Agrotechnology for Dryland Farming

2nd Revised Edition

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Dedication

Dedicated to fond memories
and
remembrances of my beloved mother
Late SEETA DHOPTE
who worked in dryland farm and
died in field by thunderbolt hit.
With all odds, she made me
What I am today

KEY - NOTE

Agricultural production has seen a spectacular growth in India during the past 50 years, contributing significantly to the growths and food self-sufficiently. Irrigated areas were largely responsible in bringing about this change from a "begging bowl" situation to self-sufficiency. But even when the full irrigation potential of the country is utilized, nearly 50% of the cultivated area will continue to be rainfed. Rainfed areas support about 40% human population and over 65% cattleheads. Major chunk of nutritive cereals (90%), oilseeds (80%) and cotton (65%) is produced in rainfed conditions.

There are many biophysical and socio-economic conditions in rainfed areas. Soils are highly degraded with poor nutrient status and low water holding capacity. Rainfall, the only source of water for agriculture is scantly in quantity and erratic in distribution. Farmers are poor in terms of resources and depend solely on agriculture and related enterprises for livelihood. The vicious combination of all these factors has made dryland farming a risky proposition leading to lack of investment in rainfed areas and low or non-adoption of technologies.

India is one of the pioneers in dryfarming research. The National Agricultural Research System (NARS), over the past 50 years has addressed the problem of low productivity in drylands through its network of ICAR institute, State Agricultural Universities and All India Coordinated Research Project for Dryland Agriculture. A host of location specific technologies have been evolved for yield stabilisation in dryland farming and conservation of the fragile ecosystem by sustainable use of soil and water resources. The results, though not as dramatic as in irrigated areas have been promising. There was a marked increment in the average productivity of nutritive cereals and oilseeds under rainfed situation. The effect of rainfed agricultural technologies was more visible when they were adopted on a watershed basis. With the Government of India's emphasis on area development on watershed basis, dryfarming technologies hold the key for the sustainable development of rainfed areas.

Despite, spectacular results in some of the watershed projects and their countrywide spread has not been encouraging due to non-adoption of all the components of technologies by farmers. One of the main reasons for this low adoption is their lack of participation in technology generation and dissemination processes. Research related to watershed development needs to be conducted with farmers as focal point in a Participatory Technology Development (PTD) mode and in a farming systems perspective. Therefore, any future efforts in development of dryland agricultural technologies should address the issue at multi-institutional and multi-disciplinary resource- building approach with the farmer at centre stage.

Sound dry farming agricultural technologies along are the answer for the present problem of low productivity (0.8 t/ha) in rainfed agriculture. In order to feed the ever-increasing population, the average productivity of rainfed areas must be increased to at least 1.5 t/ha in the next decade. Besides increasing the productivity, the food and nutritional security of the expanding population is

also of great concern. In this context, farming systems perspective assumes a much wider connotation covering livestock, poultry, fisheries, horticulture, and agroforestry besides food grains. A paradigm shift is needed towards attaining the food and nutritional security of teeming millions of human beings by integrating various production components for synergy and with farmers, participation as the core issues. This also calls for adoption of a consortium approach to share knowledge and experience with a view to addressing the problem with a holistic perspective.

Dr. A.M. Dhopte has made an excellent effort in bringing together all the relevant aspects of dryland farming in a realistic frame work. Being a multidisciplinary area of research it is indeed a difficult task to bring together all strategies and applied issues on dryland farming in a single volume. Dr. Dhopte has been able to do this job in a commendable way by integrating the topics in a systematic manner.

I hope the book meets the expectations of all those interested in the subject of dryland agriculture in the developing country and India in particular.

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MESSAGE

Dryland farming necessarily refers to raising of crops with available rain water. Rain water management is primary factor in sustainable agriculture and starts right where rain drops fall on the earth and secondly to harvest every drop effectively with essential agrotechniques. First concept involves *in situ* water conservation with watershed development in a field on a community scale with small holdings or individual watershed on large farms of sizeable area.

Farms are never leveled and have some slope of 0.5 to 10%. Contour farming, formation of live bunds and broad based furrow can be easily adopted for soil conservation and to minimise the run off losses. Rain water is better percolated down the soil and excess run off losses are stored in watershed reservoir during active period of monsoon. With this, we accomplish both water and soil conservation, a must for sustainable and precision farming. Moreover, the stored water can further be used for lift irrigation under occurrence of intermittant drought of short period to save the crop and optimise the productivity.

