 : Influence of different types of terraces on crop yields* (kg ha)

Crop	Control (no *bund*)	Contour *bund*	Broad base terrace	Graded *bund*
Jowar Grain	245	184	362	280
Straw	543	480	1101	1650
Seed cotton	131	92	153	163
Safflower	192	117	584	215

*Average for 3 years.

(Source : Chittaranjan *et al.*, 1980)

perties of black soils, clearly call for change of the present method of contour *bunding* to alternate proven measures, such as graded *bunds* or broad base terraces. Graded *bunds* are more preferable in areas of fragmented holdings and broad base terraces in larger holdings.

The most important aspect is grading the land between *bunds* and terraces, which would help *in situ* conservation of moisture and smooth movement of runoff water to waste weir. This could be accomplished by using bullock or tractor drawn levellers.

Soil conservation measures, as recommended above, are to be adopted on watershed basis and the watershed may be subdivided into sub-watersheds. The sub-watersheds situated at the head of the main watershed are to be tackled first. The total runoff produced in each sub-watershed may be stored and used on the watershed itself with the help of farm ponds or it may be safely disposed. Proper gully control structures are to be provided coupled with waterways. The standard design principles are to be adopted in deciding the size of the gully control structures and waterways. Lastly, the most important thing is that the Soil Conservation section of the Department of Agriculture should be fully equipped with proper technical people to give design details of different structures for various soil and agroclimatic conditions. At the sub division level there must be Agricultural Engineering personnel, specialised in soil and water conservation, to achieve the above objectives.

REFERENCES

Chittaranjan, S., Rama Mohan Rao, M. S. and Ramanath, B. 1980, " Mechanical structures for soil conservation in deep black soils". Bellary Ext. Bull. No.1, Central Soil and Water Conservation Research and Training Institute, Research Centre Bellary.

Richard, K. Frevert *et al.* Soil and Water Conservation Engineering.

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Soil and Moisture Conservation Practices in Red Soils

L. A. Dixit, B. R. Hegde and T. C. Channappa *

RED soils are extensively found in southern Karnataka, Andhra Pradesh and Tamil Nadu. These soils are generally shallow to medium in depth, well drained, light to medium in texture and low in moisture retention capacity. Runoff is more in case of shallow soils when compared to medium and deep soils.

Red soils are highly erodible. Nearly 80% of the red soils are considered to be requiring some type of conservation measures (Anonymous, 1964). Soil losses to the extent of 0.9 to 3.8 tons per acre along with a runoff of 26 to 37 cm under a normal rainfall of 83 cm are reported (Krishnamurthy, 1971). Research at the Dryland Project, Bangalore indicated that 24 to 36 per cent of seasonal rainfall is lost annually as runoff.

Contour *bunding* as a soil conservation practice is followed in red soils and huge amount is spent annually for this purpose by the State Department of Agriculture. Though the *bunds* are stable in red soils, these structures posed problems like water stagnation and wastage of area and therefore, have not become popular. Too much deviation from the contour to adjust the *bund* line with the property boundary have posed further problems. Recent studies at ICRISAT showed that there can be an yield reduction upto 10 per cent of the potential yield due to prolonged saturation of the profile just above the *bunds*. Further, 5% of the cultivable area is lost under *bunds*. This practice, however, does not reduce the soil loss from the area between the *bunds*.

Alternate methods of soil conservation were tried at the Dryland Project, GKVK from 1970 onwards and the qualitative observations over a period of 10 years are considered reliable and reported in this paper.

Bunds AND TERRACES

Contour *bunds* with open ends

Contour *bunds* with 0.36, 0.54 and 0.74 sq m cross sections at 1 m vertical interval were constructed on the research station with open ends during 1971. The excess water from these open ends is connected to waterways located on both sides of the farm roads. Observations on different cross sections of the *bunds* have revealed that when the ends are open, 0.54 m^2 cross sections is quite sufficient. There was no problem of concentrated flow through the waste weirs eroding the next field. Overflowing and breaching of *bunds*

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were not noticed even under high rainfall conditions (139.5 mm in a day). Rainfall of 179.5 mm received in five consecutive days in August 1971 also did not breach the *bunds*.

The *bunds* were constructed by manual labour taking a burrow pit on the upstream side. The cost of construction was approximately Rs. 200/- per hectare.

Broad base *bunds*

Broad base *bunds* constructed on about 2.5 ha land on the farm during 1971 were also on contour at 1 m vertical interval with open ends. The *bund* height was 60 cm with a base width of 7 metres. The *bund* sloped in the upstream direction, whereas the downstream side was given an abrupt cut of about 70°. The *bunds* were constructed using tractor drawn scrapers. The cost of construction was approximately Rs. 200/- per ha. Except during the first year of construction, there were no breaches. *Ragi* crop yields on these plots were observed to be nearly 10 per cent higher than the corresponding open end contour *bunded* area. This was considered to be mainly due to extra area available for cultivation under broad base *bunds*. No additional moisture was found in the soil. However, the system facilitated easy movement of machinery from one field to another.

Such *bunds* can be adopted when the area is fairly large and not practicable on small holdings.

Graded *bunds*

The graded *bunds* are normally used for safe disposal of excess runoff in high rainfall areas and regions where the soil is relatively impervious.

Graded *bunds* with a grade of 0.3 to 0.4% and cross section of about 0.3m² were constructed during 1977 and 1978 in an area of about 7 ha with a vertical interval of 1 m. Such *bunds* have been found to be quite satisfactory in controlling gully erosion in the field. Even with high intensity rains, gullies were not observed in the inter *bunded* area. The *bunds* also served as an effective disposal system as they directed the flow of water at non-erosive velocity. No overflow was observed in these *bunds* indicating that the dimensions are sufficient for normal rainfall conditions in the region. The cost of construction of these *bunds* was only Rs. 75/- per hectare and smoothening of the inter *bunded* area, carried out with bullock drawn scrapers, costed Rs. 200–250 per hectare.

Such graded *bunds* were found to be useful in aligning the crop rows on a gradient. When sowing was done parallel to the *bunds*, the crop rows also maintained 0.3 to 0.4 per cent gradient.

Restricted contour *bund*

The results of experiments conducted at Anantapur Research Station (APAU) revealed that contour *bunding* + cultivation across the slope + *bund* former *bunding* recorded the highest grain yield of *jowar* and groundnut pods compared to *unbunded* plots and up and down cultivation (Venkatanadhachary, 1979). Optimum spacing between contour *bunds* was found to be 50 m for fields having slope upto 2%. Annual soil loss was estimated to be 3 to 4 tonnes/ha. However, because of zig zag nature of contour *bunds*, they were not liked by the farmers. These *bunds* also had a bigger cross section of 0.84 sq.m. To overcome this difficulty, *bunds* with a cross section of 0.47 sq. m at 50 m horizontal interval on a restricted contour with a surplus weir of 2 m length is recommended.

Graded border strips

Graded border strips, two each with 0.1, 0.2 and 0.5% gradients having 130 m length and 11 m width were constructed at GKVK, Bangalore in 1972. There was one additional plot of the same dimension without any internal levelling. Subsequently, two more unlevelled strips were added, in the year 1978. The plots were constructed by using both tractor and bullock drawn levellers at an approx. cost of Rs. 1000/- per hectare in 1972. Not more than 15 cm cutting and filling was required with the general slope of the area being 2.5 per cent. Runoff on such developed strips was 18-20% whereas the runoff with 2.5% slope was 24-36 per cent of the annual rainfall.

Due to the extra opportunity time available for rain water to soak into the soil on such lands, conditions for sowing remained favourable for 2-3 days more than that observed on slopy lands. Land developed in this fashion is better suited for practising double cropping. In medium to deep red soils, disturbance of fertility due to levelling is least as the soil itself is poor in phosphorus and nitrogen status. Fertility correction can easily be done by additional application of farm yard manure, superphosphate and zinc. The yield of *ragi* from border strip plots was 150 kg more per hectare compared to graded or contour *bunded* area.

Stabilization of *bunds* and waterways

Among the grasses tried for stabilising the *bunds*, hybrid napier, thin napier, thick guinea, rhodes, blue panic and green panic were found to be successful. In the waterways, thick guinea, rhodes and paragrass were found to be more useful as other grasses encouraged silting up of the channels allowing overflowing into the fields. *Lotononis beinesii*, an Australian legume was introduced as a *bund* stabilizer during 1977. These vines, propagated by cuttings, established well within a year and were found to be quite useful for *bunds* as well as waterways. The vine withstood the summer and sprouted with onset of rains.

Inter terrace management of the land

With all the soil conservation structures mentioned earlier, complete control of soil erosion is not possible, while moisture conservation is possible to lesser extent. For better moisture conservation, increasing the infiltration of water is essential.

One of the serious problems of crop production in red soils is crust formation at the surface. There are many associated problems of crusting : in the non-crop season crusting creates soil capping, leading to considerable runoff even in light soils; under cropped conditions besides encouraging runoff, crusting permits considerable evaporation losses; and crusting just after seeding, due to soil dispersing rains and sudden drying, results in improper or poor emergence of seedlings. At ICRISAT, it was observed that with a total rainfall of 499 mm, the runoff in cropped alfisol was 140.6 mm as against 73.0 mm in cropped deep vertisol (Krantz, *et al.*, 1978).

Tillage

The red soils are shallow, usually overlying a hard soil layer. This hard layer can be penetrated by roots, if loosened. Tillage practices like ploughing and chiselling open up the hard layers and increase the infiltration and storage capacity of soil. Studies at Hyderabad revealed that deep ploughing reduced soil strength as evidenced by penetrometer readings. Deep ploughing also increased the infiltration rate and crop yields. Summer tillage helped in reducing the runoff losses and thereby increased the depth of penetration (Table 1).

Table 1 : Influence of deep tillage on the profile moisture status

Depth of soil (cm)	Moisture percentage (after 81 mm rain in May)	
	Ploughed area	Unploughed area
0–15	10 74	3.59
15–30	13.22	7.13
30–60	12.27	8.59
60–90	13.44	Dry

Ridge-furrow cultivation and bedding system

Crops like maize are either planted on a ridge and furrow system across the slope or earthed up after 45 days of sowing to form ridges. In any case, the ridges thus formed have been found to reduce runoff, and thereby improve moisture availability to crop growth. Observations with maize crop during 1980 in Bangalore, have shown that the runoff with ridges and furrows on a gradient of 0.3 to 0.4% was 17.77% of the total rainfall as compared to 31.21% in bedding system. This system is useful for widely spaced crops at 60 to 90 cm between rows. Opening furrows after two seed drill widths (3 m interval) on a gradient of 0.3 to 0.4% was found to be advantageous for *ragi*.

Incorporation of crop residues

Red soils are usually poor in organic matter. Increasing organic matter content helps in extra retention of rain water and in increasing yields. At Bangalore, incorporation of maize residue at 4 tons/ha continuously for three years had its good effect as seen in 1980, a dry year. The moisture content at sowing time in residue incorporated plots was 11.24 and 14.03% in 0–15 and 15–30 cm depths compared to 8.85 and 13.39% respectively in plots without residue. The *ragi* yield from the plots with residue was 3497kg/ha compared to 1982 kg/ha from control plots.

Soil conservation structures on farmers' fields (ORP experience)

Most of the soil conservation structures are difficult to be adopted because of fragmented holdings and farm boundaries. In the Operational Research Project at Singanayakanahalli near Bangalore, structures like border strips were found to be highly acceptable to the farmers, whereas graded *bunds* were accepted only by a few. For any type of conservation structure to be effective, a suitable disposal system was found to be very essential. Fortunately, in the red soil areas of southern Karnataka, most of the fields have some sort of waterways. What is needed is, their development and establishment of vegetative cover.

REFERENCES

Anonymous (1964). Planning commission of India, P.E.O, Pub No. 41.

Anonymous (1978). Salient findings of research, Dryland Project, Bangalore.

Krantz, B. A., Kampen, J. and Virmani, S. M. (1978). Soil and water conservation and utilization for increased food production in the semi arid tropics. Paper presented in the 11th Congress of International Society of Soil Science, 19–27 June, 1978, Edmonton, Canada.

Krishnamurthy, K. (1971). Dryland farming problems in Mysore, UAS Research series, 12.

Venkatanadhachary, G., Prasad Rao, G.P. and Padmaraju, A. (1979). Improved agricultural practices for dryland crops in Rayalaseema region. Tech. Bull. No. 1.

Soil Erosion and its Control in the Red Soil Areas of Telangana

Shriniwas, V. Kameswara Rao and D. S. Rajput *

A substantial portion of agricultural lands is being affected by serious soil erosion in the country. The problem is more serious in the cultivators' fields without adequate soil conservation measures, because of runoff from intense storms. This leads to poor moisture conservation in the uplands and thereby very low grain yields.

The need for systematic research towards conserving soil was felt seriously only after early 50s in this country. The Government of India established a chain of Soil Conservation Research Centres in 1954. But, red soils, which form nearly 10 percent of the cultivated area in the country, received attention in this respect much later.

Systematic research on runoff and soil loss in red *chalka* soils was initiated in early 60s at Gunegal research farm, Ibrahimpatan. A few micro watershed hydrological studies were also undertaken at Hayatnagar farm in 1976. Field scale research for the efficient management of the resources was started at different locations under the farming systems research programme in 1977. Observations on soil conservation measures from the above cited studies with special reference to Hyderabad region are presented in this paper.

Soil, climatic, physiographic and land use conditions of Telangana area

A major portion of Telangana area has red *chalka* soils. These soils are generally characterized by low fertility and high infiltration with serious problems of crust formation. They are generally shallow in depth, sometimes even shallower than 10 cm, receiving an average annual rainfall of 770 mm. The rainfall is bimodal in distribution and is limited to the period from June to October. A dry spell of two to six weeks is likely from second fortnight of July to August. Rest of the year is practically dry. General topography is rolling and undulating with slopes in cultivated areas varying from 2 to 5 per cent. Sometimes, even steeper slopes are cultivated, leaving small area under permanent grass cover. Mono cropping either with *jowar* or castor is practised in the region.

* All India Co-ordinated Research Project for Dryland Agriculture, Hyderabad.

Runoff and soil losses from different land treatments

Crop cover plays an important role in reducing runoff. The effect of different crop covers on runoff and soil loss recorded at Hayatnagar during 1976 to 79 are presented in Table 1. The total annual rainfall during this period varied from 529 mm (1979) to 950 mm (1978).

Table 1 : Effect of crop cover on runoff and soil loss on 3 per cent slope

Crop	Runoff (mm)	Soil loss (tons/ha)
Jowar	85.82	3.21
Bajra	77 08	2.00
Jowar followed by horsegram	97.05	1.91
Bajra followed by *cowpea*	77.55	1.91
Jowar + redgram	77.65	1.59
Castor	111.98	3 97
Cultivated fallow	118.93	5.00
Grass (*Cenchrus ciliaris*)	64.74	0.59

It is seen from the table that soil loss from bare plot is 5.00 tonnes followed by 3.97 and 3.21 tonnes per hectare under castor and *jowar* respectively. These erosion rates are very much alarming in view of limited soil depth available for crop production and hence, need intensive conservation measures on sloping agricultural lands, particularly, when they are either kept fallow or under castor / *jowar*, compared to other crops.

Role of mechanical measures

The menace of soil erosion can be overcome effectively by providing suitable mechanical measures in the cultivated lands. Keeping this in view, comprehensive evaluation of mechanical measures for the rolling red *chalka* soils was undertaken at Gunegal research farm since 1964. Crop yield, runoff and soil loss are given in Table 2. Contour *bunds* performed slightly better than graded *bunds* in respect of crop yields, though the differences are not considerable. But graded *bunds* are preferred because of the advantage of harvesting runoff water for supplemental irrigation to enhance crop yields.

Studies were conducted to arrive at the optimum spacing for contour and graded *bunds* on lands with two per cent slope between 1966 and 1971, using castor as the test crop. Average grain yield is presented in Table 3. The results suggest that *bund* spacing can be increased from 60 to 90 m on 2 per cent slope. This will reduce the cost of *bunding* by nearly 50 per cent.

Table 2 : Influence of conservation structures on castor yield (kg/ha), runoff (cu m/ha) and soil loss (kg/ha)

Treatment	Castor yield	Runoff	Soil loss
Contour *bund*	600	11.46	5.0
Graded *bund*	495	113.77	138.0
Graded trench at 4.5 m horizontal interval	730	197.39	65.6
Annual rainfall (mm)	737		

Table 3 : Yield of castor (kg/ha) as affected by different slope lengths

Slope length (metres)	Yield (Av. of six years)
60	926
90	1114
120	847
150	923

Watershed approach for efficient soil and water conservation

From long term studies at several locations, it is found that soil and water conservation programmes prove to be highly effective and useful when planned and implemented on watershed basis instead of on individual holdings. It has also been recently stressed that other water conservation measures and improved agronomic practices should be followed in addition to graded or contour *bunds*. Thus *in situ* water conservation practices and inter terrace land treatments play an important role.

The crop performance with different inter terrace land treatments was studied at Hayatnagar farm for three years. *Jowar* grain yield for two land treatments given in Table 4 reveals that, flat sowing on grade with ridging incidental to interculture, registered only a marginal increase over bed system. However, the latter requires high initial investment, whereas the flat system does not require any special equipment and the small ridges can be formed as a result of cultural operations. Bed system also produces more runoff compared to flat system (Table 5).

So far, the effects of crop husbandry and land treatments were studied independently. Now there is a growing realisation that the improved crop management practices as well as land treatment should go hand in hand, as both these practices complement each other to reduce erosion in their own way. Work is being carried out on independent watersheds of 2.0 and 2.5 ha to evaluate the effect of combination of improved crop management and *in situ* water conservation practices in improving yields and reducing runoff. *Jowar* grain yield and runoff from the watersheds given in Table 6, indicate, that the improved crop management combined with effective land treatment reduces the runoff considerably. When water harvesting is practised within the catchment, silt, which otherwise would have been lost forever, is trapped.

Stepwise introduction of conservation practices

As the immediate benefits from the soil conservation measures are only marginal compared to improved crop management practices, it is natural that the farmer is less inclined to adopt the soil conservation measures. To gain the confidence of the farmer, improved crop management practices alone are to be introduced in the first year, followed by guide lines with small *bunds* of 0.1 sq m cross section, across the slope in the second year to facilitate contour cultivation. As the farmer is used to the cross-slope cultivation for one year, he will be less reluctant to accept the larger cross section *bund* of about 0.8 sq. m at 1.2 to 1.5 m vertical interval in the following year. At Operational Research Project, positive response has been received to this approach.