Next approach for effective rain water use is to adopt microirrigation, organic recycling with loppings and use of various mulches. Clubbing this practices with ideal cropping system as explained in this book shall be more rewarding to the poor farmers to achieve viable and sustainable farming. Continuous contour trench (CCT) for development of plantation under agrohorticulture, agroforestry and other perennial systems leads to uniform *in situ* conservation for rainwater, soil and organic matter.

I must appreciate the hard work and dedication of Dr. A.M. Dhopte, Ex. Professor of Agri. Botany, College of Agriculture, Nagpur and the other authors. I am sure that the publication will definitely be useful to the teachers and researchers serving the two third of our national agricultural land. I wish that the book shall have better patronage in India and abroad.

Akola

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FOREWORD

It is needless to emphasize any supportive efforts for making unviable dryland farming a more viable and sustainable enterprise for millions of poor farmers all over the world. This is absolutely essential under conditions when more than 90% land in India is rainfed. Globally, the picture is not different in developing countries. Consortive efforts that were needed in the past, unfortunately are not in hand today. Barrying few examples of few big dams, the efforts towards management of rain water in India were not satisfactory instead of full natural resources. Agriculture sector is not rightly looked into its right perspective as it should have been after 53 years of independence. Quantity and quality of produce need to be monitored right from field production technology and this exactly lacks in previous fifth year plans.

Food quantity is the criterion in rainfed farming though quality can not be ignored. Major share of land asset in India is at the mercy of nature, erratic behaviour, drought and flooding. Any effort to improve living quality of rural folks engaged in rainfed farming with agrotechnology for several crops is worth appreciating. Rainfed crop is cared with every drop of rain water through appropriate measures such as *in situ* conservation of water, micro-watersheds, continuous trenches, restricting run-off, broad based furrow, organic recycling etc.

Second approach is to allow guided flow of water through plants without affecting crop growth to accomplish marginal yields, which a farmer is deprived off, to make agriculture a sustainable enterprise. Pre- and post-planting care is needed for sustainable productivity. Book includes all relevant aspects of rainfed farming and is therefore, a valuable addition for dryland farming. Long outstanding demand has, thus fulfilled the requirements with this book. The approach of the editor is novel and he made an attempt where a farmer lacks to manage the land and he purposefully attempted to provide technologies to monitor the adversities of dryland farming with expertise available in the country.

After going through the contents of the book, I do hope that an editor of this book, Dr. A.M. Dhopte (Former Professor of Agri. Botany) has made full justice to the current problems of dryland in the country and abroad and he deserves appreciation in bringing out such long needed outstanding book for the benefit of scientists, researchers, extension workers, planners and farmers to accomplish marginal productivity from today's unviable non-productive dryland farming of poor cultivators, spread all over the world. To wipe out the tears from eyes of the Indian peasants was the dream of Mahatma Gandhi and such efforts if rightly and timely adopted by the planners and properly executed, I am sure, a dream of

Former Prime Minister of India, Late Lal Bahadur Shastry may come true in days to come. I profoundly, wish, this book is a grand success.

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MONSOON AND RAIN WATER MANAGEMENT — EDITOR'S VIEWS

Economics of any country depends upon agriculture developments and it is commonly approved fact universally. There cannot be progress in India unless growth rates is increased to at least 6.0. As per statistics of 2011, 26 crores of people are totally dependent on agriculture. In past, 70 years after independence, agriculture dependency has raised from 12 crores to 26 crores and out of this 12 crores are peasants and 14 crores are landless labours. This is red signal for economic growth. The people without work is in no way good for any country

Water is a source of life to farm and animals. Satisfactory supply of water to agriculture is essential for progress in agriculture. This has not been attempted in any governance of India during past 70 years. Because of no infrastructure, Dryland farming is 60% in India and 70% in Maharashtra state. The life style of Indian peasant is for sustenance traditionally and it is not planned for income generation at national level. The rainfed farming has become a gambling for crores of people. The crops like sugarcane, wheat and rice have satisfactory source of water supply which is roughly 93%, 85% and 26% respectively. Because of no timely source of water to crops like pulses, oil seeds, sorghum and lesser millets, the production is limited in India as compared to other countries.

This made the Indian economy paralyzed. No ruler has made serious thought over this important issue during past 65 years. The efforts made so far are inadequate to cater the needs of 130 crores of people.