Table 4 : Influence of land treatments on *jowar* grain yield (kg/ha)

Land treatment	1978	1979	1980	Average
F.G.	1812	750	2560	1710
B.F.	1968	648	2230	1615

Table 5 : Runoff and soil loss from different land treatments (1979)

Runoff event	Land treatments	
	B.F.	F.G.
February		
Total runoff (Cu m/ha)	120.650	46.520
Peak rate of runoff (Cu m/sec)	0.042	0.012
July		
Total runoff (Cu m/ha)	180.400	52.070
Peak rate of runoff (Cu m/sec)	0.016	0.061
Soil loss (kg/ha)	205.700	54.000
August		
Total runoff (Cu m/ha)	147.800	58.760
Peak rate of runoff (Cu m/sec)	0.025	0.008
Soil loss (kg/ha)	186.000	69.000

F.G. = Flat sowing on grade with ridging incidental to intercluture

B.F. = Bed and furrow on grade

Table 6 : Influence of different treatments on total runoff (cu m/ha) and *jowar* yield (kg/ha)

Treatment	*Jowar* grain	Runoff
Poor crop management + land treatment	789	107.86
Improved crop management + land treatment	910	38 68
Improved crop management + land treatment + water harvesting	2553	13.40

REFERENCES

Anonymous. (1971). "Annual progress Report of Soil Conservation and Dry-land Agriculture Research Centre, Hyderabad".

Anonymous. (1979). "Annual progress Report of Farming system studies" (Main Centre, Hyderabad).

Shriniwas and Rajput D. S. (1980). "Soil and water consevation practices for small farmers in Dryland areas."

Shriniwas Sharma, Gupta P. D. and Das S. K. (1980). "Runoff and soil loss studies on red *chalka* soils at Hyderabad." Paper presented at National Symposium on Soil Conservation and Water Management held at Dehra Dun in 1980.

Soil and Water Conservation in Alfisol Areas - Rayalaseema Region of Andhra Pradesh

G. Venkatanadhachary, B. Sreenivas and B. C. Katama Reddy *

IN a broad sense, "Soil and Water Conservation" means all measures taken to prevent the land from deterioration and thereby promoting higher productivity per unit land over time. It, in fact, constitutes the optimal management of scarce resources like soil and water essentially involved in agricultural production. Kanwar (1972) identified accelerated erosion as one of the causes for the deterioration of land productivity. Rainfall analysis shows that the area receives an average annual rainfall of 560 mm with 6 runoff producing events (Table 1).

The extent of hazard in the absence of suitable conservation measures is further illustrated by the data in Table 2, pointing out that choice of crop and agronomic practices play a vital role in conserving soil and water in the region. Runoff and soil losses were highest (26.3% and 4.4 tonnes / ha respectively) with the erosion permitting crop *(setaria)*, with cultural operations along the slope while they were lowest in groundnut when sown across the slope (10.4% and 2.4 tonnes / ha). Hence efforts to improve production in this region should aim at :

identifying measures to alleviate the ill effect of high intensity storms and ;

conserving moisture and recycling runoff wherever feasible during failure of rains.

SOIL AND MOISTURE CONSERVATION PRACTICES

Since the rain water is the prime cause of soil erosion coupled with other edaphic factors, attempts to conserve them should be aimed at minimizing their contribution by suitable managerial techniques of land, soil and plant canopy. This cannot be achieved by any single measure - say mechanical structure. The past experience suggests that, an integrated approach *viz.*, biological, cultural and mechanical measures of conservation only saves the situation.

INCREASING *Insitu* CONSERVATION OF RAIN WATER

In the vast tracts of dry farming, the philosophy of soil and water conservation is to ensure maximum water intake - they may be engineering or agronomic, and these are discussed below:

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Deep tilling or chiselling

Venkatanadhachary *et al.*, (1979) observed that deep ploughing in soils having textural profiles helps to conserve moisture and thereby improve yields (Table 3). The beneficial effect on crop yields due to deep tillage persisted for two years. Hence, deep tillage once in three years with "*Pedda Madaka*" (big wooden country plough) is recommended.

Table 1 : Likely runoff incidents and maximum per day rainfall at Anantapur

Annual rainfall (mm) (1921-41)			No. of runoff incidents			Maximum/day rainfall (mm)		
Highest	Lowest	Normal	Highest	Lowest	Normal	Highest	Lowest	Normal
778	283	560	7	3	6	145	62	78

Table 2 : Soil and water losses under different plant canopies and management practices (Av. of 3 years)

Treatment	Water loss by way of runoff (%)	Soil loss (T/ha)	Grain/pod yield (kg/ha)	Straw yield (kg/ha)
Groundnut along the slope	12.1	4.1	890	1190
Groundnut across the slope	10.4	2.4	950	1430
Setaria along the slope	26.3	4.4	260	960
Setaria across the slope	12.7	3.6	270	1100
Crop season rainfall (mm)	411.8			

Table 3 : Influence of shallow and deep tillage and its residual effect on various crop yields (kg/ha)

Crop	Shallow tillage				Deep tillage			
	First year	Residual effect			First year	Residual effect		
	1972–73	1973–74	1974–75	1975–76	1972–73	1973–74	1974–75	1975-76
Castor	640	1010	580	1280	898	1300	800	1510
Redgram	900	910	1030	520	1170	1180	1500	760
Bajra	1200	770	490	20	1540	1030	740	30
Groundnut	420	860	570	1350	540	1170	820	1420
Sunflower	—	840	—	—	—	790	—	—
Setaria	410	—	—	—	490	—	—	—
CD at 5%	214	205	211	—	—	—	—	—

Contour farming

Contour cultivation recorded 15 to 20% increase in yield and reduced erosion by 20–40 per cent over up and down cultivation (Katama Reddy, 1979 and Sreenivas and Venkataramudu, 1980).

Ridge and furrow system of cultivation

Studies on inter terrace land treatments by Katama Reddy (1979) revealed that forming a dead furrow and forming compartments with *bund* former conserves rain water and improves grain yields by 15–30% (Table 4). This practice costs only Rs.20/- per ha/yr. The land should be made free from localised humps and depressions before practising the above system.

Mulching

Moisture losses due to evaporation are considerable in the region. Among different mulches, dust mulch (two times by harrowing at an interval of 10 days within 35 days after seeding) improved productivity and thereby resulted in greater water use efficiency (Table 5).

Table 4 : *Bajra* grain yield (kg/ha) as affected by different land treatments

Treatment	1976–77	1977–78	1978–79
Furrows at 2m interval across the slope (broad ridges)	380	1025	152
Treatment 1 + filling with *bajra* straw	390	1009	146
Compartmental *bunding* with compartments of 16m × 9m formed with *bund* former	390	997	158
Treatments 1 and 3	470	1230	197
Cultivation across the slope	350	898	177
Cultivation along the slope	290	885	147

Strip cropping

Growing groundnut in 60 ft strips alternated with 30 ft *jowar* strips gave highest returns (Anonymous, 1968). This practice is feasible with large holdings.

Bunding

Bunds spaced at 49 m consistently gave higher yields of *jowar* and groundnut when compared to the normal practice of 69 m spacing currently followed by the Department of Agriculture (Anonymous, 1966 to 1968). Studies on different cross sections of *bunds*, viz., 0.84, 0.65 and 0.47 m^2 showed no yield differences between 0.84 and 0.65 m^2 cross sections when spaced at 49 m. *Bunds* with 0.47 m^2 cross section breached badly. It was further observed that the graded *bunds* are equally efficient in these soils as seen from the crop yields furnished in Table 6. These results point out the need for graded *bunds* where runoff harvesting is to be practised.

However, *bunds* of 0.47 sq m cross section with 2 m surplus weir were found to be as efficient as contour *bunds* of bigger cross section, with the advantage of easiness in execution in farmers' fields (Venkatanadhachary, *et. al.*, 1979).

Table 5 : Influence of different mulches on *bajra* yields (kg/ha) and water use efficiency (kg/ha/cm)

Treatment	Grain		Moisture used (cm) 1974–75	Water use efficiency 1974–75
	1973–74	1974–75		
Dust mulch through harrowing with bullock drawn harrow	340	1740	25.8	67 4
Mulching with *bajra* straw-5 cm thick	370	1410	23.5	60.1
No mulch	190	810	22.4	39.7
CD at 5%	54	220		

Table 6 : Yields (kg/ha) of groundnut and *setaria* as influenced by contour and graded *bunds*

Type of *bund*	Groundnut	*Setaria*
Contour *bund* (0.65 m^2 cross section)	90	815
Graded *bund* with 0.1% grade	80	845
Graded *bund* with 0.2% grade	70	840

RUNOFF COLLECTION AND RECYCLING FOR CROP USE

Under Anantapur conditions, it has been observed that more than 20% of the rainfall is lost as runoff (Venkatanadhachary, *et al.*, 1979). This runoff could easily be collected and stored in a farm pond of appropriate size. Such stored water in farm ponds play a vital role in stabilizing crop production in the region through recycling during dry spells. Thomas and Jayakumar (1973) developed a system of graded *bund* and storage pond at Hyderabad, which is feasible enough for adoption by a single farmer or group of farmers. But in red soils storage of runoff in farm pond is a problem in the absence of a proper sealant. Venkatanadhachary, *et al.*, (1979) observed that sodic soil (washerman's earth) usually available in every village to be a good and cheap sealant material for control of seepage losses in farm ponds.

EVALUATION OF CONSERVATION PRACTICES

The reports by and large on *bunding* are contradictory and the typical beneficial effect on red soils documented in Andhra Pradesh can be summarised as shown in Table 7.

Table 7 : Beneficial effect of *bunding* on red soils of Andhra Pradesh

Saving of top soil	:	Soil saved varies from 20–150 tonnes/ha depending on soil, climate and cropping system.
Increase in level of water table	:	Rise in water table ranging from 0.3 to 5.1 m thereby increasing the irrigation potential.
Increase in crop potential	:	As shown below.

Period of observation	*Kharif jowar*	*Rabi jowar*	*Bajra*	Groundnut	Castor	Redgram
1961–63	8.70	—	26	11.63	4.66	11.33

(Source : Sankara Reddy, Subba Reddy, 1963)

The enthusiasm and response from the farmers to *bunding* as a soil conservation measure is debatable and the usual excuses put forward are loss in cultivable area, water logging and breaching. From scientific point of view, the failure can be ascribed to lack of planning and integrated approach on a watershed basis. If one wishes to achieve the desired take off to come, execution of soil and moisture conservation measures on watershed basis should form a part of integrated resource management with good planning. The steps in good planning involve :

- preparation of topo maps with distinct individual field boundaries and contours at 0.5 m interval ;
- soil survey reports with maps ;
- present and proposed land use maps ;
- action plans ;
- sub catchment plans ;
- individual farm plans ;
- statement of maintenance works ; and
- total outlay.

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REFERENCES

Anonymous, (1966-77). Annual Report of the Soil Conservation Research Station, Anantapur.

Kanwar, J. S. (1972). Presidential address, Indian Society of Soil Science, 37th annual general meeting, Ludhiana.

Katama Reddy, B. C. (1979). Note on the Soil and Moisture conservation structures at Agricultural Research Station Anantapur (Unpublished).

Sankar Reddy, G.H. and Subba Reddy, K. (1963). The Andhra Agricultural Journal, 10 (6): 28–37.

Sreenivas, B. and Venkataramudu, J.(1980) A note on the effect of soil and water losses on yield of groundnut and *setaria*. Paper presented in connection with Indian Society of Soil Conservation annual Meeting held at Dehra Dun.

Thomas, P. K. and Jayakumar, M. (1973) Land use with reference to *kharif* and *rabi* cropping in dryland agriculture. Principal Investigators meeting of All India Co-ordinated Research Project for Dryland Agriculture, 1973.

Venkatanadhachary, G., Prasada Rao, G. P. and Padma Raju, A. (1979). Research station (Dryland Farming) Anantapur, release in commemoration of the Golden Jubilee Celebration of Indian Council of Agricultural Research, New Delhi : pp 1–37.

Session III

Water Conservation Measures

Chairman : Dr. BARDE

Rapporteurs : Dr. B. G. RAJASEKHARA

Dr. V. RANGA RAO

Summary

IN this session three papers were presented two from black soil and one from red soil areas and the following recommendations were made.

BLACK SOILS

Dr. M. S. Rama Mohan Rao and Mr. C. J. Itnal presented their papers. After discussion following recommendations were adopted :

Keeping *jowar* stubbles vertically in trenches of 30 cm deep, 15 cm wide, protruding 10 cm above the ground level at 4 m spacing helps in greater conservation of moisture and higher crop yields ;

Application of gypsum for improving infiltration rate is recommended in soils which suffer from low to very low infiltration rates ;

Early sowing of *rabi jowar* helps to realise higher yields and hence needs to be popularised ; and

In high rainfall areas, formation of ridges and furrows after deep tillage early in the season before sowing and subsequently breaking the ridges after monsoon rains during crop growth to create dust mulch helps in conserving moisture.

Items for further research

Identification of practices for improving infiltration rate in problem soils ;

Identifying locations for improving cropping intensity to 200% in black soil areas ; and

Identification of materials alternative to *jowar* straw for using as vertical mulch.

RED SOILS

One paper was presented by Mr. V. Kameswara Rao. Following recommendations were adopted after discussion ;

Soil surface be kept loose with early rains either by shallow tillage, deep tillage or by incorporating crop residues, depending upon the location, for better moisture conservation and higher yields ;

For disposing excess water, graded furrows at an interval of 3 m can be followed ;

Sowing flat on gradient of 0.3 to 0.4% and subsequently ridging with each intercultivation in case of row crops helps moisture conservation and results in increased yields. Hence, the above practice can be followed in low and high rainfall areas ; and

In soils deeper than 30 cm, graded border strips of 10–15 m width with 0.2 to 0.3% gradient, by forming ridges at suitable intervals and levelling the area in between the ridges using bullock drawn scrapers, helps in better moisture conservation and increased crop yields and hence to be followed.

Items for further research

Further studies on specification of farm ponds with respect to catchment size for different locations ; and

Studies on controlling seepage losses in farm ponds.

Moisture Conservation for Higher Crop Yields in Black Soils

M. S. Rama Mohan Rao *

BLACK soils constitute 23.1% of rainfed lands in the country and possess great production potential. They are poor in organic matter and structure and suffer from higher expansion and shrinkage properties. Being alkaline in reaction, the soils disperse easily and the net result of all these unfavourable characteristics is the low infiltration rate (0.8 mm / hr) and consequent high runoff. Thus, the effectiveness of the already inadequate rainfall (500 to 700 mm) is further reduced. Cropping in the *kharif* season is not possible due to scanty and uncertain rainfall. Generally, crops are sown in October and are grown on stored moisture as there is little or no post sowing rainfall. Hence, moisture is the major constraint in crop production in the region. This constraint could be alleviated by effective moisture conservation practices. The possible ways of improving rainfall use efficiency are :

- *in situ* conservation of rainfall ;
- water collection ; and
- water utilization.

In situ CONSERVATION OF RAINFALL

The region is characterized by high intensity rains occurring over short periods. One way of conserving moisture is to increase the opportunity time for enhancing the effective rainfall. Contour cultivation provides a series of miniature barriers to rain water moving along the slope and thereby conserves more moisture. Such a practice registered an increase of 34% in *jowar* and 17% in *setaria* yields at Bellary (Table 1).

However, all attempts to increase opportunity time in the inter terraced area by practices such as compartmental *bunding*, listing, tied ridges and corrugations have resulted in water stagnation which in turn adversely affected the yields (Table 2). While Kanitkar *et. al*, (1960) reported similar results from Bijapur and Solapur, Gopal Krishna Rao *et. al*, (1975) observed 18 to 24% yield increase with compartmental *bunding* in case of slightly more permeable soils. The failure of such practices could be traced to low intake rate of

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Table 1 : Effect of contour *vs* up and down cultivation on crop yields (kg/ha)*

Crop		Contour cultivation	up and down cultivation	% increase over up and down cultivation
Black soils				
Rabi jowar	Grain	284.6	210.9	34.9
	Straw	1606.6	1208 9	32.9
Setaria (H 2)	Grain	194.9	159 4	22.3
	Straw	430.2	390.3	10 2
Red soils				
Kharif jowar (K 340)	Grain	311.9	188.5	65.5
	Straw	6097.0	3823.8	59.4

* Average of 3 years

Table 2 : Influence of different moisture conservation practices on *jowar* grain yield (kg/ha)

Treatment	1963	1964	1965	Mean
Tied ridge	12.2	227.0	233.4	157.5
Single lister	127.6	353.9	1156.6	546.0
Corrugations	252.5	394.7	1073.1	573.4
Bund former *bunds*	190.5	390.4	980.7	320.5
Control	172.3	344.2	1026.9	514.5
CD at 5%	130.2	—	512.8	—

these soils. These results suggest that unless intake rate *per se* is improved through improvement of structure, moisture conservation remains to be a problem in these soils. Studies in this direction showed severe water intake problem in soils having exchangeable sodium percentage greater than 7.0. The problem could be overcome by reducing ESP to less than 7 as was done at Bellary through gypsum application (Table 3).

Movement of rain water into black soils takes place initially through cracks charging the sub soil with moisture. Once the cracks are superficially closed further movement is governed by intake rate *per se*. This being very low, it results in a dry layer sandwitched between two wet layers in years of low rainfall, leading to crop failure. Keeping *jowar* stubbles as vertical mulch in trenches of 40 cm deep, 15 cm wide, protruding 10 cm above the ground level enhanced soil moisture by 4 to 5 cm and grain yields by as much as 400 to 500% in dry years and 40 to 50% in normal years over control (Table 4).