The experts who have made five year plans though were in right direction, were not successfully implemented because of many reasons. The funding system has failed to cope up the urgent needs of the country and now we are at the edge of degradation fast. The execution plan of responsible for poor economy of the farmer. The dryland farmers have become poorer and poorer day by day. He is loaded with loans and suicides have become a common feature among farmers. As per statistics of 2001, 28% of poverty is found among farmers and 43% among landless labours. Large number of farmers take only one crop and they remain workless for rest of the period. It amounts to increase in unskilled and uneducated workless people in the country. The maoist and naxalites are the victims of this systems. The workless hands have opted for such dangerous options. Six crores of our national youth are in the trap of such zone and they become easily vulnerable for sustenance. Under such situation 40% of pleasants are ready to sell their lands without considering nation and nationality. This is because of their uneducation and unskilledness and therefore they always remained under below poverty line. This concept involves two main steps- human resource and economy. The solution is to increase the productivity of dryland farming to make the farmer sustainable economically and save them from being workless. This will definitely lead to dryland

farming better both in production and economy. We shall have to wait for next two decades for self sufficiency in present crisis. The Indian governance is failure at both the two ends.

The funding for agriculture researches in India is hardly half percent of total agricultural production as compared to one percent in china. The farmer economy is improved in China due to production and this is a land mark at global level for poverty eradication. The improvement in loan system cannot be a bold solution for viable farming in dryland agriculture but to provide them improved and better technology is the ultimate and absolute system that may help them on sustainable humanitarian ground.

The 3000 farmers in Maharashtra state have made suicides in past five years and this is specially found in Vidarbha region where irrigation facilities are meager and crops are taken on the mercy of rains. Non availability of water at critical stage leads either to total failure of crop or partial production that never allows the farmer to attain self sufficiency. The rainfall is abundant but irrigation sources are meager and therefore they become helpless to supply water during critical stages of the crop. The upliftment of farmer's economy is only possible if irrigation is made available at proper stages of the crop.

The watershed concept is the right choice and necessary steps are taken by the central government before two decades corrupt practices in Indian system however do not allow to have benefit as envisaged by planners. Hopefully, the improvement in governance may allow us to havest the fruits of planners in future.

Various symposium and seminars have been organized at national and international level by reputed societies. Scientist's views are crystal clear and they have emphasised the need to conserve rain water effectively for betterment of human welfare. The concepts that have come in reality are few erected big dams for renewable hydro-electricity and irrigation. This has created some more problems rather solving problems at grass-root level. Huge areas are trapped in high water table leading to flooding effects, salinity, upheld aqualayer and thousands of hectares of land uncultivable. These problems are being tackled at government level now. If one problem is solved, another problem crops- up and this goes on and on keeping real problems unmatched with the requirements. Necessity is the mother of invention. The plans for connecting big rivers in India was the first approach putforth by the scientists in early fifties that could avoid the drought and flooding in some areas of the country. This demanded millions of grants and unfortunately, it could not be implemented by the planners. A march was on in various V^{th} year plans and slowly, some dams (Big and Small) were erected for two purposes of electricity and irrigation in the country.

First priority was given to the industries primarily to erect industries and barren lands remained neglected till today. The water could not reach to poor farmer's field. Central plains of penninsular India remained neglected and today it is dependant totally on rain water, called dryland. Dryland farming is necessarily a rainfed farming. The yield levels remained marginal in past and it was enough to cater the needs of sizeable population of 60 crores. Now it has increased over a billion and the food basket may be now inadequate to meet the growing demands today. The concept of *in situ* water conservation of rain water is only the solution. How do we implement it effectively ? There are some considerations that should be seriously viewed by the policy makers and I try to illustrate here for the use of readers.

We have set-up innumerable departments and organizations for various purposes like:

1. Water power production
2. Irrigation and soil conservation
3. Management of rivers, harbours and flood control

4. Watershed and drainage management
5. Desalinization and ground water investigations and
6. Experiments with weather control.

The water comes to earth as rains and this water can be used and controlled for the use of humanity. The ability to manage water is one of the man's greatest achievements. Limited progress has been made to manage the water. It remains for the next generation to coordinate these activities to make them more effective and inexpensive. The India can ill - afford the unplanned approach to water management. A more coordinated approach is needed. Average rainfall in India is 550 mm. The world average is around 800 mm. The monsoon rainfall is India's valuable resource which is a unbeatable combination for agricultural development. India is supposed to be the potentially the most productive agricultural country in the world. The question is how to realize this potential. Coordinated nationwide programme can be implemented with primary emphasis on monsoon rainfall. The monsoon water is received during four months period. It therefore should be effectively stored for rest of the year. Certainly, the important reservoir for water is right where the rain drops fall.

The efficiency of soil water storage is determined by water management. The owner of the land where the water falls, has the primary responsibility for water management, both in the quantity stored and the prevention of evaporation losses. This concept must first be established very soon.