Table 3 : Effect of gypsum application on infiltration rate (mm/hr)

Treatment	Crop season				
	1974	1975	1976	1978	1979
Gypsum	4.1	4 6	4.5	5 5	7.2
No gypsum	0 75	0.75	0.75	1.0	1.0

Table 4 : Influence of vertical mulch on yield of *jowar* (kg/ha)

Treatment	Location			
	Bellary (1973–76)		Solapur (1974–76)	
	Grain	Straw	Grain	Straw
Control	836	2157	840	4774
Vertical mulches at 2 m interval	1172	2961	1237	6276
Vertical mulches at 4 m interval	1281	3037	1266	6445
Vertical mulches at 8 m interval	1186	2927	1123	6231

WATER COLLECTION

Even with the best of soil and water conservation measures, it is impossible to reduce runoff from agricultural catchments to near zero. At Bellary, it is estimated that about 10% of the annual rainfall which goes as runoff can be easily harvested using drainage type of terraces through grass waterways and could be stored in dug out ponds (Table 5). Similarly, at Solapur and Bijapur it was proved that runoff water could be collected and stored in farm ponds under normal conditions. Based on the studies conducted at Bellary, a farm pond of 3 to 5 m depth (1.5:1 side slopes) having a capacity of 0.25 to 0.3 ha m is recommended for every 8 to 10 ha catchment. The cost of making such a pond works out to Rs. 8000/- to Rs. 10,000/- at current rates. In areas like Bellary, 25 to 30% of the initial cost can be recovered by disposing off excavated *murrum* for rural roads. Seepage losses, if any, can be reduced considerably by lining the ponds with soil, cowdung and straw in the ratio 10:1:1 or preferably through a 10 cm thick plastering with saline sodic soil.

Gauging studies revealed that the water so harvested can be recycled on to 80% of the catchment area for providing one life saving irrigation of 5 cm.

Runoff water so collected from periods of excess rainfall, when transferred to the catchment in the event of failure of rains, helped to increase yields from 500 to 1400 kg/ha with one irrigation (Table 6). This practice would bring stability to agriculture in the tract which is the crux of the problem in the region. Since the quantity of water is limited, utmost care has to be taken for maximising the water use efficiency so that large area can be covered. Application of 5.0 cm irrigation in alternate furrows before the development of cracks resulted in maximum water use efficiency.

WATER UTILISATION

Planting time

Traditionally farmers take up sowing of *rabi* crops sometime in October. This practice puts *rabi* crops to a great disadvantage as little or no rains occur after sowing. Consequently, the crops invariably suffer from poor stands and moisture stress at or before flowering. Studies on time of planting revealed that advancing *jowar* planting by 20 to 30 days gives substantial yield increases (Table 7). Response to early seeding is more pronounced with improved genotypes of *rabi jowar* than traditional types. Early seeding is also helpful in case of other *rabi* crops. The best sowing time for safflower is first fortnight of September in case of Solapur, second fortnight of September in Bijapur and first fortnight of October in Bellary regions. Early sown crops have the advantage of higher moisture availability and thereby better utilisation of applied nutrients.

Surface mulch

The soils are devoid of vegetative cover by the time rains commence in September. Beating action of rain drops causes structural deterioration resulting in further

Table 5 : Yield of runoff water from 16.0 ha catchment

Year	Total rainfall (mm)	Total runoff from the catchment (mm)	Runoff as % of the rainfall	Total runoff from the catchment (ha m)
1964-65	558.6	71 0	12 7	1.151
1965-66	481.2	49.6	10.3	0.803
1966-67	588.2	49.5	8.4	0.802
1967-68	533.0	46.4	8.7	0.752
1968-69	541.6	45.5	8.4	0.736
Average	540.5	52.4	9.7	0.849

Table 6 : Effect of supplemental irrigation on *jowar* yields (kg/ha)

Treatment	Bellary						Solapur	
	1972		1973		1975			
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Control	530	2540	430	1770	2190	5180	884	—
Irrigation at mild stress	1360	2620	1370	3580	2450	5180	1477	—

reduction of rain water penetration. Evaporation losses are also high due to the absence of crop canopy. Either application of organic material as surface mulch and / or timely intercultivation to create adequate dust mulch would reduce these losses and improve the moisture availability, thereby resulting in higher yields, as is evident from Table 8. Under Bellary conditions, application of surface mulch and dust mulch resulted in 1760 and 1833 kg / ha of *jowar* grain respectively as against 934 kg / ha with control.

The above results indicate that crop yields could be enhanced by adopting suitable moisture conservation measures.

Table 7 : Effect of seeding time on yield of *rabi* crops (kg/ha)

Crop	Seeding time	Bellary	Bijapur	Solapur
Jowar	August 2nd fortnight	NT	NT	2080
	September 1st fortnight	NT	1906	2144
	September 2nd fortnight	3993	2127	NT
	October 1st fortnight	2908	1444	1293
	October 2nd fortnight	1952	894	884
	November 1st fortnight	532	NT	NT
Safflower	September 1st fortnight	330	2237	1271
	September 2nd fortnight	870	1393	915
	October 1st fortnight	2231	1098	708
	October 2nd fortnight	2130	750	462

NT = Not tried

Table 8 : Effect of surface mulch on the yield of *jowar* (kg/ha)*

Treatment	Grain	Straw
Control	728	3430
Jowar stubbles	1035	4720
Wheat straw	1120	5190
Redgram stalk	1182	5620
Dry grass	1265	6240

*Average of 3 years

REFERENCES

Gopala Krishna Rao, M., Kulkarni, M. V., Havanagi, G. V., Venkata Rao, B. V. and Patil, S. V. (1975). Studies on problems of Dry Farming at Hagari (1906-1970). UAS Station Series No. 1, Bangalore.

Kanitkar, N. V., Sirur S. S. and Gokale, D. H. 1960. " Dry Farming in India ". 2nd Edition, ICAR, New Delhi, pp. 470.

Water Conservation Measures for Increased Production in Black Soils of Bijapur Region

C. J. Itnal *

THE primary constraint for agricultural development in semi arid tropics (SAT) is the lack of suitable technology for land and water management. The rainfall in the region is generally received with high intensity (3 mm / min) causing soil erosion and runoff. It is estimated that 22.5 tonnes / ha of top soil is lost annually from lands having 1.25% slope along with 107 mm of rain water through runoff in this region. The crops suffer for want of moisture at critical stages due to uneven distribution of the already inadequate rainfall, resulting in low yields and some times in total failure. To increase the crop yields in general and in *rabi* in particular, it is most essential to conserve *in situ* as much rain water as possible.

The research on water conservation during early 40s did indicate that crop yields could be increased by following compartmental *bunding* and scooping. These practices were however, not found to be applicable for all conditions of soils and climate. Suitable technology integrating soil, water and crop management is felt essential to overcome the moisture shortage in drylands. The results of such investigations carried out at Bijapur in this direction are presented here.

Bunding

Contour *bunds* are provided to arrest soil erosion and to conserve rain water. The general experience has been that the contour *bunds* have done more harm than good and the farmers at present show reluctance for having the contour *bunds*. Studies conducted at Bellary during 1960-67 on the efficacy of *bunding* on crop yields revealed that contour *bunding* resulted in 25, 29 and 19.6 per cent decrease in *jowar*, cotton and safflower yields respectively due to problems of water stagnation (Chittaranjan *et. al.*, 1980).

Tillage to increase infiltration of rain water

Keeping the soil surface in a rough condition helps to increase infiltration in the early monsoon season. The data on

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tillage experiments carried out at Bijapur reveal that shallow ploughing (10 cm depth) and harrowings (3–4 times) provide an optimum tilth for establishing a good crop stand. Crop yields are enhanced by 200–300 kg/ha over the conventional tillage practice of only harrowing or deep tillage. Better infiltration (1.6 cm/hr) of rain water was however observed with deep tillage as compared to 0.4 cm/hr with conventional tillage or 0.52 cm/hr with shallow tillage.

Experiments on land shaping within the *bunded* area showed that *rabi jowar* yields could be enhanced by 16 per cent by forming ridges and furrows across the slope, 45 days prior to planting and retaining the same till sowing time. Sowing in furrow increased the yield by 20.4% over flat sowing. Similarly, tied ridges enhanced the yields by 36.0% over control (*vide* Tables 1 & 2).

Table 1 : Effect of land shaping on *rabi jowar* grain yield (kg/ha)

Treatment	Grain yield*
Opening ridges-furrows at 45 cm distance, 43 days prior to planting and sowing them in furrows and breaking the ridges to form a thick soil mulch by subsequent intercultivation	2041
Opening ridges and furrows at 90 cm distance, 45 days prior to planting and sowing 2 lines in furrows and breaking the ridges during the first intercultivation	2064
Harrowing 3 times and 3 intercultivations (control)	1760

*Average of two years

Vertical mulching

Vertical mulches put across the slope provide a barrier for the runoff water, which in turn charges sub-soil. These vertical mulches function as open ditches into which runoff and rain water freely flow and redistribution of moisture takes place in the sub-soil. The influence of vertical mulching on crop yields for four years is presented in Table 3. Moisture distribution between the two vertical mulches revealed higher values near the trenches and decreased towards the centre of the mulches. Averaged over four seasons, vertical mulch placed at 5 m interval gave an increased yield of 343 kg/ha (26.3%) over control.

Land shaping for conservation

In case of less permeable soils, our aim should be to alter the land topography to have efficient *in situ* moisture conservation through reduction in runoff in seasons of less rainfall, and to act as a safe disposal system in seasons of excess rainfall and thereby enhance and stabilise crop yields.

The performance of the different land shaping treatments viz., 1.5 m broad ridges and furrows, ridge–furrow system (0.45 m) and flat on grade was tested at Bijapur. No over topping of ridges under high rainfall conditions either with the ridge-furrow or broad ridge-furrow was noticed. However, there is deshaping of beds and ridges due to soil settling. Averaged over two seasons ridge-furrow system appeared to be more promising over flat on grade in relatively dry seasons (Table 4).

Table 2 : Influence of different land shaping treatments on *rabi jowar* (1977–78)

Treatment		Yield (kg/ha)	
		Grain	Straw
No gypsum	Flat sowing	1496	3098
	Tied ridges	2035	3790
	Ridges and furrows	1719	2493
	Compartmental *bunding*	1582	2801
	Broad beds and furrows	1384	2949
Gypsum @ 2 T/ha	Flat sowing	1956	3411
	Tied ridges	2349	3675
	Ridges and furrows	2143	3411
	Compartmental *bunding*	1959	3593
	Broad beds and furrows	1955	3164
'F' test (main plots)		NS	NS
CD (Sub plots) at 1%		404	439

Table 3 : Effect of vertical mulching on yield of *rabi jowar* (kg / ha)

Treatment	Grain			Average
	1973–74	1975–76	1977–78	
Control	1661	1065	1191	1306
Vertical mulches at 5 m interval	2050	2015	1884	1649
Vertical mulches at 10 m interval	1823	902	1008	1244

Table 4 : *Rabi jowar* (kg / ha) as influenced by land shaping treatments

Treatment	1979–80		1980–81	
	Grain	Straw	Grain	Straw
Broad beds and furrows	1500*	2540	546	1108
Ridge–furrow system	1500**	3100	640	1328
Flat on grade	1500**	2850	476	927

* Av. of two replications ** Av. of three replications

REFERENCE

Chittaranjan, S., Ramanath, B. and Rama Mohan Rao, M. S. 1980. Mechanical Structures for soil conservation in deep black soils. Ext. Bull No. 1, CS & WCR & TI Research centre, Bellary.

Rain Water Management in Red Soils of Telangana Region

V. Kameswara Rao, K. P. R. Vittal and K. Vijayalakshmi *

WATER management in rainfed agriculture is important as it solely decides the fortunes of many farmers involved. These lands, apart from being dependent on rainfall for moisture replenishment, are also beset with problems of soil erosion, high evaporation rates *etc*. One such area is the red soil region around Hyderabad with problems like undulating topography resulting in soil erosion, shallow soil depth affecting the water holding capacity, soil crusting leading to runoff, high temperatures causing water loss through evaporation both from land and water surfaces. In addition to these natural problems, farmers' social and economic backwardness hinder any introduction of technology involving cash inputs.

Topography

The rainfed lands around Hyderabad have slopes varying from 2 to 5 per cent which are multidirectional. This not only causes sheet erosion but results in rill and gully erosion wherever runoff concentrates into small streamlets. Poor water holding capacity because of shallow top soil and poor physical characteristics and low intake when the soil crusting takes place further enhances the prospects of runoff, which in turn aggravates erosion problem. Soil and water losses differ depending upon crops grown and land management practices followed, as seen in Table 1.

On the other hand, water that enters the soil is also not held in the root zone because of low water holding capacity and excessive drainage, leading to ground water contribution. Solution to this problem lies in conserving a part of the rain water *in situ* and allowing the rest to flow into a water storage structure to be used for supplemental irrigation.

In situ water conservation

Terraces (graded or level) constructed at regular intervals on sloping lands prevent soil erosion. However, their ability to conserve the moisture is being questioned. The moisture distribution is also not uniform.

To ensure uniform distribution of moisture in the inter terraced land and to

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Table 1 : Runoff and soil loss under various land and crop managements on 2% slope (1976)

Crop or land management practice	Rainfall (mm)	Runoff (%)	Soil loss T / ha
Jowar	175.7	25.9	2.28
Bajra	150.1	22.2	1.85
Jowar + redgram	136.9	20.2	3.06
Castor	220.0	32.5	3.39
Cultivated fallow with ridges	187.2	27.6	2.86
Cultivated fallow without ridges	198.0	29.2	3.01
Grass (*Cenchrus ciliaris*)	136.9	20.2	0.84

check probable sheet and rill erosion, land treatment to the inter terrace area is essential. Land treatment consists of corrugations across the slope on a mild grade which increase the opportunity time for rainfall to soak into soil. At the same time these corrugations serve as surplussing channels. The corrugations may be narrow ridges and furrows at 0.75 m apart or broad bed and furrorws at 1.5 m apart or ridges created with cultural operations such as intercultivation, top dressing *etc.* The data from experiments on land treatments on red soils indicate that the " broad bed and furrow system " produces more runoff compared to " flat sowing on grade with ridging incidental to interculture ". The results are presented by Shrinivas *et al.* (*vide* Table 5 of page 37).

The " bed system " also suffers from a disadvantage that it needs a specially designed tool carrier to make and maintain beds. On the other hand "flat sowing on grde and ridging later " is labour intensive practice and easily adoptable by the farmer. The effect of land treatments on crop yields is given in Tables 2 and 3.

Tillage

Off–season tillage and creation of mulch are the two time bound operations that are very important in rainfed agriculture. The former keeps the soil open for the rains received in the beginning of monsoon. The length of sowing period could be extended, if more rain water is held in the profile by keeping the soil open with off-season tillage. The advantage of following off-season tillage over plough and plant system is given in Table 4.

Table 2 : Yield of sunflower under different land treatments (1975)

Treatment	Yield (kg / ha)
Contour cultivation (Control)	296
Ridges and furrows	511
Graded trenches	400

Table 3 : Grain yield (kg/ha) of crops under different land treatments (1979)

Crop	Crop management			
	Improved		Farmers'	
	B.F.	F.G.	B.F.	F.G.
Jowar + redgram	648+ 119	750+ 84	557+ 49	580+ 113
Castor	348	467	246	382

B.F. = Bed and furrow system on grade

F.G. = Flat sowing on grade with ridging incidental to interculture

Table 4 : Effect of off-season tillage on *jowar* yield (kg/ha)

Treatment	1978	1979
Plough and plant system	930	490
Off-season tillage	1340	1240

Creation of dust mulch would further prevent the loss of water from soil through evaporation. Off-season tillage and creation of dust mulch are two labour intensive practices and do not involve any cash inputs. Doing the job in time is the only cost involved.

Deep tillage

Moisture storage capacity of the soil for use by the crops can be increased by deepening the profile through mechanical means. However, unless the residual effect persists for a minimum of 2-3 years, the practice would not be economical on real-farm situations. A case study from the shallow soils of Anantapur is presented by Venkatanadhachary *et al.*, (*vide* Table 3 of page 41).

Whenever the profile modification is not feasible the best use of available water in soil, can be made by the selection of crops having deeper rooting system. The effect of shallow soil depths on crop yields is presented in Table 5.

Water collection through runoff harvesting

Because of the limitation of shallow depth of the soil, it is imperative that enough rain water can not be held in the root zone for the crops. Rainfall, in excess of infiltration, has to be guided into a small dugout pond whose size would depend on the amount of water that could be collected and needed for minimal irrigation. A pond with a capacity of 2.5 ha cm for every hectare of catchment would be a reasonable size (assuming that 50 per cent of rainfall of 5 cm received in one or two days, flows as runoff). Ponds of three to four times bigger capacity may be desirable from the view point that the cost of lining per unit storage created would be less. Since the pond will be owned by a group of farmers, the understanding between the constituent 2 to 3 farmers in using the water will be the pre-requisite for any such venture on co-operative basis.

The pond could be located in the middle of a graded terrace and fed by

Table 5 : Effect of shallow soil depth on crop yields (kg/ha)

Soil depth (cm)	*Jowar*				*Bajra*		Redgram	
	1973	1974	1975	1977	1973	1974	1974	1975
5.0– 7.5	1230	2860	1680	1730	2590	2090	1070	1560
7.5–10.5	1350	2840	2010	2110	3220	2030	1210	1620
10.5–12.5	1380	3040	2380	3050	3520	2070	1150	1670
12.5–15.0	1670	3610	2180	3270	3560	2390	1200	1570
15.0–17.5	1610	3540	2220	3660	3490	2090	1190	1440
17.5-20.2	1490	3290	2020	4070	3680	2240	1300	1560

Table 5 : (Contd)

Soil depth (cm)	Castor				Cowpea		Grass (green)		
	1973	1974	1976	1977	1975	1976	1973	1974	1976
5.0– 7.5	1840	1150	590	540	610	990	29110	19870	22090
7.5–10.5	2120	1480	660	560	620	1030	37440	22470	21680
10.5-12.5	2110	1430	700	590	650	960	45560	24410	24170
12.5–15.0	2390	1290	610	580	670	910	48890	24280	25560
15.0-17.5	2060	1350	730	590	700	990	57500	28940	28750
17.5–20.2	2020	1400	560	570	730	940	59060	30410	24860

cutting it. The problem of surplussing arrangement could be overcome by adopting a 'two in one' design (raised inlet type entry) where the spillway and feeding point would be same. Alternatively, the pond could be connected to a waterway to take maximum advantage of runoff from catchment area.

Water storage

Storage of water over a period of time from the date of collection to utilisation which is likely to be about 1 to 2 months is a problem in red soils owing to high seepage rates. Various sealants have been tried successfully (Table 6).

Of all the sealants tried, barring cement lining which gave zero seepage rate, asphalt is found to be useful. However, application of asphalt and its retention over the sloping side of the pond is a problem as it tends to flow down in summer. Slopes flatter than 1.5:1 should be used, as steeper than this results in flowing down of melting asphalt. Covering the asphalt with soil plaster and use of herbicides to check the weed growth on sides of the pond are further improvements in this direction.

Experience at Operational Research Project indicates that in view of the unprotected nature of the farms, it is essential that the sealant should be strong enough to withstand the onslaught of grazing animals which come to drink the water. Alternatively, the pond should be protected by a fence.