Farm storage of water must be in the soil and not on the surface. Surface storage is subject to evaporation and is very wasteful in anything but deep tanks and reservoirs. Studies in the state of Maharashtra have indicated that at least 65% of all water collected back of bunds is lost by evaporation. We wait for rains for nearly eight months in a year and it looks good to have water around. Water held needlessly may represent a sereous loss to the nation in damaged crops, waterlogged soil or wasteful evaporation that could have been used more productively in downstream. This should be remembered by every farmer very critically because life exists where water prevails. The ancient civilization has begun in nearby areas of rivers. The Indus valley civilization was first found near Punjab where five rivers flowed. The ganges valley civilization progressed further. Unfortunately today our farmers do not understand the importance of water and are not after its conservation barrying few cases. We wait for monsoon for eight months but still, when it arrives, conservation part is neglected. Why this happens is the mystery. The run off losses are not controlled and we never care to stop this phenomena. More importantly, it is the right place where it needs to be stored. Excess water goes to the nalla, bunds, ponds, deep crevices and finally it reaches to the river. Precautionary measures are not employed by the farmers. Field ponds were the common approach in areas where paddy cultivation was predominant but in plains, this concept was not practiced.

Each field in India should be considered as primary unit for water conservation. The water management starts right here. The depth, the permeability and the water holding capacity of the soil is considered in relation to the crop and the character of the rainfall. Water moves by gravity, so the slope and the nature of the slope must also be considered. The idea is to plan a system of farming that will enable the cultivator to control the water and put the maximum amount to beneficial use. When a field is prepared to make optimum use of monsoon rainfall, very little additional work is required to make proper use of irrigation, if or when available. How do we plan a field for water management? It is really simple. First determine where excess water should leave the field. Then a drainage system should be planned. Broad contour-bottom sodded drains are used for slopping lands, deep drain ditches are preferred for flat or leveled land. If the land has a long slope, bunds - base terraces may be needed. These should be laid out as a definit part of the drainage system, and

must be on an exact contour or graded contour. They may serve as guide lines for contour farming. This practice is mostly followed in hilly areas only but the concept is not followed by farmers of plain lands.

The land is never found leveled. The slope is found some where in the field and contour bunding is the only answer. Live bunds of subabhul, vetiver, grasses, dhancha (*Sesbania rostrata*) can easily be adopted for water conservation and help minimize the run off losses. Better percolation of rain water can be achieved effectively. The terraces or bunds can not be straight unless land has a uniform slope. Property line bunds, road side bunds and nala bunds are usually very wasteful to crop acreage and damaging to productive land and should always be removed when they interfere with a proper field or community water management programme. Deep soils to be used for rice or small grain production may be leveled to a non-erosive grade or to form straight or contour border strips. Border strips are a series of parallel bench terraces constructed across the slope and the land then is leveled, so the water falling on land will flow slowly and uniformly down the strip between the borders.

The borders also serve as guide lines for graded furrow farming of row crops. Border strips are also used for irrigation farming. This is suggested to secure high yields of food grains with monsoon rainfall. Border strips serve the purpose of irrigation and utilised for water conservation.

Graded contour furrow farming is good for steeper slopes. Steeper slopes require deeper furrows. It can hold-up the water until it can be absorbed by the soil or move slowly down the furrows and into the drainage way. The erosion can be controlled and water is stored in the soil for crop use from each rain. The contour furrows control few heavy rains during drought more efficiently. Famine condition will never prevail in India if available water both from irrigation and rainfall are managed effectively on every field.

Consumptive use studies indicate that very few crops mostly perennial one require more water than the monsoon normally supplied during four months' rainy season. India is not a dry desert with insufficient water resources. The only desert in India is along the Pakistan border. The damage to the crop in India is, mostly due to much water rather than not receiving enough. Normally, drought affects the crop on shallow soils. Such piece of land can be efficiently used for fruit crops like Ber, Amla, Sitaphal, Tamarind, Guava, etc. and intercrops of food grains can be cultivated. Strip plantations of these crops can have effective control on soil erosion and can result in conservation of rain water. More rain water results flooding and damages crop growth on millions of hectares of land and also affects more productive land in the world. The probability of such situation is found every year and it affects the soil as well as crops. Large hectares of land is spoiled due to waterlogging, high water table and the accumulation of alkali salts. New irrigation projects are adding to this menace each year. Adequate drainage system is therefore necessary for every field. Soil is precious input in agriculture and million tonnes of soil is lost due to erosion and added to the sea every year.