Methods of supplemental irrigation

Conventional surface irrigations are not appropriate for supplemental irrigation to rainfed crops owing to limited water and high evaporation losses. The departure from the conventional systems is that the supplemental irrigation should be used to optimize the production per unit quantity of water rather than per unit area of land. The sub-surface systems as well as the trickle (drip) irrigation systems are efficient but are capital intensive and are not justified considering the economic backwardness of the farmer.

A system of confined furrow application and alternate (skip) furrow application is found to be useful (Table 7) in making the water to move deep into the root zone compared to conventional methods, where water spreads over an area before getting into the root zone, thereby resulting in considerable evaporation and runoff losses. Further, a given quantity of water could be applied in split doses to keep evaporation and runoff losses at the minimum.

Water utilization

The water collected in the pond could be utilized for giving a life saving irrigation for crop. Many a time, failure to make the crop overcome a severe moisture stress, as that in August which has high probability, results in total failure of the crop even though subsequent rains are adequate. The water could also be used

Table 6 : Seepage rate in ponds with different sealants

Sealant	Seepage rate (mm/day/m^2)
Cement concrete (0.25 m thick)	0
Asphalt with soil cover	1.5
Soil + cowdung + straw (10 : 1 : 1) 10 cm thick	8.1
Soil+cement (12 : 1) 4 cm thick lining	53.6
Control	421.2

Table 7 : Effect of method of irrigation on crop yield (kg/ha)

Method of Irrigation	Ratoon *jowar* (1977)	Ratoon *jowar* (1978)	Castor (1978)	Chillies (1978)
Wide furrow	770	190	1030	1340
Confined to furrow	830	300	1240	1670
Confined to alternate furrow	920	180	1270	1460

for growing short duration vegetables or cash crops, 'in the event of normal rainy season, after the harvest of main crop. The effect of irrigation on yield of different crops is given in Table 8.

Though the benefits of better moisture conservation are realised, unless the extra moisture is effectively made use of through better agronomic practices, the advantage may not be felt. Therefore, it is essential to match good management practices with better moisture conservation techniques.

Table 8 : Effect of minimal irrigation on the yield (kg/ha) of different crops.

Jowar

Treatment	1973	1974	1979
Control	380	2510	1110
Irrigated	830 (1.5 cm)	3680 (0.6 cm)	1600 (3 cm)

Ratoon *jowar*

Treatment	1977	1978
Control	720	110
Irrigated (0.75 cm)	880	230

Castor

Treatment	1977	1978	1979
Control	740	530	1020
Irrigated	930 (1.5 cm)	660 (1.5 cm)	1320 (4 cm)

Red gram

Treatment	1980 (two pickings)
Control	50
Irrigation	250 (4.0 cm)

Table 8 : (Contd.)

Vegetables

Treatment	Beans (1977)	Brinjal (1977)	Chillies (1978)
Control	130	1770	1270
Irrigated (1 cm)	1430	2670	1690

Session IV

Economic Analysis of the Recommended Dryland Practices

Chairman : SRI B. M. RAMPUR

Rapporteurs : SRI U. S. PATNAIK

Dr. B. R. HEGDE

Economic Analysis of Improved Dryland Practices

V. Ranga Rao and S. Selvarajan *

PRODUCTION levels of dryland crops from traditional *rabi* tract in the *Deccan* plateau are abnormally low and unstable, thereby leading to widespread rural poverty in the region. Paradoxically, climatic conditions are not wholly responsible for this dismal state of affairs. Unlike in case of *kharif* crops, the techniques of soil and crop husbandry in semi arid black soils underwent little or no change from the age old practices which are inecffiient in exploiting the available resources. Research conducted on farmers' fields, over a wide spectrum of seasonal conditions, demonstrated existence of tremendous scope for raising the productivity and production levels of black soils hitherto under exploited, by nearly 2 to 4 folds. *Jowar* registered highest yield potential among various *rabi* crops grown in the region (Table 1).

Safflower, which is seldom cultivated as a pure crop ranked second in yields. In fact, it showed consistent superiority over dryland cotton, which is extensively grown in the region not only in terms of yields but also in net profits (Table 2). Attempts should therefore be made to hasten its

Table 1 : Scope for improving the production potentials of rainfed *rabi* crops through improved farming practice

Crop	Average yields* from traditional technology (kg ha)	Average potentials from improved technology (kg/ha)
Jowar	275	952
Safflower	197	834
Gram	189	454

*Data based on average yield of crops obtained from farmers' fields over a wide range of seasonal conditions

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popularisation as a pure crop. Of the various *rabi* grain legumes tested at the centre, field beans and cluster beans proved more productive and stable than gram emphasising the need for broadening the grain legume base in *rabi*. Eventhough the new farming techniques developed at the centre and elsewhere in the region offer good prospect of improving and stabilising crop yields in the region, they will hardly have any production impact unless they are economically viable and feasible to be adopted.

Economics of improved farming practices on rainfed black soils

Profitability and viability of any improved technology in drought prone areas should be determined on the basis of its performance over a cycle of seasons rather than on isolated experiences from extremely good or bad seasons. Judged against this criterion, adoption of improved techniques (Table 3) that have been tested on farmers' fields in the areas adjoining the research farm as well as in the Integrated Dryland Agricultural Development Project, Hagaribommanahalli over years, turned out to be distinctly viable over the prevailing traditional systems (Tables 4 and 5). Since, fertilisers alone account for 56 to 85% of the additional working costs, its use involves risks in drought years. Hence, emphasis should be more and more on recycling scientifically prepared organic manure for meeting atleast a part of the nutrient requirement of crops in these areas.

Table 2 : Relative economics of safflower *vs* dryland cotton on farmers' fields

Place	Mean yields (kg ha)		Net profits (Rs/ha)	
	Seed cotton	Safflower	Seed cotton	Safflower
Bellary	124	474	80.00	532.60
Chitradurga	266	784	435.00	1154.60
Average	197	634	268.23	853.63

Low monetary inputs in the improved farming practices

Simple cultural practices, such as use of proper variety, timely seeding, recommended seedrate and spacing, timely weeding and intercultivation that involve little or no additional expenditure over what the farmer incurs under his conventional system helped farmers reap addi-

Table 3 : Recommended new farming practices

Practice	Crop		
	Jowar	Safflower	*Gram*
Preparatory tillage	2–3 harrowing with blade harrow during monsoon. Deep ploughing once in 3 years when the field is infested with pernicious weeds		
Seeding time	Within 3–4 days after the receipt of 1st soaking rains in September	1st fortnight of October	1st fortnight of October
Variety	M 35–1 and SPV 86	A 1 and S 144	A 1
Seedrate and population	M 35–1 : 5 kg; 1,00,000/ha SPV 86 : 6 kg; 1,30,000/ha	3.5–4 kg/ha: 50,000/ha	50 kg/ha: 2,50,000/ha
Fertiliser use	30 kg N & 30 kg P_2O_5/ha	20 kg N & 20 kg P_2O_5/ha	15 kg N & 30 kg P_2O_5/ha
Row spacing	60–75 cm	60–90 cm	45 cm
Thinning	Thin excess plants	Thin excess plants	Thin excess plants
Weeding and interculture	2–3	2–3	2–3
Mid seasonal correction in plant population in sub-normal years	Thin every 2nd or 3rd row within 30 days depending on severity of stress in case of *jowar*		
Pest and di ease	Shootfly, caterpillars and earhead pests	Aphids and caterpillars	Pod borers

Table 4 : Economic analysis of improved *vs* traditional farming practices under dryland conditions

Particulars	Crop					
	Jowar		Safflower		Gram	
	Improved	Traditional	Improved	Traditional	Improved	Traditional
Average cost of cultivation (Rs/ha)	626.75	378	570	302.80	761.69	305.51
Average grain yield (kg/ha)	952	275	472	175	464	189
Average straw yield (kg ha)	1769	777	—	—	—	—
Average gross return (Rs/ha)	1407.75	447	1321.60	490	1299.20	529.20
Average net return (Rs/ha)	781	69	751.60	187.20	537.51	223.69
Average total human labour required (man days/ha)	61.9	50.7	48.9	36 3	51.7	38.4
Average total bullock labour required (pair days/ha)	13.7	13.1	10.3	10.0	11 5	10.8

tional harvests and net returns. For instance, in case of *rabi jowar*, low monetary inputs, when tested as a single package registered 608 kg more grain yields and Rs. 741/- more net returns per ha than the prevailing local practices (Table 6). Use of optimum seedrates, which are devised for normal and near normal seasons, very often leads to higher plant population than otherwise required under sub-normal seasonal conditions, in case of sensitive crops like *jowar* and consequently exposes it to moisture stress at critical stages of growth. Simple practice of thinning plant population to around 2/3 or 1/2 of the initial stands at around 30 to 40 days after planting, proved to be a very effective life saving device, whenever October rains fail and / or soil moisture is inadequate for crop growth. Even on large scale plots, removal of alternate rows in a below normal season led to significant improvement in both grain yield and net returns of *jowar* over that of unthinned plots. Interestingly, the beneficial effects of thinning were observed to be more marked at low level of inputs than at higher levels (Table 7). Available research data clearly show that low cost practices are very critical for realising the full benefits from costly inputs like fertilisers (Table 8). Hence, farmers should be educated on the importance of these low monetary inputs to achieve efficient use of fertilisers and moisture.

Constraints in the adoption of improved technology

Although, the benefits of improved technology have been demonstrated on farmers' fields over a number of years, the spread of improved dryland technology is, in general, low for *jowar* and negligible in case of safflower and *gram*. Results of opinion surveys carried out among the farmers exposed to improved farming practices, on various constraints leading to either partial or non-adoption of improved practices, advocated by the research centres in the region, revealed no insurmountable barriers. In fact, most of the apprehensions expressed are based on traditional beliefs than actual experiences. The only major constraint appears to be socio-economic. What is, therefore, needed to remedy the situation and attain the potential crop yields from these chronically drought prone areas is an intensive extension drive backed up by timely input supply, creation of adequate marketing facilities and crop insurance coverage and seed banks to shield farmers against total crop failures as it happens in years of extreme drought.

Table 5 : Benefit cost ratios for improved farming practices

Crop	Additional benefits over control (Rs/ha)	Additional costs over control (Rs/ha)	B/C ratio
Jowar	960.75	248.75	3.86
Safflower	831.60	267.20	3.11
Gram	770.00	456.18	1.69

Table 6 : Economics of various low monetary practices tested as a package on farmers' fields

Particulars	*Jowar*	
	Traditional	Low monetary inputs*
Average cost of cultivation (Rs/ha)	378.00	456 22
Average grain yield (kg/ha)	275.00	883.00
Average straw yield (kg/ha)	777.00	1380.00
Average net returns (Rs/ha)	69.00	810.38
Average total human labour utilisation (man days/ha)	50.70	58 80
Average total bullock labour utilisation (pair days/ha)	13.1	13.7

*Low monetary inputs include ; early seeding, use of improved variety, maintenance of adequate plant stands, timely weeding and intercultural operations

Table 7 : Economics of mid seasonal corrections in plant stands of *jowar*

Particulars	Input levels	
	Low inputs	High inputs
Additional grain yield (kg/ha)	188	106
Additional income (Rs/ha)	188	110
Additional cost (Rs/ha)	18 42	18.42
B/C ratio	10.23	5 97

Table 8 : Fertiliser response as influenced by simple low monetary inputs

Levels of N (kg/ha)	*Jowar* grain yield (kg/ha)	
	Traditional farmer's practice	Low monetary inputs
0	787	1585
25	1011	2016

Economic Analysis of Improved Dryland Practices in Red Soils

B. Gopalakrishna Hebbar

INCREASED attention paid to research on dryland technology has led to the development of new farming techniques in recent years. The economic viability of recommended technology is decided based on its economic performance on farmers' fields. Accordingly, the technology consisting of "bedding system", double cropping with cowpea – *ragi*, improved varieties in different crops, fertiliser application in *ragi* and redgram and others as alternate crops, advocated by Dryland centre at Bangalore have been tested on farmers' fields at Seethakempanahalli, by the Operational Research Project and IDLAD in Doddaballapur taluk, during 1977–79. The results of the above studies are presented below practicewise.

BEDDING SYSTEM

Bedding system in dryland *ragi* cultivation involving opening furrows at every two seed drill widths (3 m) at the time of sowing and subsequently deepening twice, has resulted in 88.4% increase in net returns with recommended fertiliser level and 23.8% increase in net returns with farmer's level of fertiliser application over the control plot, involving no bedding and farmer's practice (Table 1). Hence, farmers depending on their resource availability can either invest Rs 20/– per ha for only bedding and reap an additional profit of Rs 138 per ha or adopt bedding alongwith recommended fertiliser level at a cost of Rs 142 per ha to realise additional net benefits worth of Rs 509 per ha.

DOUBLE CROPPING WITH COWPEA-*ragi*

This double cropping system is recommended in place of mono cropping with *ragi*, which is being followed in the region. The cost of cultivation of cowpea–*ragi* system was worked out to Rs 2063 per ha as against Rs 1362 per ha of *ragi* grown under traditional practices. As seen from the results presented in Table 2, this system yielded an additional net return of Rs 1624 per ha for an additional cost of Rs 701 per ha. B/C ratio of 2.18 for cowpea–*ragi* as against 1.57 obtained from monocropping, highlights the potentiality of this double cropping system in replacing the existing monocropping with *ragi*.

IMPROVED VARIETIES IN DIFFERENT CROPS

Ragi

Two recommended varieties namely Indaf 3 and PR 202 were tested against the local variety and the results are presented in Table 3. The improved

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Table 1 : Average costs and returns of *ragi* cultivation under bedding system in demonstration plots during 1978–79.

Particulars	Level of fertiliser application			
	Recommended dose of fertiliser application		Farmer's level of fertiliser application	
	Bedding system	Control (no bedding)	Bedding system	Control (no bedding)
Cost of cultivation (Rs/ha)	1021	1002	899	879
Grain yield (Rs/ha)	993	909	812	756
Gross income (Rs/ha)	2120	1873	1627	1469
Net return (Rs/ha)	1099	871	728	590
Additional net return (Rs/ha)	228	—	138	—
Additional cost (Rs/ha)	19	—	20	—
Output–input ratio	2.08	1.87	1.81	1.67

Table 2 : Average costs and returns of (i) Double cropping with *ragi* and (ii) groundnut under improved *vs* traditional farming Practices – Bangalore.

Particulars	Double cropping		Groundnut	
	Double cropping (Cowpea–*ragi*)	*Ragi* alone (Control)	Improved	Control (Local Varieties)
Cost of cultivation (Rs/ha)	2063	1362	2329	1977
Grain yield (Kg/ha)	416 2363	1400	1150	679
Gross income (Rs/ha)	4487	2162	2413	1680
Net return (Rs/ha)	2424	800	84	–297
Additional cost (Rs/ha)	701	—	352	—
Additional net return (Rs/ha)	1624	—	381	—
Output-input ratio	2.18	1.57	1.04	Negative

Table 3 : Average cost and returns from (i) *Ragi* and Redgram – Bangalore

Particulars	*Ragi*		Fertiliser application to *Ragi*		Redgram *Vs Ragi*	
	Improved variety	Local variety	Recommended dose	Farmer's level	Redgram (Improved)	*Ragi* (Improved)
Cost of cultivation (Rs/ha)	1500	1152	1573	1569	1818	1500
Grain yield (Kg/ha)	1804	1013	1879	1428	1730	1804
Gross income (Rs/ha)	2195	1341	2835	2207	4757	2442
Net return (Rs/ha)	695	189	1262	638	2939	942
Additional cost (Rs/ha)	348	—	4	—	318	—
Additional net return (Rs/ha)	506	—	624	—	1997	—
Output–input ratio	1.46	1.16	1.80	1.41	2.62	1.63

varieties with all the recommended practices recorded an additional net returns of Rs 506 per ha when compared to local variety grown under traditional practice. Switching over to these cultivars increased the cost of cultivation by Rs 347 per ha over control. The labour utilisation has gone up by 11.25 in improved varieties over that of local variety. B/C ratio of 1.46 with this practice suggests it to be economically viable as the B/C for traditional practice was found to be only 1.16.

Fertiliser use in *ragi*

Farmers in the region are applying adequate N but less of P_2O_5 for *ragi* crop, while the recommendation is for application of equal doses of N & P_2O_5. When the improved variety Indaf 3, was tested under both the fertiliser levels, an additional profit of Rs 624 per ha was obtained from improved practice as compared to farmer's practice, while the difference in cultivation cost was negligible(vide Table 3). This indicates the economic soundness of recommended fertiliser use alongwith other associated practices in the cultivation of *ragi* in this region.

Groundnut

Two improved varieties namely BH 8–18 and DH 3–30 were demonstrated by adopting all improved practices (Table 2). Average cost of cultivation for improved varieties worked out to be Rs 2329/ha which was 17.8% higher than that of local variety grown under farmers' practice. There was no much variation in the inputs between demonstration and control plots excepting that the seedrate is almost doubled (100 kg/ha) in demonstrations when compared to control plots (54 kg/ha). In case of returns, the local variety incurred a net loss of Rs 297 per ha while improved varieties gave a marginal net returns of Rs 84 per ha.

Alternate crops

Redgram (HY 3) is being introduced in this region as a cash crop in place of *ragi*. When both the crops were tested for their comparative economic performance by following all recommended practices, the cultivation cost worked out to Rs 1818 per ha for redgram while that of *ragi* was Rs 1500 per ha (vide Table 3). However, redgram gave the highest net returns of Rs 2939 per ha as against Rs 942 from *ragi*. B/C ratio was 2.62 in case of redgram as against 1.68 of *ragi*, thus indicating the high potentiality of redgram to replace *ragi* in this region.

Economic Analysis of Improved Dryland Practices in Red Soils

K. R. Chowdry

THE improved dryland practices must be economically viable on farmers' fields under their own resource levels for acceptability. The technology demonstrated for different crops on farmers' fields in Anantapur and Hyderabad regions consisted of improved practices such as, high yielding varieties, fertiliser use and plant protection measures, as a package. Intercropping system was another important component of technology recommended for minimizing risk and thereby stabilising productivity.

The economic viability of the recommended practices for different crops (Table 1) was measured in relation to traditional practice on the basis of cost structure, gross returns, net returns and B/C ratio. The major items of expenditure under improved dryland practices were seeds, fertilisers and plant protection chemicals (Table 2). Cost of seed almost remained same in case of groundnut both under improved and traditional practices, but not so in case of cereals, pulses and castor. The results of these studies are discussed below.

INTERCROPPING SYSTEM

Groundnut + Castor

Intercropping system with groundnut as the base crop and castor as an intercrop in 5 or 7 : 1 row proportion, when adopted with all recommended practices as listed in Table 1 resulted in additional net returns of Rs 339.01 per ha as compared to control namely conventional farming practice. High intensity of input use in the recommended technology boosted the cultivation expenses by Rs 116.37 per ha over traditional technology. B/C ratio of this intercropping system under improved practices was 2.12 which is 9.8% higher than that of farmer's practice.

Groundnut + Redgram

When redgram was grown as intercrop with groundnut in 1 : 5 or 1 : 7 proportion, cultivation cost differed marginally (Rs 41 per ha) between improved and traditional practices. However, increase in net returns was substantial to an extent of Rs 424.01 per ha under improved farming practices which is 52.2% higher than what is realised under farmer's practice. B/C ratio was

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Table 1 : Salient recommended new farming practices

Crops	Varieties	Fertilizer dose (kg/ha)	Important pests and diseases	Remarks
INTER CROPPING SYSTEM				
Groundnut + Castor	Ground nut : TMV 2, TMV 3 & K 1 Castor : Aruna	20 N, 30 P_2O_5 & 30 K_2O	Groundnut : Leaf minor, red hairy caterpillar, tikka leaf spot Castor : Semilooper	In 5 : 1 or 7 : 1 Proportion
Groundnut + Redgram	Ground nut : TMV 2 & TMV 3 Redgram : PDM 1	20 N 30 P_2O_5 & 30 K_2O	Redgram : Pod borer	In 5 : 1 or 7 : 1 Proportion
Setaria + Redgram	*Setaria* : ISC 377 Redgram : PDM 1	40 N & 40 P_2O_5		In 5 : 1 Proportion
Jowar + Redgram	*Jowar* : CSH 5 Redgram : PDM 1	40 N & 40 P_2O_5	*Jowar* : Shoot fly, caterpillarh, ear head bug	In 2 : 1 Proportion
SOLE CROPS				
Groundnut	TMV 3 & Kadiri 1	20 N, 30 P_2O_5 & 30 K_2O	—	—
Setaria	ISc 377	40 N & 40 P_2O_5	—	—
Bajra	BJ 104	40 N & 40 P_2O_5	—	—
SOIL AND MOISTURE CONSERVATION PRACTICES				

Opening up a furrow in the cropped field at an interval of 2 m with country wooden plough, on receipt of rains preferably within a fortnight after germination.

Table 2 : Average cost and returns for important crops in Anantapur region (1977–78)

	Groundnut + castor		Groundnut+redgram		*Setaria* + redgram	
	I.D.P.	T.P.	I.D.P.	T.P.	I.D.P.	T.P.
COSTS (Rs/ha)						
Seed	347.53	326.63	330.61	319.78	20.75	20.50
Fertilizer	314.75	76.63	302.73	97.78	209.65	—
Pesticide	39.38	17.63	55.31	27.44	12.50	—
Farm yard manure	Nil	230.00	Nil	236.00	74.70	150.00
Labour cost	372.73	328.20	389.30	346.21	278.75	273·00
Other costs	102.81	81.74	106.22	115.70	80.51	96.40
Total cost of cultivation	1177.20	1060.83	1184.17	1142.91	676.86	539.90
RETURNS						
Physical return (kg/ha)	787.62	648.13	755.86	582.54	780.00	254.00
Gross return (Rs/ha)	2497.98	2042.60	2377.17	1911.90	1232.00	546.04
Net return (Rs/ha)	1320.78	981.77	1193.00	768.99	555.14	6.14
B/C RATIO	2.12	1.93	2.01	1.67	1.89	0.97

Table 2 : (Contd.)

	Jowar+redgram		Groundnut		*Bajra*		*Setaria*	
	I.D.P.	T.P.	I.D.P.	T.P.	I.D.P.	T.P.	I.D.P.	T.P.
COSTS (Rs/ha)								
Seed	39.24	31.27	320.00	311.67	16.44	12.25	22.50	13.33
Fertiliser	235.20	9.70	318.02	85.00	161.25	—	170.67	—
Pesticides	30.83	1.15	35.48	11.33	11.00	—	53.50	—
Farm yard manure	50.00	160.00	108.33	275.60	Nil	135.66	42.54	233.20
Labour cost	196.00	165.00	321.67	308.43	124.00	98.57	67.76	61.82
Other costs	80.76	89.70	115.77	111.85	77.14	60.72	71.12	78.39
Total cost of cultivation	632.03	456.82	1219.27	1103.88	389.83	307.20	428 09	386.74
RETURNS								
Physical return (kg/ha)	380.85	259.62	849.50	624.60	1244.00	663.20	520.00	410.00
Gross return (Rs/ha)	1008-03	652.17	2273.75	1733.16	1288.00	703.20	630.00	540.60
Net return (Rs/ha)	376.00	195.35	1054.48	629.28	898.17	396.00	201.91	153.86
B/C RATIO	1.59	1.43	1.86	1.57	3.30	2.29	1.47	1.39

Note : 'Other costs' include land rent, miscellaneous costs and interest on working capital
'Labour cost' includes both hired and family, human and bullock labour.

I.D.P = Improved dryland Practice
T.P. = Traditional Practice

also higher in improved (2.01) than in traditional (1.67) farming practice which confirms the economic viability of recommended package of practices in intercropping redgram with groundnut either in 1 : 5 or 1 : 7 ratio.

Setaria + Redgram

When *setaria* and redgram were grown in 5 : 1 proportion and tested under both recommended and traditional farming practices, the former gave a net return of Rs 555 per ha while the latter gave a marginal amount of Rs 6.14 per ha. Additional investment under improved practices amounted to Rs 136.96 per ha over traditional system. B / C ratio for this intercropping system was 1.89 when recommended package of practices as given in Table 1 were adopted, while it was less than unity under farmer's practice.

Jowar + Redgram

When redgram was intercropped with *jowar* in 1 : 2 proportion and demonstrated on farmers' fields, the net returns realised were Rs 376 per ha under recommended practices and Rs 195 per ha under farmer's method of cultivation as against an increase of Rs 175 per ha in cultivation cost with the adoption of all recommended package of practices. B / C ratio for improved practices was 11.2% higher than that of farmer's traditional practice.

SOLE CROPS

Groundnut

Improved varieties of groundnut (TMV 3 and Kadiri 1) when cultivated with all other recommended practices as given in Table 1 gave higher net profit of Rs 425.20 per ha at an additional cultivation expenses of Rs 115.39 per ha as compared to local variety grown under farmers' traditional system. B/C ratio for improved practices was worked out to be 1.86 which is 18.5% higher than that of farmers' practice. Thus, the results show that by switching over to improved varieties and recommended practices in the cultivation of groundnut, the profit could be increased by 66% over what the farmers are presently realising.

Setaria

An improved variety I Se 377 grown under improved farming practices incurred a cultivation cost of Rs 428 per ha which is 10.7% higher than that of local variety and farmers' method of cultivation. The net returns and B/C ratio obtained were Rs 202 per ha and 1.47 respectively under improved farming practices as against that of Rs 154 per ha and 1.39 realised under traditional method of cultivation.

Bajra

Adoption of all recommended practices with BJ 104 trebled the net returns obtained from local variety grown under traditional practice. Cost of cultivation with improved practices has gone up by 26.9% over that of farmers' practices mainly due to fertilizer use. The net returns realised from improved variety are Rs 898.17 per ha as against Rs 396.00 per ha recorded in the local plots. Accordingly, the recommended technology gave a B/C ratio of 3.30 as against 2.29 observed under farmer's traditional method of cultivation.

SOIL AND MOISTURE CONSERVATION PRACTICES

Dead furrow

The cost of opening up a furrow in the cropped area was worked out to be only Rs 10 per ha while all other items of expenditure for *bajra* (BJ 104) remained the same under both improved and control plots. But the increase in yield due to dead furrow was substantial to the extent of 205 kg per ha over control. Thus an additional income of Rs 205 per ha was realised by investing Rs 10 per ha on dead furrow, which indicates the economic soundness of this practice.

The important crops for Hyderabad region were *jowar* and castor. The efficiency of varieties and fertilisers was demonstrated. The economic advantage of square planting over normal planting (rectangular) in castor and narrow row over wide row planting in *jowar* were also demonstrated. Intercropping system with *jowar* and redgram in 2:1 ratio was tried. The particulars of cost structure, gross and net returns and B/C ratio are given in Table 3. The results are discussed below practicewise.

INTERCROPPING SYSTEM

Bajra + Redgram

The *bajra* + redgram intercropping system in 2:1 ratio was demonstrated by adopting all other recommended practices for both the crops. The total cost of cultivation of this system was worked out to be Rs 838 per ha while the net returns were Rs 1239 per ha with B/C ratio of 2.48 and thus indicating its economic viability in this region.

Jowar + Redgram

Redgram was intercropped with *jowar* in 1:2 ratio and tested against control where *jowar* was grown under farmer's practice. Cost of cultivation was 7.7% higher in demonstration plots. The net returns from this intercropping system was worked out to be Rs 248 under improved practices while growing of *jowar* alone under traditional practice gave net returns of Rs 114 per ha. B/C ratio for improved technology is 1.52 as against 1.26 under traditional farming system.

NARROW ROW SPACING IN *Jowar* WITH FERTILISER

Adoption of narrow row spacing in *jowar* (CSH 6) cultivation alongwith fertiliser application and other associated inputs increased the net returns from Rs 81 to 1188 per ha with B/C ratio being 2.44. Cultivation expenditure was more under improved technology by 20% over that of traditional practice.

SQUARE PLANTING *vs* RECTANGULAR PLANTING OF CASTOR

When the improved practice of square planting and other recommended farming practices were adopted castor yielded an

Table 3: Average cost and returns from improved farming practices in Hyderabad region.

Crops/Practices	Cost of cultivation (Rs/ha)		Grain yield (kg/ha)		Gross income (Rs/ha)		Net income (Rs/ha)		B/C ratio	
	Demonstration	Control	Demonstration	Control	Demonstration	Control	Demonstration	Control	Demonstration	Control
JOWAR										
Jowar + Redgram *vs jowar*	474.49	440.55	296 + 106	403	722.96	554.39	248.47	113.84	1.52	1.26
CSH 6 *vs* local *jowar*	844.81	624.20	924	235	985.28	336.98	140.47	—287.22	1.17	Negative
Narrow row (with fertiliser) *vs* wide row	822.76	685.87	2050	751	2010.98	766.39	1188.22	80.52	2.44	1.12
CASTOR										
Square planting *vs* rectangular planting	960.43	922.25	904	713	2169.18	1710.30	1208.75	788.05	2.26	1.85
BAJRA										
Bajra + Redgram	838.44	—	1386 + 232	—	2077	—	1238.56	—	2.48	—

additional net returns of Rs 420.70 per ha at an additional cultivation cost of Rs 38.18 per ha over that of rectangular planting. B/C ratio was 2.26 for the improved technology and 1.85 for the farmer's method of planting.

HYBRID *Jowar*

Recommended hybrid variety CSH 6 was tested against the local variety. The major items of expenditure under improved practices were observed to be seeds and fertilisers. Investment on pesticides remained same under both the practices. Under improved technology, the cultivation expenditure increased by Rs 220.61 per ha over that of traditional practice. Cultivation of CSH 6 with all improved practices resulted in net returns of Rs 140 per ha with B/C ratio of 1.17 as against a net loss of Rs 287 per ha incurred in the control plots with local variety.

Appendix I

Package of Practices for Soil and Water Conservation and Crop Management

Package of Practices for Red Soils

Chairman : G. V. Havanagi

Members : K. Vijayalakshmi

T. C. Channappa

S. Chittaranjan

M. S. Rama Mohan Rao

Name of practice	:	CONTOUR *BUNDS* WITH OPEN ENDS
Description	:	Trapezoidal *bunds* constructed on contour with permissible deviations, with open ends connected to waterways.
Area of applicability and scope	:	Both in shallow and deep soils receiving annual rainfall of 600 mm or below.
Specifications	:	

Land slope (%)	Cross section (Sq m)	Vertical interval (m)
Upto 3	0.54	1.00
3 to 4	0.65	1.25
4 to 5	0.81	1.50

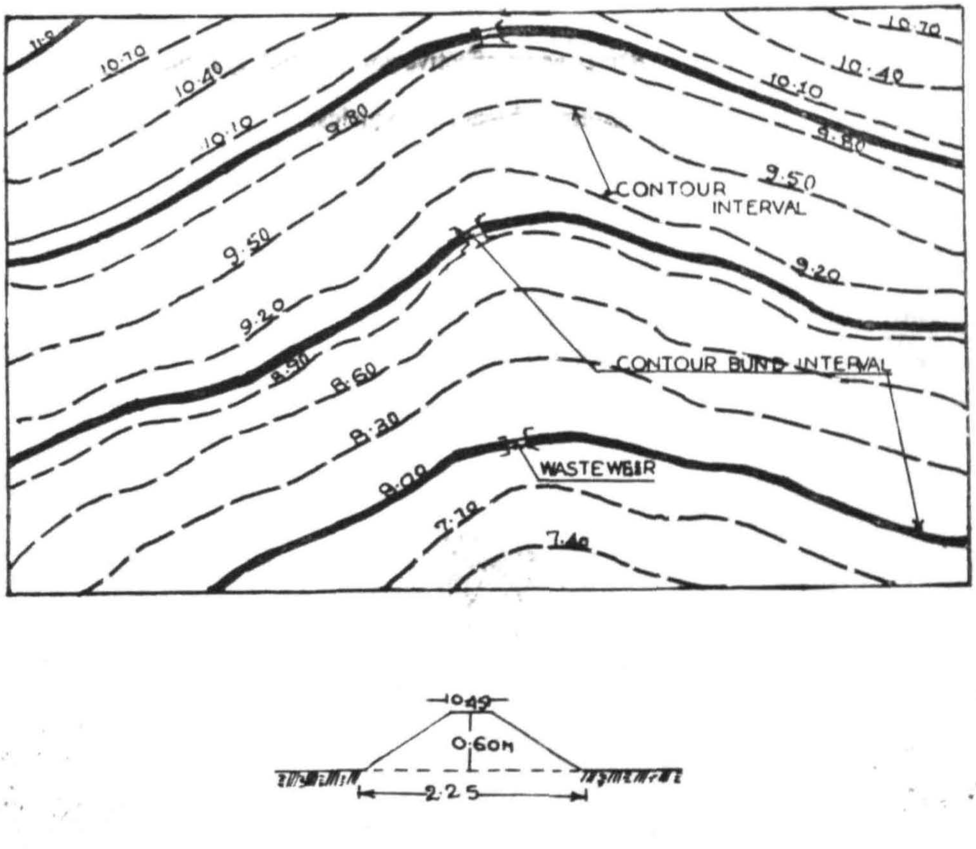

Fig. 1 Contour *bunds* with waste weirs

Field procedure, method of implementation and maintenance	:	*Bunds* to be constructed strictly on contour with permissible deviations (not exceeding 15 cm while crossing a ridge and 30 cm while crossing a depression, keeping the top of *bund* at the same level). Open ends should lead to grassed/protected waterways. Smoothening to be done in the inter *bunded* area.
Cost	:	Average cost works out to Rs 200–250 per ha.
Benefits	:	No problem of concentrated flow through the waste weirs. Over flowing and breaching are avoided even with high intensity rains. Serves as an effective conservation system. Results in higher crop yields.

Name of practice : GRADED *BUNDS*

Description : Graded *bunds* are those constructed with a slight gradient to the channel for leading the excess water at non-erosive velocity.

Area of applicability and scope : In areas of annual rainfall more than 600 mm, in regions where runoff is high and *insitu* moisture conservation does not alone help to improve production because of profile limitations and in locations where surplussing of excess runoff is essential.

Specifications :

Land slope (%)	Cross section (Sq m)	Vertical interval (m)
1 to 3	0.40	1.0
3 to 5	0.54	1.5

(Grade : 0.2 to 0.4%)

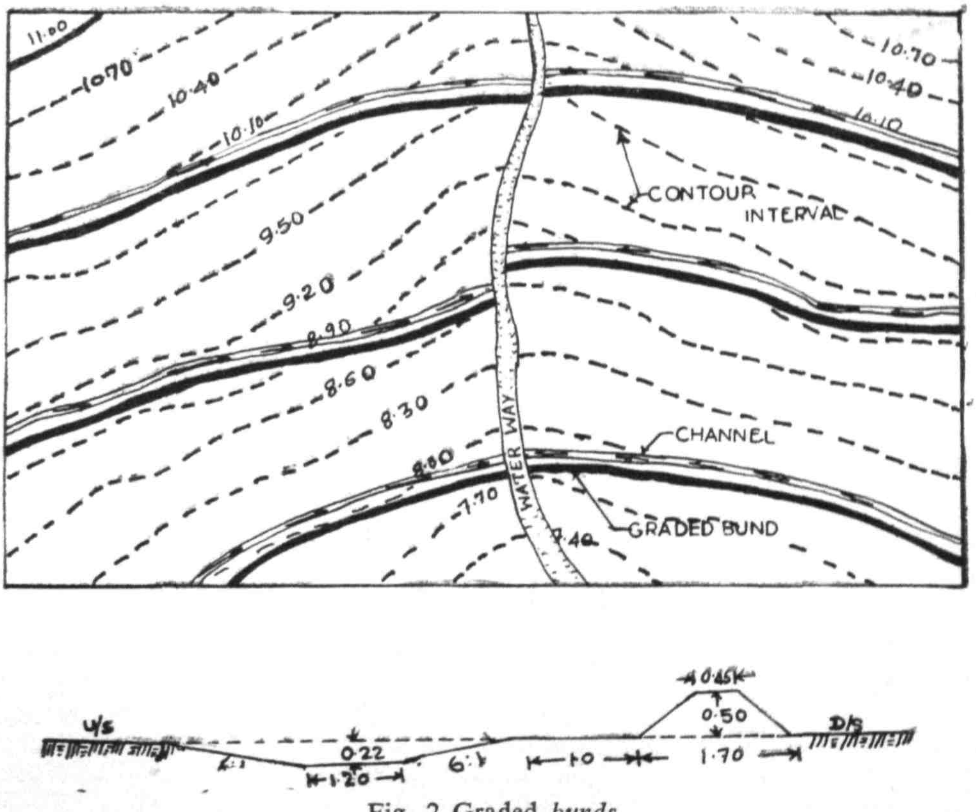

Fig. 2 Graded *bunds*

Field procedure, method of implementation and *maintenance*	:	*Bunds* to be constructed on graded contour. **Graded** channels to lead into grassed / protected **waterways.** Smoothening of inter *bunded* area.
Cost	:	Construction of the *bund* including **smoothening of the** (**inter terraced** area costs around Rs 200 to **Rs 250/ha.**)
Benefits	:	No gully formation in the inter *bunded* area even with high intensity rains. Serves as an effective disposal system and offers **advantage** for management of inter terraced area for ***insitu*** moisture conservation.