What a farmer needs to do for water management on his field is explained. Drainage for each field is must. The neighbour farmer complains about this run-off water. All the poor land in the neighbourhood floods and damages crops and soil on all the best lands. The neighbour farmer becomes helpless for this water. This should be the responsibility of organised society. If government programme has to be effective, the programme should start where it begins at local level and then move to the state and national jurisdiction. Very effective implementation of such situation has been achieved in western Maharashtra by forming organised corporate sectors. The "Village pond", Lakes system has been established in Deccan valley tract of western Maharashtra to monitor, manage and distribute available rain water for the needy farmers in critical conditions. This

has made the revolution in dryland agriculture in this region. A radical change is seen in past decade and the area which was neglected for years together, is now brought under timely irrigation for better productivity. Protective irrigation can be managed and productivity can be assured. This is a unique example what farmer's community can do on corporate sector. Barren lands have changed to green festivity among farmers due to collective wisdom of the people and good leadership. Such examples can be a land mark for others to follow in central plains for better livelihood, harmony and happy living at village level. Individuals who have common problems of water management should join together to solve their difficulties. The organizations should be endowed with the full authority of Law, as a functioning unit within the block, the district, the state or the federal government. A legislation has come in force in some states of India to deal with such water problems. Water management deserves the undivided attention of enthusiastic and well qualified persons at all levels.

Water management programmes should be coordinated by the government. Around 50 to 100 farmers should join together and form a society for rain water management, arranging watershed in an area of 100 hectares. Expertise can be had from Agri. universities of Govt. Deptt. of Agriculture. A honest leader among the farmer's community is needed to lead the activities in a right and lawfull manner. Unfortunately, farmers are much involved in fighting, confrontation with neighbour farmers for bunds and flood water and this is highly attributed to mostly illiteracy rather greedyness. The training, demonstrations, set examples survey and benefits derived by them need to be brought into the focus of such farmers who are always involved in fighting with neighbour farmers. Unless the sence of brotherhood for mutual benefit is developed within them, the societies though formed may not work and it will lead to poor results. India is sufficient in sunlight, soils, water resources, ideal topography and large forests but overall the crop productivity is poor due to lack of coordination and proper leadership. Honesty, determination and strong nationality lack in most of us and the problems have become much acute and farmers are far behind the world in productivity of food grains in India and developing countries. A radical change can be had provided the people are honest in work and leadership. Many factors can be responsible for such attitude of farmers and the people but some time some day, this approach needs to be adapted if we have to survive in global competition for food and water in days to come.

Population has now increased over one billion and if productivity is not raised from 90% dry land, no one could come to our rescue to feed the people. Begging bowl policy shall not work in future. One can imagine what will happen if food security is remote. Social health can be spoiled leading to anarchy and arson. This situation may be disastrous. A new cell has been launched by federal government on rainfed farming and production of watershed is being promoted at all India level in IX^{th} year plan. Hopefully, the prodigal action may be improved in Future.

India uses about three times a much water than what is really needed by the crop. Due to bright solar radiation during rest of eight months (Excluding rainy days), the ET is higher. Global warming era of millennium shall again add to this and probably, more water could be required to raise the successful crop by 2025 AD. Flood and furrow irrigation system must be stopped to save the water and drip system should be promoted as done in Isrsael and some arid regions of the world. Water management is also required for rice because it is not a swamp grass. Rice likes water but precise water management is needed for maximum yield. Water is only pivotal factor in other managements of nutrients and fertilizers. All other stresses start when water is deficit. India has large water wealth and we have to make the most of it in days to come. The *in situ* conservation is the only key to remedy the problem in dryland farming.

The soil and water are inseparable. The soil resource is old and tried from centuries for farming. Because of heat and monsoon climate, soil forming process in India is most relatively rapid than other temperate countries. The conservation of rain water in America is 90% as against 10% in

India though average rainfall does not vary much (550 and 500 mm/year). During last four decades, the plans for rain water management are not predominantly executed. Paper plans are ideal but reality is unsatisfactory. The water utilization efficiency in India is lowest in the world. Few rainfed crops use 20% of available water and irrigation water efficiency is hardly 10 to 12%. The water resource should be precisely managed. What can be done to increase the water use efficiency? Complete programme of watershed management like reseeding and reforestation on steep or shallow soils, contour farming, strip cropping, cover and green manure crops, graded contour bunds etc. have to be tackeled. Block bunding alone does not contribute to water use efficiency. They hold back water and help control gullies, but the water they hold back does not increase the water available for crops on more than 15% of the total land area. Bunds or broad-based terraces are recommended for farm lands. The campaign to increase moisture use efficiency is much more appealing to the public when it is applied to irrigated land. What is the basic of increasing unit production/unit area? Plant needs water where it is planted and it is almost static. The water need of a plant must be satisfied at its place. Plant roots are searching for water below ground. Competition prevails within plant population. Roots that face horizontally must face more competition than verticle roots. To a plant, soil is just what plant roots can penetrate. At germination, the plant area is low but as it grows to maturity, more and more soil area is covered. The water holding capacity may become more important, not the total quantity but what the plant can extract.