Name of practice : IMPROVING MOISTURE CONSERVATION THROUGH

a) Deep tillage,
b) Shallow tillage, and
c) Application of organic residues.

Description : a) Ploughing and chiselling the soil upto 25 to 30 cm depth.

b) Tilling the soil upto 10 cm depth.

c) Addition and incorporation of any organic residues through shallow tillage.

Area of applicability and scope : a) In soils with underlying hard pans.

b) Shallow tillage for entire red soil region.

c) In areas where crust problems exist.

Specifications & field procedure : a) Ploughing or chiselling upto 25 to 30 cm depth immediately after the harvest of the crop with iron mould board plough.

b) Tilling the soil upto 10 cm depth with either peg tooth cultivator or blade harrow whenever the soil comes to condition after harvest of the crop.

c) Apply crop residues @ 4000 kg/ha and incorporate through shallow tillage continuously for 3 years with first rains in April/May along with 15 kg heptachlor/ha. The material is to be cut into pieces in case of incorporation with bullock drawn implements.

Benefits : a) Better root proliferation.

Increases effective soil depth for crop growth.

Controls perennial weeds.

b) Ensures moisture conservation through higher infiltration and results in low runoff.

c) Improves organic matter.
Retains more water in the surface as well as subsurface.
Avoids crust formation.
Increases crop yields.

Name of practice : INTER TERRACE MANAGEMENT — RIDGE AND FURROW CULTIVATION.

Description : Sowing flat on a gradient (0.2 to 0.4%) and later forming ridges with intercultivation.

Area of applicability and scope : This system is useful for widely spaced crops having a row spacing of 45 cm and above.

Specification : Ridging is to be done 30 days after sowing.

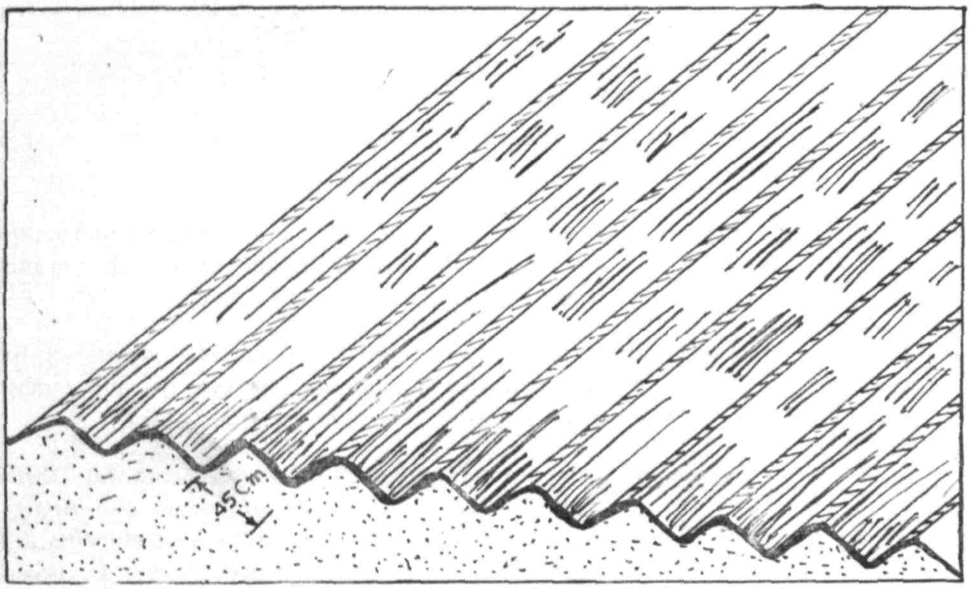

Fig. 3 Inter terrace management with (a) Ridges and furrows.

Field procedure, method of implementation and maintenance : Sow parallel to the graded *bund* starting from top.

In case of un*bunded* areas, establish key line on a grade and sow parallel to it.

Ensure that the point rows lead to the *bund* or waterway.

Repeat furrowing with each intercultivation.

Benefits : Helps in reducing runoff, thereby making available more moisture for crop growth uniformly in the inter terraced area.

Retention of this system helps to conserve moisture during the post harvest period.

Name of practice	:	INTER TERRACE MANAGEMENT—GRADED FURROWS
Description	:	Bedding system or opening furrows on a gradient at suitable intervals.
Area of applicability and scope	:	In medium to deep soils having annual rainfall more than 600 mm.
Specifications	:	Opening furrows 3 m apart with a grade of 0.2 to 0.4%.

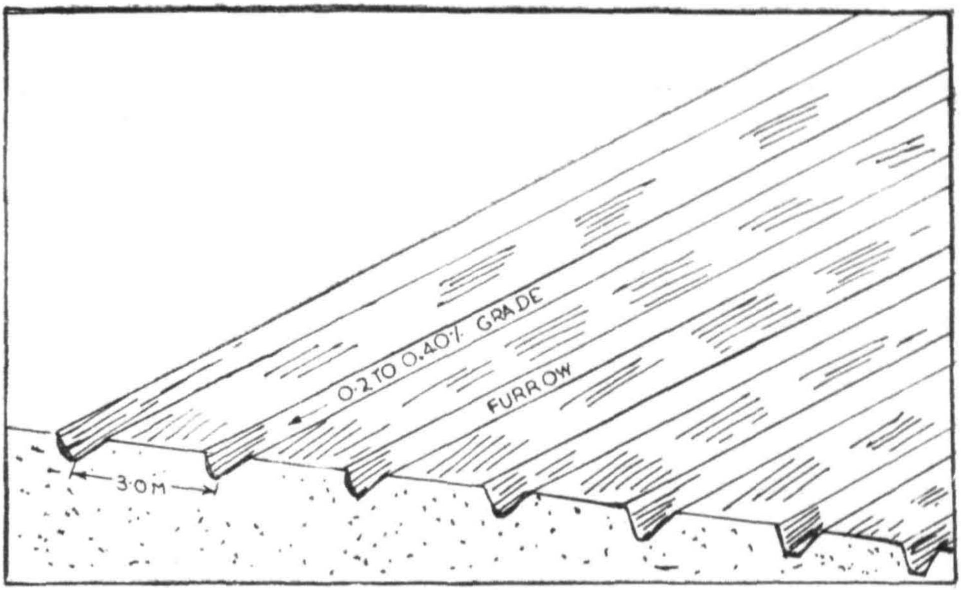

Fig. 4 Inter terrace management with (b) bedding system with graded furrows.

Field procedure, method of implementation and maintenance	:	Sow flat on a grade. The furrows are to be opened up at sowing, with a ridger attached to the seed drill at one end or by using a plough/ridger. Maintain the furrows by deepening once or twice
Benefits	:	Ensures moisture conservation as well as disposal of excess water during high intensity storms.

Name of practice	:	**INTER TERRACE MANAGEMENT** **GRADED BORDER STRIPS**
Description	:	Developing series of graded border strips across the slope.
Area of applicability & scope	:	Suitable to areas of high as well as low rainfall.
Specifications	:	Border strips of 100 to 200 m length and 10 to 15 m width with 0.2 to 0.3% gradient longitudinally and with no cross slope.

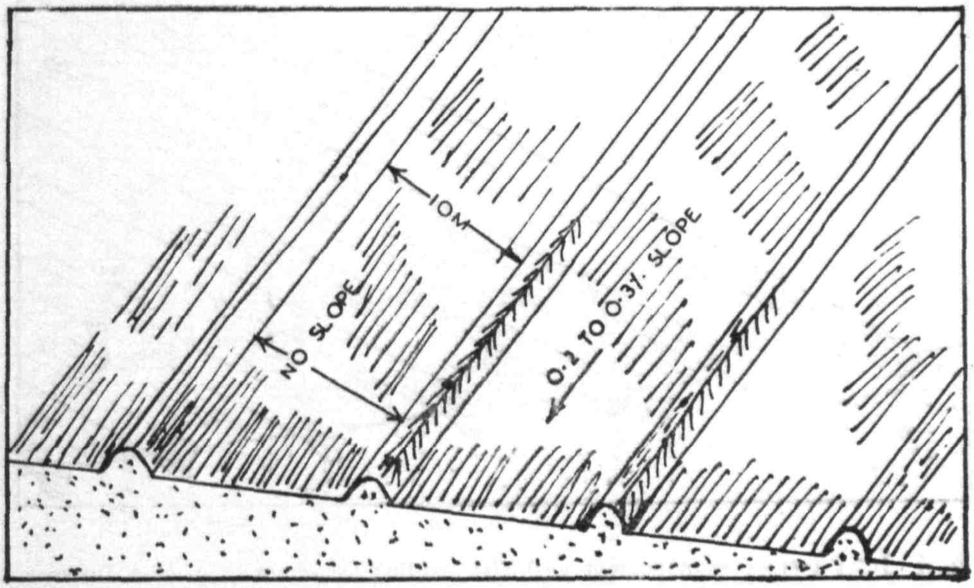

Fig. 5 Inter terrace management with (c) graded border strips

Field procedure, method of implementation and maintenance	:	Graded border strips are formed by using both tractor and bullock drawn levellers. Not more than 15 cm cutting and filling. Give gradient to the length. Maintain zero level along the width.

Cost : Cost of developing strips is about Rs 1000/ha.

Benefits : Runoff on developed strips was 18–20% as against 24-36% on undeveloped area with 2.5% slope.

Due to increased opportunity time available for rain water to soak into the soil, conditions for sowing remained favourable for 2–3 days more than on slopy lands.

Increased crop yields.

Name of practice	:	**FARM PONDS FOR RUNOFF HARVESTING AND RECYCLING.**
Description	:	Storing excess runoff in dug out ponds and re-using the same for irrigation of rainfed crops.
Area of applicability and scope	:	This practice can be advantageously adopted in areas where the rainfall pattern is such that most of the rainfall is received in short durations and with intensities.
Specifications	:	Location : Natural depressions should be made use of. The ponds may be located in the lower elements of topography where seepage losses are low or else lining of ponds with soil and cement in 8 : 1 proportion or asphalt or sodic soil is required. Catchment area (ha) : 6 to 8 Depth (m) : 3 to 5 Side slope : 1.5 : 1 Capacity (cum) : Upto 2000 Silt trap (pit of suitable size) is recommended on the upstream side to reduce silting. Minimum capacity could be 100 cum for a catchment of 0.6 ha.
Field procedure, method of implementation and maintenance	:	Lifting of water by oil engine or indigenous method. Irrigation during drought spell for dryland crops. It is preferable to grow cash crops or vegetables to realise maximum benefits. Depth of irrigation may be varied from 2 to 5 cm depending upon the soil type and crop.
Cost	:	Rs 2000/– to Rs 8000/– depending on size.

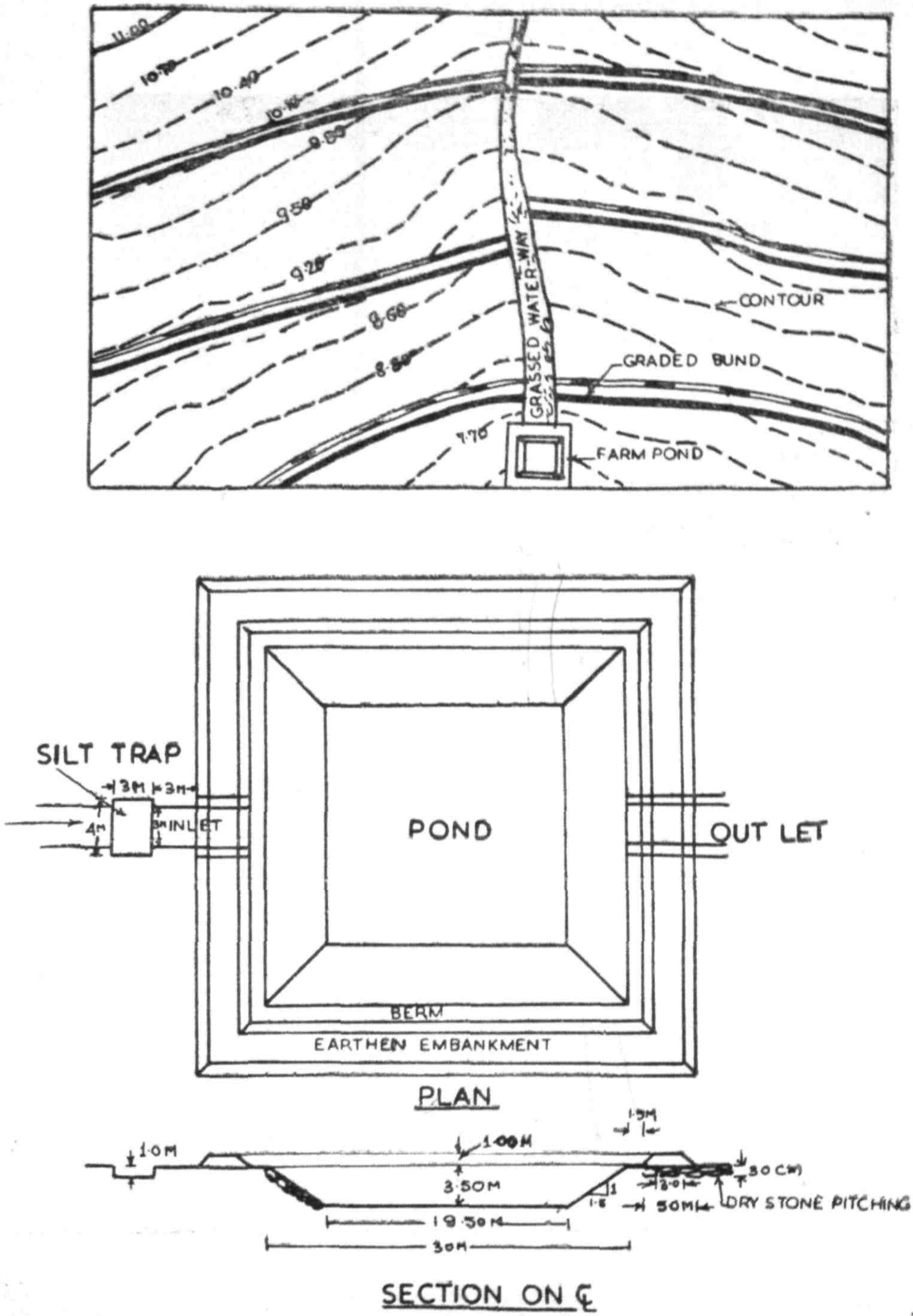

Fig. 6 Farm pond for runoff harvesting and recycling.

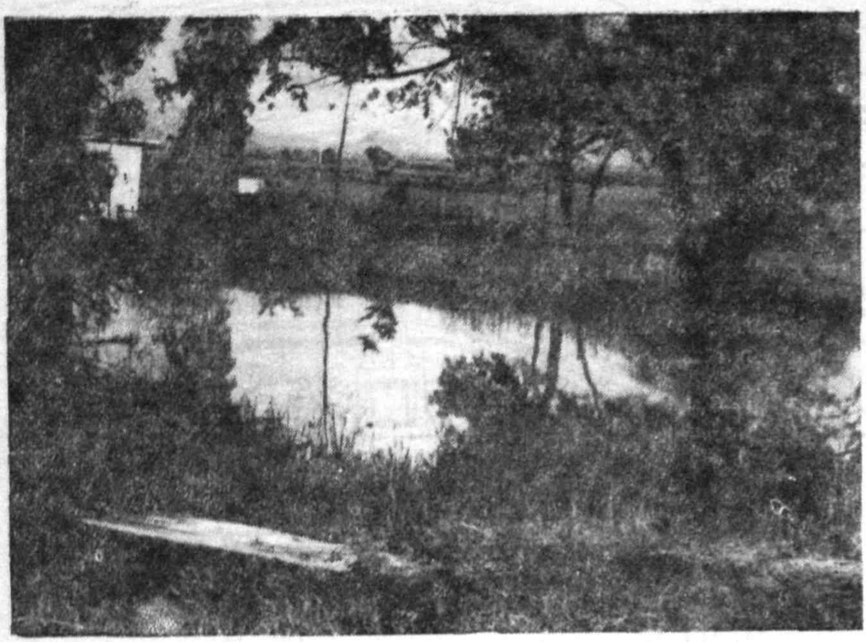

Fig. 7 Farm pond with runoff water

Benefits

Effect of supplemental irrigation on crop yields (kg/ha) in Hyderabad region.

Crops	Control	Irrigated*
Jowar (3 years)	1383	2037
Castor (1977–79)	763	970
Redgram (1980) (Two pickings)	50	250
Beans (1977)	130	1430
Brinjal (1977)	1770	2670
Chillies (1978)	1270	1690

* Depth of irrigation varied from 0.6 to 4 cm.

Name of practice	:	IMPROVED TECHNOLOGY FOR RAINFED CROPS
Description	:	Adopting improved technology in the cultivation of rainfed *jowar*, castor, *bajra*, groundnut, *ragi*, maize and groundnut for higher yields.
Area of applicability	:	Red soils of Anantapur region (*bajra*, groundnut, castor), Bangalore region (*ragi*, groundnut, redgram) and Hyderabad region (*jowar*).
Specification	:	Refer Table 1.
Benefits	:	Cost of cultivation and net returns are given below.

Region	Crop	Technology	Cultivation cost (Rs/ha)	Net returns (Rs/ha)
Anantapur (1977–78)				
	Bajra			
		Improved	706.57	581.43
		Traditional	524.89	178.31
	Groundnut			
		Improved	1229.27	1044.48
		Traditional	1103.88	629.28
	Castor			
		Improved	668.57	220.19
		Traditional	554.21	52.94
Bangalore (1977–78)				
	Ragi			
		Improved	1499.68	695.56
		Traditional	1152.40	188.86
	Groundnut			
		Improved	1536.28	1221.36
		Traditional	1642.07	296.35
	Redgram			
		Improved	1818.14	2938.54
		Traditional	1499.68	942.66
Hyderabad (1977–78)				
	Jowar			
		Improved	844.81	140.47
		Traditional	624.20	-287.22

Table 1 : Improved technology for rainfed crops

Practice	*Jowar*	Castor	*Bajra*
Preparatory tillage	One to two ploughings followed by 2 to 3 harrowings and in case of castor 2 to 3 ploughings		
Seeding time	End June	End July	1st fortnight of July
Fertiliser use (kg/ha)	10 N, 30 P_2O_5 as basal and 30 N as top dressing	10 N, 30 P_2O_5 as basal and 40 N as top dressing	10 N, 30 P_2O_5 as basal and 30 N as top dressing
Variety	CSH 5 & CSH 6	Aruna & Ganch 1	BJ 104 & Vijaya
Row spacing (cm)	45–60	60–90	45
Seedrate (kg/ha)	8 to 10	10 to 12	3
Interculture	2 to 3 hoeings depending upon the season and furrowing after intercultivation		
Important pests	Shoot fly, stem borer & earhead bug	Semilooper	—

Table 1 : (Contd.)

Practice	*Ragi*	Maize	Groundnut
Preparatory tillage	One to two ploughings in May/June followed by 2 to 3 harrowings		
Seeding time	1st fortnight of July for medium duration varieties; 1st fortnight of August for short duration varieties	June/July	June/July
Fertiliser use (kg/ha)	25 N, 37.5 P_2O_5 at sowing and 25 N at 30 days after sowing	37.5 N, 50 P_2O_5 & 25 K_2O as basal & 37.5 N at 30 days after sowing	25 N, 50 P_2O_5 & 25 K_2O as basal dose only
Variety	Medium duration : Indaf 1 and Indaf 3 Short duration : PR 202 and Indaf 5	Deccan and D 101	Spanish imp. TMV 2 DH 3-30
Row spacing (cm)	30	60	30
Seedrate (kg/ha)	10 to 15 (drill sowing)	15	100
Interculture	2 to 3	2 to 3. Earthing up at 30 days after sowing	2 to 3 before 40 days after sowing
Important pests	—	Stem borers Cob worm	Leaf minors pod borer

N.B. In case of *jowar*, if stress at flowering is noticed, ratoon with 20 kg N/ha after receipt of rains. Give protective irrigation at stress during flowering for *jowar* and *bajra*.

Name of practice	:	CROP SUBSTITUTION
Description	:	Replacing traditional crops with more remunerative crops.
Area of applicability and scope	:	Bangalore region : Redgram to replace *ragi*. *Cowpea* to replace horsegram for delayed sowing. Hyderabad region : *Cowpea* to replace horsegram after *bajra* as second crop. *Bajra* to replace *jowar* for delayed sowing.
Field procedure	:	Redgram can replace *ragi* in all seasons. For August/September sowings *cowpea* may be preferred to horsegram. *Bajra* is preferred to *jowar* for sowing in the first fortnight of July. After *bajra*, cowpea should be grown in place of horsegram.
Benefits	:	

Crop	Cultivation cost (Rs/ha)	Net returns (Rs/ha)
Bangalore region (1977-78)		
Redgram	1818.14	2938.54
Ragi	1499.68	695.56

Name of practice : IMPROVED TECHNOLOGY FOR INTERCROPPING SYSTEM

Description : Growing redgram as an intercrop alongwith groundnut/*jowar/setaria/bajra* under improved technology as an insurance against total failure of crops.

Area of applicability and scope : Red soils of Anantapur, Bangalore and Hyderabad regions.

Specifications, method of implementation and field procedure :

Improved technology - Salient practices.

Crops and ratio	Varieties	Fertiliser dose (kg/ha) (N: P O_5 : K_2 O)	Pests and diseases
Groundnut + Redgram (4 : 1 or 6 : 1)	Groundnut : TMV 2 Redgram : PDM 1 for Anantapur, HY 3 for Bangalore.	20 : 30 : 30 for Anantapur region and 25 : 50 : 25 for Bangalore region.	Groundnut : Leaf minor, Tikka leaf spot Redgram : Pod borer
Jowar + Redgram (2 : 1)	*Jowar* : CSH 5/CSH 6 Redgram : PDM 1 for Anantapur & HY 2 for Hyderabad regions.	40 : 30 : 0	*Jowar* : shoot fly, stem borer and earhead bug
Setaria + Red gram (5 : 1)	*Setaria :* ISC 377, Redgram : PDM 1 for Anantapur region.	40 : 40 : 0	

Costs and returns :

Costs and returns from different intercropping systems in Anantapur and Hyderabad regions (1977–78)

Intercropping system	Cultivation cost (Rs/ha)		Net returns (Rs/ha)	
	Improved	Traditional	Improved	Traditional
Anantapur				
Groundnut + redgram	1184.17	1142.91	1170.77	768.99
Jowar + redgram	332.03	456.82	376.22	195.35
Setaria + redgram	676.86	539.90	580.45	-17.55
Hyderabad				
Bajra + redgram	838.44	—	1238.68	—

Name of practice	:	DOUBLE CROPPING WITH COWPEA - *RAGI*
Description	:	Introduction of double cropping system with cowpea followed by *ragi* in place of monocropping with *ragi* which is being followed in Bangalore region.
Area of applicability and scope	:	Red soil areas of Bangalore region with rainfall in May.
Field procedure and method of implementation	:	Sow cowpea with rains in May when 30 cm of soil profile is moist. After the harvest of cowpea in end July or early August, sow *ragi* (transplant *ragi*, if harvest of cowpea is delayed due to intervening droughts). Adopt suitable plant protection measures.
Cost and returns	:	Double cropping system yielded an additional net returns of Rs. 2335/ha for an additional cost of Rs. 701/ha.

Package of Practices for Black Soils

Chairman : B. M. Rampur

Members : V. S. Patil

S. Chittaranjan

C. J. Itnal

M. S. Rama Mohan Rao

Name of practice : CONTOUR CULTIVATION

Description : Conducting all field operations such as ploughing, tilling, seeding, cultivation *etc.*, along the contour.

Area of applicability : All regions where soil and moisture conservation is required. It is necessary that all farming operations are done along contour. The ridges and furrows, formed in the field across the slope, will help in intercepting runoff and thereby facilitate increased infiltration.

Specification : All farming operations must be carried out on contour or across the slope.

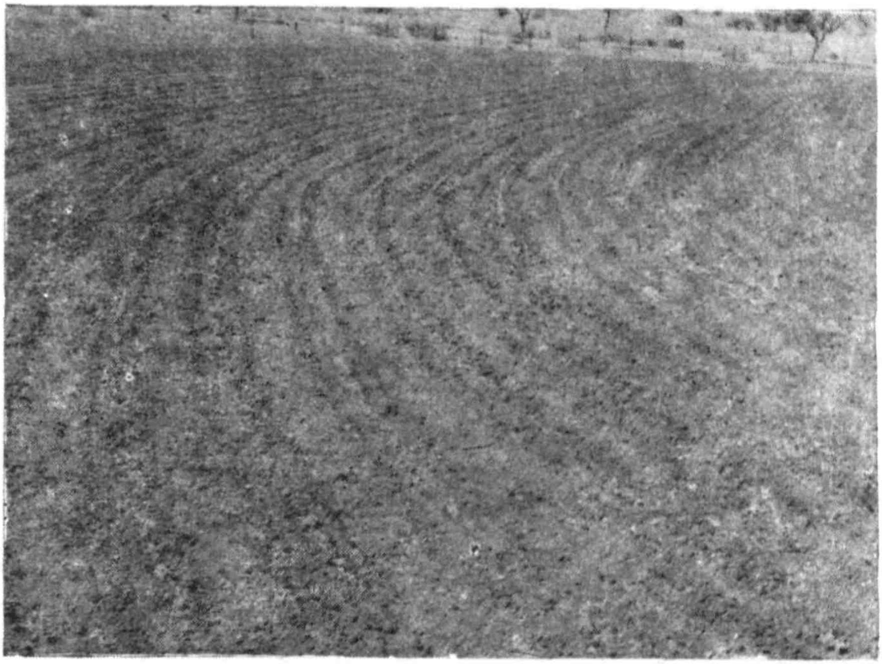

Fig. 1 Contour Cultivation

Field procedure, method of implementation and maintenance : To facilitate contour cultivation, contour guidelines are to be formed with the help of *bund* former in the field at suitable intervals, say 30 m and all operations to be carried out along these contours. In *bunded* area operations are to be carried out parallel to the *bund*.

Benefits : Contour cultivation by itself registered 35 and 22% yield increase in *jowar* and *setaria* compared to up and down cultivation with no additional cost.

Name of practice : CONTOUR *BUNDS*

Description : Traypezoidal *bunds* constructed on contour with premissible deviations and surplussing arrangements for soil and moisture conservation.

Area of applicability and scope : In black soils of less than or equal to 60 cm depth with permeability more than 7 mm/hr in areas of low rainfall.

Specifications : Cross section (Sqm) 1.0 to 1.4 | Vertical interval (m) 0.75 to 1.50 depending on land slope

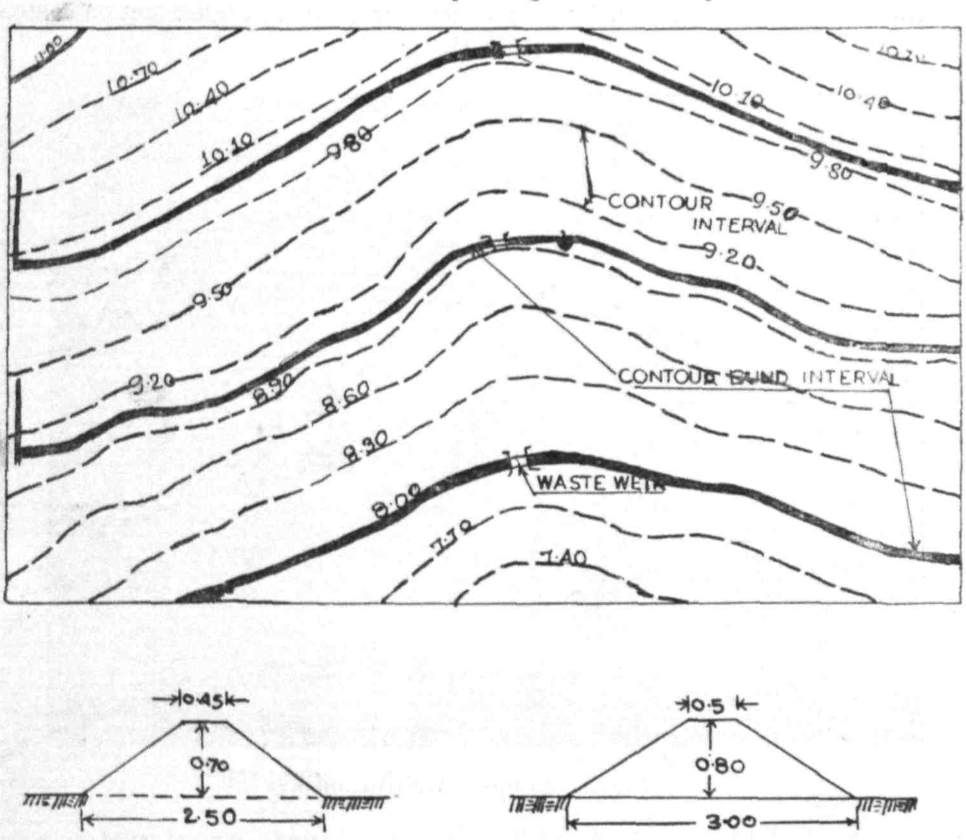

Fig. 2 Contour *bunds* with waste weirs

Field procedure, method of implementation and : *Bunds* to be constructed on contour with permissible deviations *viz.*, 15 cm on the ridge and 30 cm in the valley.

Waste weirs to be located at the lowest point with crest level 15 cm above the contour.

Bunds to be stabilised with vegetation. Land on upstream side of the *bund* to be smoothened.

Name of practice	:	GRADED *BUNDS*
Description	:	Mechanical conservation structures consisting of shallow channel and narrow based trapezoidal *bund* constructed on graded contour at regular vertical intervals for soil and water conservation.
Area of applicability and scope	:	In black soils deeper than 60 cm having moderate to low infiltration rate (less than 7.0 mm/hr).
Specifications	:	Cross section (sqm) : 0.83 Vertical interval (m) : 0.75 to1.0 (depending on land slope) Channel grade (%) : 0.1 to 0.2 Permissible length (m) : 300

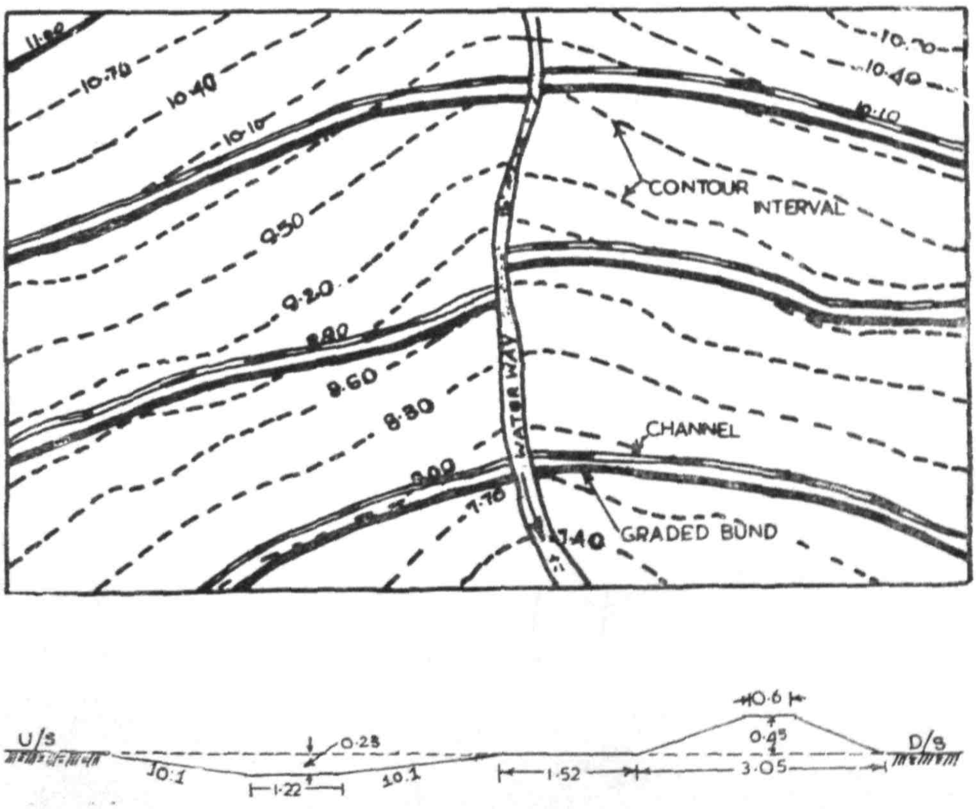

Fig. 3 Graded *bunds*

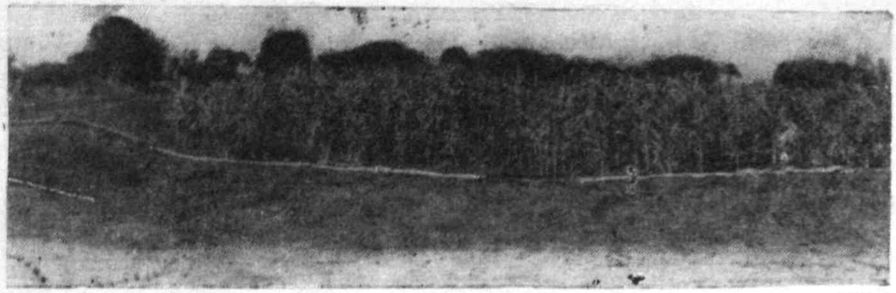

Fig. 4 Graded *bund* in field

Field procedure, method of implementation and maintenance : The entire structure to be aligned on graded contour. Channel to be excavated and excavated earth put in the form of trapezoidal ridge on the down stream side.

Graded *bunds* to empty into grass waterways.

Bunds and waterways to be stabilised by grasses like *Dichanthium annulatum* and *Cenchrus ciliaris*, with drop structures wherever necessary.

Name of practice	:	BROAD BASE TERRACES
Description	:	Mechanical conservation structures consisting of shallow channel and broad based low ridge constructed on graded contour at regular intervals for soil and water conservation.
Area of applicability	:	In black soils having moderate to low infiltration rate (less than 7.0 mm/hr) and depth greater than 60 cm. This practice is only suitable for large holdings.
Specifications	:	Cross section (sqm) : 1.50
		Vertical interval (m) : 0.75 to 1.0 (depending on land slope)
		Channel grade (%) : 0.1 to 0.2
		Permissible length (m) : 300

Fig. 5 Broad base terrace

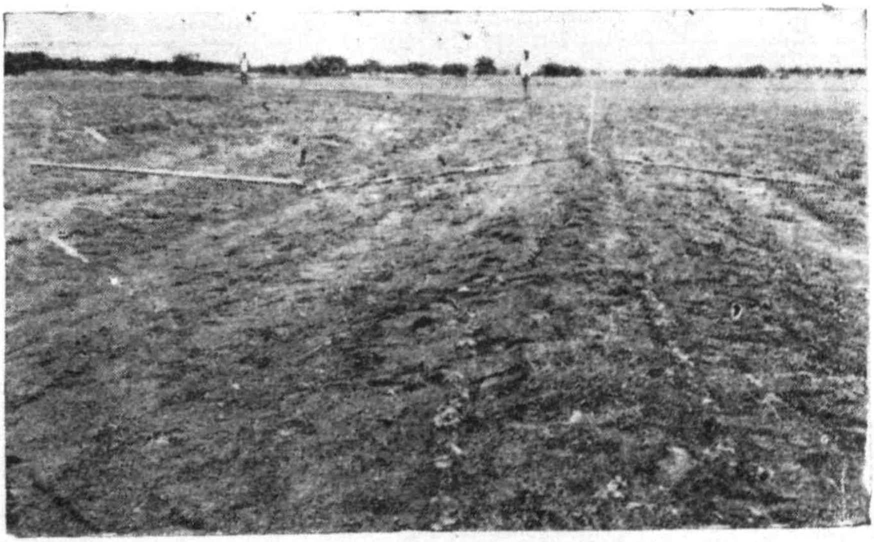

Fig. 6 Broad base terrace in field

Field procedure, method of implementation and maintenance : Entire structure to be aligned on a graded contour, channel to be excavated and the spoil put in the form of a broad based low ridge on the down stream side.