The water requirement of every crop differs and it is dependant on leaf area index. Evapotranspiration (ET) refers to the total amount of water required to raise the crop for entire season. The water use pattern as per percent growth increases to grand period of growth and further decreases in sigmoidal manner. The water deficit brings about the wilting in plants and acute stress terminates into death of tissue. Some crops grow in deficit water and produces marginal. Therefore, we must study every crop and soil and entire irrigation system to supply the water needed for the crop growth. If the root zone water holding capacity of a soil is too low to meet the requirements, the soils need not be irrigated because it is simply a wastage. The ET studies have produced some very useful information and there is now system of irrigation based on crop coefficient. Transpiration and evaporation losses should be separately studied in every crop to know the details of where water goes. Infra-red thermometers have been devised to know the period of water stress in a crop period. The moisture utilization in this country is low. Correcting plant population/ha is the main factor in moisture use. More canopy results in more requirement of water but this thumb rule may not be applicable in field. Several factors are involved in ET of a crop and water requirement.

The factors like radiation, temperature and relative humidity play significant role in crop ET. A complete cover is necessary to utilize maximum solar energy. It is found that narrow spaced crop yields more under dryland conditions. What is harvested by a farmer is the solar energy. India has plentiful of solar radiation and photoefficient species need to be evolved. The algae utilizes 16% of solar energy while terrestrial plants utilize it by only 6%. Unfortunately, very little work is done in this aspect. Normally, dryland crops have less canopy and if more solar harvest is to be attempted, more plants/unit area has to be followed. Theoretical considerations are not experienced in reality under dryland conditions. Crop modelling attempt has been made on certain parameters related to water requirement, but in general biological phenomena can not be put in mathematical equations. Light energy is weak during active monsoon and every inch of space be occupied by leaves in order to make maximum use of limited sunlight. The cloud reduces the light intensity to nearly half (500 W/m^2) and all kharif crops suffer growth during active precipitation. With plenty of available water, a poor crop will use just about as much water as a good crop. This means that with a proper stand and irrigation when needed, yield per unit of water can be greatly increased by careful attention to other things like adapted crops and varieties, planting dates, fertilizers, tillage practices, plant

protection, soil amendments, drainage or anything else that will increase production. The water use efficiency can be increased by "good farming" only. The use of some antitranspirants (Radiation reflectant types) are known to have better water use efficiency in crops.

The primary factor limiting the irrigation is the method of irrigation. Drip irrigation is the best system of irrigation under dryland conditions and it saves 40-60% of water. While in furrow irrigation, lot of seed is lost if the bunds are formed before irrigation. Germination is poor and crop stand is inadequate to have expected yield. The water use is very inefficient until plants cover the surface to protect the soil from solar radiation. The studies indicated that sprinkle irrigation is more suitable for vertisol soils if pipes are inexpensive. A computerised schedules of irrigation are prepared for every crop and available water can be monitored as and when necessary. As per expert reports, the agricultural production can be doubled in India provided proper system of water management is adapted by every farmer.

I tried to illustrate the fate of rain water starting from precipitation to river end, importance of *in situ* conservation of water, what approach can be suitable for dryland and how to increase the water use efficiency by plants and assure productivity under unpredicted weather. It is needless to emphasize the importance of rain water conservation. Coordinated and systematic approach on corporate basis can only be the answer to dryland problems. A unique example of village pond concept has been set up in western Maharashtra by devoted leaders among farmers community and such system needs to be adapted by every dryland region to bring another water revolution in the country. It must be remembered that life exists where water prevails.

This book deals with several approaches for dryland questions in India like reclamation of degraded land, enriching the soil with organic matter and construction of watersheds in an area of 100 hectares according to the topography. The use of various mulches, use of field organic waste, selection of suitable drought tolerant and waterlogged tolerant varieties, selection of crops, water requirement, water use efficiency, suitable medicinal plants, best use of waste lands, coordinating the weather forecast and timely precautions to be undertaken, use of antitranspirants and various crop life saving agrotechniques are dealt for the use of readers. How to avoid the yield losses by harvesting the crop according to physiological maturity is suitably explained with photographs. Maintenance of required crop stand is a key factor for assured yield in dryland farming. The subsidies may be accorded for such kind of endeavour by the state governments instead paying farmers after a crop failure.