The terraces to empty into grass waterways.

Waterways to be stabilised by grasses like *Dicanthium annulatum* and *Cenchrus ciliaris* with drop structures wherever necessary.

Name of practice	:	VERTICAL MULCHING
Description	:	Keeping *jowar* stubbles vertically in trenches dug across slope.
Area of applicability and scope	:	Medium to deep stiff and clayey soils where intake rate is low.
Specifications	:	*Jowar* stubbles are to be kept in trenches of 30 cm deep, 15 cm wide, in such a way that the stubbles protrude 10 cm above the ground. Trenches to be spaced at 4 to 5 m distance.

Fig. 7 Vertical mulching

Field procedure and method of implementation	:	Trenches are made across the slope either manually or mechanically. *Jowar* stubbles are stuffed vertically in these trenches such that they protrude 10 cm above the ground level.
Benefits	:	Vertical mulches act as intake points and guide the runoff water to subsoil there by resulting in greater conservation of moisture in the soil profile and higher crop yields as shown below.

Influence of vertical mulch * on *jowar* yields (kg/ha)

Treatment	Bellary (1973 – 76)		Sōlapur (1974 – 76)		Bijapur **	
	Grain	Straw	Grain	Straw	Grain	Straw
Control	836	2157	840	4774	1306	N. A.
Vertical mulch at 4 m interval	1281	3037	1266	6445	1649	N. A.

N. A. – Not available

* cost involved is Rs 1650/ha which includes material cost of Rs 1200 and labour charges of Rs 450 per hectare. Material required is 16 tonnes of *jowar* stubbles (lower part).

** Average of three years between 1974 and 1978, at 5 m interval.

Name of practice	:	MULCHING
Description	:	Creation of adequate dust mulch and/or application of crop residues as surface mulch.
Area of applicability and scope	:	Medium to deep black soils.
Specification	:	Crop residues : 5000 kg/ha.
Field procedure and method of implementation	:	Ridges and furrows : Opening ridges and furrows at 90 cm distance, 45 days prior to planting and sowing 2 lines in furrows and breaking the ridges during first inter-cultivation.
Benefits	:	Helps to improve water intake, reduce evaporation losses and thus improve moisture availability for higher yields as shown below.

Mulching	*Jowar* yield (kg/ha)	
	Grain	Straw
Bellary*		
Control	728	3430
Surface mulch		
Jowar stubble	1035	4720
Wheat straw	1120	5190
Redgram stalk	1182	5680
Dry grass	1265	8240
Bijapur**		
Control	1760	N.A.
Surface mulch		
Jowar stubble	1989	N.A.
Cotton stalk	1908	N.A.
Dust mulch		
Ridges and furrows	2064	N.A.

*Average of three years
**Average of two years
N.A.—Not available.

Name of practice	:	**FARM PONDS FOR RUNOFF HARVESTING AND RECYCLING**
Description	:	Storing excess runoff in dug out ponds and re-using the same for irrigation of rainfed crops.
Area of applicability and scope	:	This practice can be advantageously adopted in areas where the rainfall pattern is such that most of the rainfall is received in short duration and with high intensities.
Specifications	:	Depth (m) : 3 to 5 Side slope : 1.5 : 1 Capacity (cu m) : 2,500 to 3,000 Silt trap (pit of suitable size) is recommended on the upstream side to reduce silting. One such pond is recommended for every 8 to 10 ha. However, minimum area to be not less than 3 ha, lest the water yield be too small.

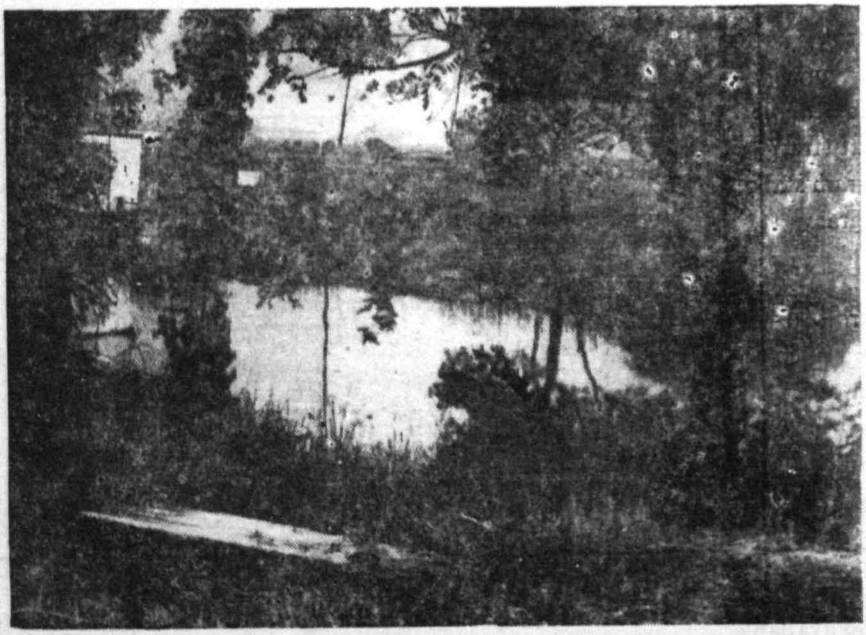

Fig. 8 Farm pond with runoff water

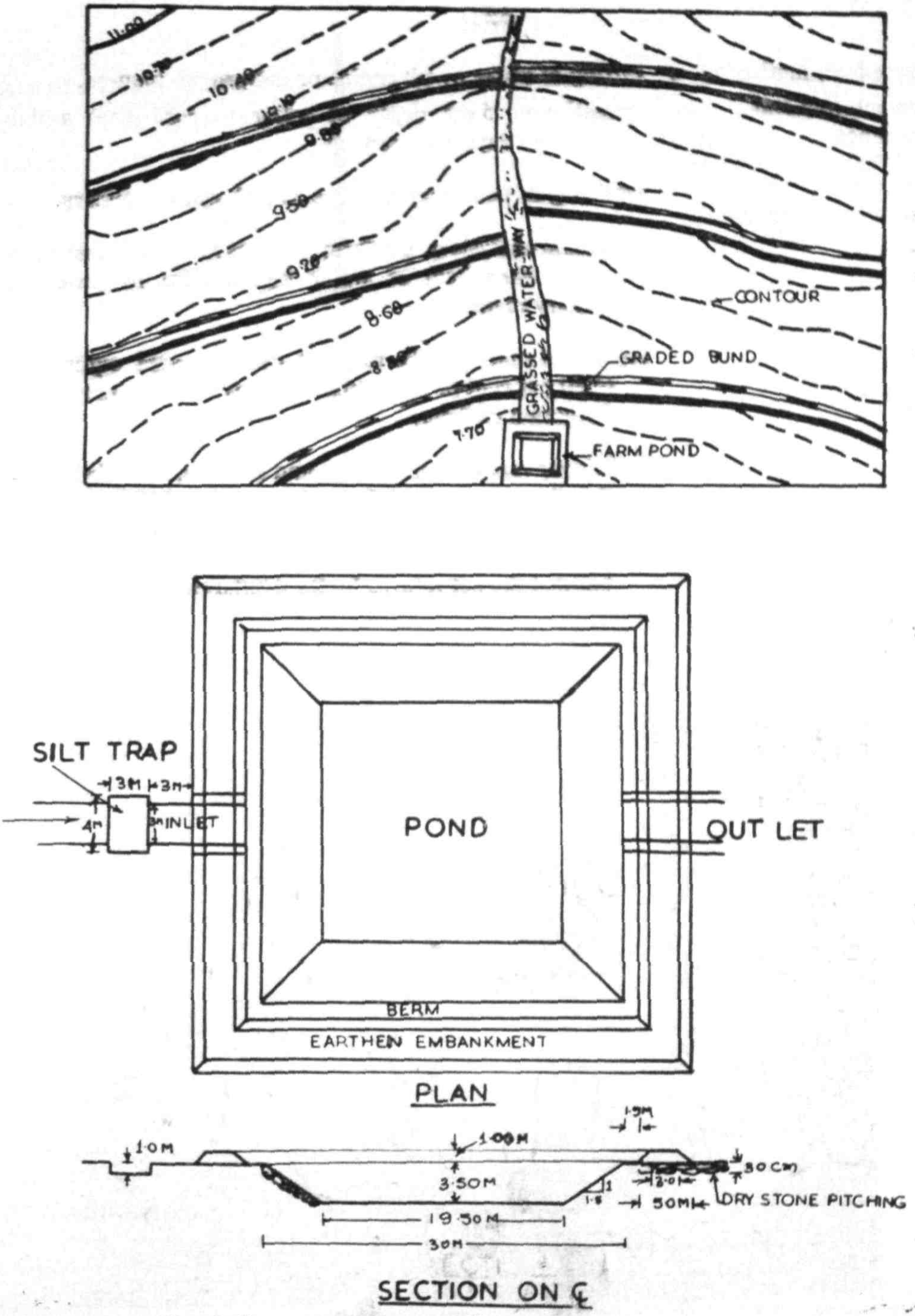

Fig. 9 Farm pond for runoff harvesting and recycling

Field procedure, method of implementation and maintenance	:	Lifting of water by oil engine or indigenous method. Irrigation of 5 cm depth of water to *rabi* crops within 30 to 40 days after sowing. Desilting of pond may be done as and when necessary.
Benefits	:	Economic analysis of the farm pond gave benefit cost ratio of 3.4 when 5 cm of water was applied to *jowar* in Bellary region. Harvested runoff can be recycled over an area equivalent to 80 per cent of the catchment giving one protective irrigation of 5 cm. In Bijapur region, *rabi jowar* and safflower recorded additional net returns of Rs 1066 and Rs 1267/ha respectively over control when two irrigations of 5 cm each were given. In case of gram one irrigation of 5 cm has boosted the net returns by Rs 448/ha over control.

Name of practice	:	IMPROVED TECHNOLOGY FOR RAINFED *JOWAR*, SAFFLOWER AND *GRAM*
Description	:	Improved technology for rainfed crops involves ; low monetary inputs such as use of proper variety ; timely weeding and interculture; and high monetary inputs *viz.*, fertiliser use and pest control.
Area of applicability	:	Medium and deep black soils.
Specifications	:	Refer Table 1
Benefits	:	Ensures efficient use of moisture and fertiliser, results in higher yields and net returns as given below :

Cost and returns in deep black soils of Bellary (1977–80) and Bijapur (1977–79)

Crops	Cultivation cost (Rs/ha)	Net return (Rs/ha)	Net return per rupee invested (Rs)
Bellary			
Jowar			
Improved	626.75	781.00	1.25
Traditional	378.00	69.00	0.18
Safflower			
Improved	570.00	751.60	1.32
Traditional	302.80	187.20	0.62
Gram			
Improved	761.69	305.51	0.40
Traditional	305.51	48.90	0.16
Bijapur			
Jowar			
Improved	533.49	679.89	1.03
Traditional	265.10	147.83	0.63
Safflower			
Improved	661.25	1002.75	1.70
Traditional	285.50	209.66	0.78
Gram			
Improved	760.50	945.63	1.25
Traditional	402.50	110.25	0.27

Table 1 : Improved technology for rainfed *rabi* crops

Practice		*Jowar*	Safflower	Gram
Preparatory tillage	:	2-3 harrowings with blade harrow during monsoon. Deep ploughing once in 3 years or when the field is infested with perinicious weeds		
Seeding time	:	With first soaking rains from first fortnight of September in Bijapur region and second fortnight of September in Bellary region	Within 15-20 days afrer first soaking rains in September/October	Within a month after first soaking rains in September/October
Fertiliser use	:	30 kg N and 30 kg P_2O_5/ha for Bellary region, 30 kg N and 15 kg P_2O_5/ha in case of calcareous soils of Bijapur region	20 kg N & 20 kg P_2O_5/ha for Bellary region and 30 kg N and 15 kg P_2O_5/ha for Bijapur region	15 kg N and 30 kg P_2O_5/ha
Variety	:	M 35-1/5-4-1/SPV 86	A 1/S 144	A1
Row spacing	:	60 cm	60-90 cm	30 cm
Seedrate & population	:	M 35-1/5-4-1 : 5 kg ; 1,00,000/ha SPV 86 : 6 kg ; 1,30 000/ha	3.5-4 kg/ha : 50,000/ha	50 kg/ha : 2,50,000/ha
Thinning	:	Thin excess plants to maintain required stand within 3 weeks	—	—
intercultivation	:	2-4	2-3	—
Mid seasonal correction in plant population in subnormal years	:	Thin every 2nd or 3rd row within 30 days depending on severity of stress in case of *jowar*		
Important pests	:	Shootfly	Aphids & caterpillars	pod borers

N.B.-If first soaking rains are delayed upto end of October, prefer safflower or gram to *rabi jowar*.

Name of practice	:	SUBSTITUTION OF COTTON/WHEAT WITH SAFFLOWER
Description	:	Safflower is more stable and remunerative than cotton/wheat in low rainfall region.
Area of applicability	:	In all types of black soils of varying depth. Safflower is particularly suitable for eroded lands and areas with subsoil salinity.
Specifications	:	Variety : A1/S 144

Seeding time : Within 15–20 days after 1st soaking rains in September / October.

Seedrate and population : 3.5–4 kg/ha : 50,000/ha

Fertiliser use : 20 kg N & 20 kg P_2O_5/ha for Bellary and 30 kg N & 15 kg $P_2 O_5$/ha for Bijapur regions.

Row spacing : 60–90 cm

Interculture : 2–3

Important pests : Aphids and caterpillars

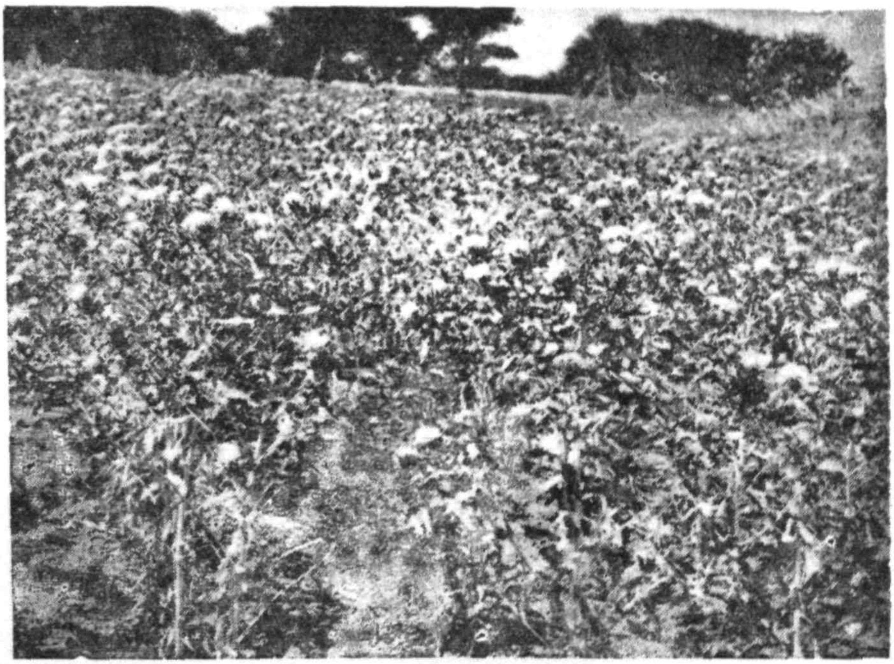

Fig. 10 Safflower (A1)

Benefits : Increased net returns as given below.

* Crop yields (kg/ha) and comparative net retu rns at Bellary and Bijapur

Crop	Average yield (kg/ha)	Average net return (Rs/ha)
Bellary (1976)		
Cotton	197	263.23
Safflower	634	853.63
Bijapur (1977–79)		
Cotton	296	102.00
Wheat	425	55.00
Safflower	500	387.00

Name of practice	:	INTERCROPPING SYSTEM
Description	:	Intercropping of hybrid *bajra* and redgram in shallow black soils (less than 22.5 cm depth) as an insurance against total failure of crops.
Area of applicability and scope	:	In shallow black soils of low rainfall areas, *Kharif* crops like *bajra* or *jowar* are generally grown. Drought occurring during grand growth period often affects crop yields. Hence, as an insurance against seasonal vagaries, it is recommended to go in for intercropping system. Research has shown that intercropping of hybrid *bajra* and redgram in shallow black soils is most economical and feasible.
Specifications, field procedure and method of implementation	:	Hybrid *bajra* and redgram in 2 : 1 row proportion spaced at 45 cm apart. Population of both the component crops should be maintained at 100 per cent each. Recommended fertilizer may be applied separately for each crop.
Benefits	:	Higher yields and returns as given below.

Cropping system	Grain yield* (kg/ha)	Gross returns* (Rs/ha)
Hybrid *bajra* alone	2456	1965.00
Redgram alone	1578	3944.00
Hybrid *bajra* + redgram (2 : 1)	2700 + 881	4369.00

* Av of 3 years

Intercropping system provides not only more gross returns but also stabilises the crop yields and serves as an insurance against seasonal vagaries.

Name of practice : DOUBLE CROPPING

Description : Double cropping of greengram (*Kharif*) and safflower/*jowar* (*rabi*).

Area of applicability and scope : Farmers generally keep the medium deep black soils fallow during *kharif* which may accelerate the runoff and soil erosion. A pulse crop with its canopy would serve as an erosion resistant crop, besides adding nitrogen to the soil, benefiting the succeeding *rabi* crop in giving higher yields.

Specification and field procedures :

	Kharif	*Rabi*
Crop :	Greengram	Safflower / *jowar*
Variety :	PS 16/PS 7	A 1/M 35–1 or 5–4–1
Seeding time :	June 1st fortnight	September 2nd fortnight
Seedrate (kg/ha) :	15	7.5
Fertilizers (kg/ha) :	25 N and 50 P_2O_5	30 N and 15 P_2O_5

Benefits : Yields and returns (Av. of 3 years) at Bijapur.

Crop sequence	Yield (kg/ha) *Kharif*	Yield (kg/ha) *Rabi*	Gross returns Rs/ha
Greengram – *Rabi jowar*	460	1433	3529.50
Greengram – Safflower	750	1291	5477.50
Rabi jowar alone	—	1281	1921.50
Safflower alone	—	1239	3097.50

Appendix II

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68	Table 1	4	kg ha	kg / ha
69	Table 2	2	kg ha	kg / ha
70	Table 3	19	di ease	disease
73	Table 7	7	5 97	5.97
80	Table 1	19	caterpillarh	caterpillar
Appendix I				
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