I suppose, that, this preliminary information may be adequate to have general information a farmer needs to have as primary infrastructure for successful and sustainable agriculture in India and developing countries as well. One should remember that rain water must be stored where it falls. Construction of huge dams, though is a solution to supply the irrigation facility, can not be a final solution. During last fifty years of independence, major break through is not seen in trapping irrigation sources for central plains where dryland is mostly predominant. Every drop of water needs to be conserved if human civilization has to be maintained in orderly and healthy manner. All wisdom is seen only when belly is full. No wisdom can prevail in people with empty stomach. The gravity and magnitude of such serious problem must be understood now without loss of time to maintain civilization on this lonely planet. The chapters, that follow, prepare the reader for rainfed farming with trump-cards opening, one by one from seeding to harvest.

EDITOR

PREFACE

Dryland farming has never been remunerative in India due to several reasons and global scenario is not different in developing countries as well. Geographically, some regions are rainshade and rainfall is highly erratic with limited assured rainfall zones. Regions are classified in various zones according to precipitation pattern and land topography. Plans for water conservation are made in last two decades but rewards are not in focus due to improper implementation. Rain water management has been a top-most priority at Govt. level but still, farmer's socio-economic condition is unsatisfactory even fifty-two years of independance elapse. Drought and flood situations are experienced every year some where and this problem is now being dealt on war-footing by launching a special cell at federal government. Third largest river in the world is Bramhaputra in India and still paucity of water is faced. Is it not a tragedy? What plans we have to utilize this water? Country is poor with all plentiful of resources and potentials. Every inch of land can be brought under irrigation if proper plans are implemented. Having ample resources of water and sunshine hours and favourable topography, the poverty among farmers exists and this is a point of serious concern. Aqua layer is getting down and down day by day due to improper rainwater management at national level. As per recent report of Int. Water Council held at Stockhom on Aug. 14, 2000, Dr. Lester Brown, the president cautioned about paucity of water in future due to dry wells. Countries like India, China, West Asia and America lifted 16000 crore tonnes of water/ year through wells resulting ground water decline heavily. In West Africa, out of every three persons, one is likely to fight for water by 2025 AD. Increasing water and food demand can not be fulfilled for increased population. For every one tonne of food, 1000 tonne of water is required and food is produced only with rain water and lift irrigation.

Recent global statistics indicates ocean salty water to be 94.5% and 1.75% of water is locked as ice on two poles. Only 4% of water is useful for environment and human consumption including animals. In India, 4250 Km^3 water is received through rains but 1880 Km^3 is lost as run-off into the sea and it amounts to 44% of total. The 1258 Km^3 of water gets evaporated and only 423 Km^3 water is percolated in soil which amounts to hardly 10.2% of total. India has 329 m hectares of land with average rainfall of 550 mm. Large quantity of water is not conserved in soil through proper planning. Sufficient grants are allotted for water conservation by Central and State Govt. in every V^{th} year plan but positive results are not in focus. Rural sector is neglected in past and now micro-level planning is essential to have proper impact on agriculture. Run-off and evaporation losses (90%) can be minimised with various systematic effects either in dams, ponds, lakes, watersheds or *in situ* conservation right in fields. One hectare land receives 110 m litres of water through rains and there is a need to conserve 1% of it to fulfill the requirements. In contrast, America and Israel conserves 94% of water in soil inspite of 500 mm average rainfall. In Konkan area of Maharashtra, Average rainfall is 2500 mm but 85% of water is drained back to sea without ground water recharging. Land topography is the limitations for such problem. Who can find the solution? Ground

water is not ever lasting if rain water is not recycled. World Bank also envisaged water shortage by 2025 AD leading to social conflicts at global level.

Though soil aqua layer is maintained at some places by construction of heavy dams, some areas face acute crisis of water for drinking and agricultural purposes. Nearly half of ground water is exhausted now and if it is not recycled today, paucity of water is bound to be faced in near future. The Maharashtra State Govt. resolved this situation by making new Act in 2000 to combat likely problems of future. Drinking water is available at 45-60 m depth of soil in some areas and borewells beyond 30 m depth can neither provide pottable water nor useful water for agriculture. It is a danger signal for next progeny to come in millennium if corrective measures are not adopted. Environment

shall come in geopardy because neither the plants nor animals can sustain if water is not provided. ``Life exhists where water prevails". Drought creates barren lands as observed in Rajasthan and some desert areas of the world. Extinction of useful plant species can

not be over ruled. Increased global warming may also lead to aberrent reproductive growth as well. Huge dams lead to upheld aqualayer leaving thousand hectares of cultivable lands non-productive due to water logging.

Promotion of watersheds is the only solution for *in situ* conservation of rain water and this has to be attempted on war footing right now. This can only be a wise attempt to march ahead for successful and sustainable agriculture and protection of environment. Suicidal attempts of farmers in some states of India during last decade are red signal for healthy democracy. Farmers are at the mercy of nature. One English author said "Indian farmers see their God in clouds" and I find this thought to be appropriate even today. Why this happens? Are we inadequate in technology? Is research not enough to resolve this problem? Why are we failure in this front when we rejoice our accomplishment in nuclear technology. Are we failure in transfer of technology? Some may Say "We are not above the nature". Weather can not be monitored. Are huge funds made on this aspects in vain? Scientists are also committed to answer these problems of poor farmers. India's economy is basically dependant on agriculture When nature disposes, we should stand together to fight the bread war. Remote sensing technology is being utilised for agriculture recently.

We are today self-sufficient in food-front only because of green revolution in varieties and hybrids with moderate increase in irrigation resources. A short break of rain during critical period of crop growth brings down the yield levels to marginal or zero level. Bankrupsy of farmer is always at his door steps. Our population is now one billion (1/6 of world) and agriculture shares more responsibility to feed this galloping population. There is therefore a dire need to think upon the problems of dryland farming. The yielding potential in semiarid tropics is uncertain and therefore *in situ* rain water conservation is highly important for assured yields in rainfed farming.

The yields are now plateaued since last two decades and better rain water management can only be the solution to expected crisis. The agrotechniques invented so far have to be transferred to the illiterate farmers. Extension workers should take this challenge through information technology, satellite communication, internet network and taking computers to the village level where no roads and telecommunication exist. The agrotechniques are compiled for successful crop management under biotic and abiotic stresses. True farmer is he who can get the normal yields under abnormal weather. This has been the focus of compiling various agrotechniques to help the farmer. We can certainly have accomplishment in this direction if measures are timely adopted. Stresses can be satisfactorily managed with advance techniques. Losses can be minimised and marginal yields can be assured. Let there be drought, waterlogging or hailstorm damage, total failure can be avoided. This book is an attempt to compile recent and old techniques to monitor crops in semiarid tropics.

After visualising the problems, the relevant aspects and scientists were selected at national levels and agrotechniques were edited.

I have covered my experiences of rain water and dry farming in the beginning for readers. Dryland problems were visualised and the relevant aspects and scientists were selected and exactly framed in systematic manner. The experts compiled various techniques to save the crop in stresses for the welfare of farmers. Experts incorporated their life time experiences and scanned the literature world wide to make the script more comprehensive and highly useful. All the strategies and applied issues on rainfed farming are purposefully dealt to have positive results.

This book deals with seed, soil, watersheds, crop, weed and nutrient management, use of weather forecast, various measures to save the crop under abiotic stresses like drought and flooding, reclamation of degraded land through organic recycling, evapotranspiration, water requirement, water use efficiency, climate and moisture relation, selection of variety and crops, agrometeorological approaches, use of antitranspirants, problematic soils and corrective measures, organic recycling and *in situ* water management, regulation of crop growth and suitable medicinal and aromatic crops for remunerative farming under dryland conditions. Over 90% of land is under rainfed farming. The chapters in this book are written by eminent scientists who devoted their services for rainfed farming in the country. Adoption of these techniques not only results in protection of dryland crops but favour environment as well in larger interest of life and world to prevail in days to come. Every scientist has given full justice to the probable problems of semiarid tropics for use of the readers.

This book could only be edited with the support of all renowned experts in the country. I am aware that the task was tremendous to find the right technology from available literature and it has been brought in limelight for the benefit of farmers. Estimations, predictions and timely operations are only the remedy for assured yields. What to do is given, but when to do is the master key for management of dryland crops. Wrong and delayed operations lead to poor yields. An ideal farmer is he who can take right decision at right time and supply the inputs what crop demands periodically. Risk is always involved in any enterprise and agriculture is not exception. Plentiful techniques are provided to save the crops under odds. One can take the horse to water but not let him drink and this is the task of farmer how best he can use the information.

Suggestions are invited for further improvements in the script. Criticisms are also welcome for better ideas which are not covered in this edition. I gratefully acknowledge the efforts made by all the contributors who have specifically compiled the required information and they deserve compliments for their efforts to ease the job of farmers. I thank them all for commendable task they have made for this book. I specially thank Dr. H.P. Singh, Director, Central Research Institute for Dryland Research, Hyderabad (AP) for writing Key-note, Dr. G.M. Bharad Ex. Vice Chancellor, for writing a message and Dr. V.B. Shekhar, Director of Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) for writing a foreword for this book. I always dreamed Indian farmers without tears and frustration. May I see my dreams come true in near future? Let us hope for the best.

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