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Suitable Land and Water

Techniques for Agriculture in Rainfed Regions

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India receives its major portion of rainfall mainly through south-western monsoon. Apart from this, the receding north-east monsoon is also one of the main reasons for rainfall in some parts of the country. It is also expected that due to local low pressure phenomena; some places may receive storms and rain with high wind. However, this phenomenon is usually noticed in coastal areas where cyclones with extreme wind and torrential rainfall leading to catastrophes are encountered on and of. Though the rainfall distribution is not uniform, yet nearly 75 per cent of the total rainfall takes place in the 4 months and rest 25 per cent in all other months. In such situations irrigation becomes an essential necessity for producing crops. For this to be achieved, the biggest challenges are collection and harvesting of the rainfall excess (runoff) from all the surfaces including rooftops, barren lands, fields etc. channelizing the rainwater without much losses and its storage over/underground as well as most efficient system for reutilization of this stored/standing waters by farmers for producing crops.

INDIA receives about 117 mm average annual rainfall on its total geographical area that amounts to nearly 400 million ha m of water volume. Out of the total, about 187 million ha m becomes rainfall that flows in the rivers and rivulets. A small portion of the total surface water, i.e. approximately 69 million ha m only remains as useable. The annual ground water has been assessed as 43.2 million ha m. In India, the created irrigation potential with medium and major projects has reached nearly 35-85 million hectare and by minor-irrigation projects nearly 12.24 million ha. The area irrigated by groundwater is 44.16 million ha.

A large portion of our land mass is still unirrigated due to uneven topographic and spatio-temporal distribution of rainfall.

As a result, the dependence on rainfall for crop production is very high. To obtain higher productivity from such region, there are more opportunities of using different engineering, biological and vegetative measures.

Medium and micro projects like. Bhakhra Nangal, Rihand, Nagarjun Saagar, Tungbhadra were created and consequently the irrigated area of the country increased substantially. Along with this, through minor irrigation projects such as tube wells, small canals and water harvesting perols could increase the irrigated area of the country to the present level. In spite of these, a large chunk of the land is still unirrigated where there are possibilities of agriculture but due to mismanagement of resources and being rainfed the same is not possible keeping the rate of agricultural development very low.

If the particular area could be facilitated with advanced technologies of rainwater conservation, soil moisture conservation and soil erosion than in rainfed region too, the successful agriculture can be adjusted. In rainfed area, those places are also included which have so far not been provided with irrigation water by some or any means as well as places receiving high rainfall but not having facilities for irrigation.

In both situations there is no assurance of water application during the critical growth stages of crops. In some places, water scarcity (arid areas having av. ann. rainfall of 50 mm) and in some water abundance (costal area, ghat region, north-eastern states, J&K, Himachal and Uttrakhand hills) is observed. In high rainfall, there is a need for water storage, appropriate disposal and management is required while in low rainfall region better management of soil moisture is required to be asked to produce. Appropriate water and land management is desired in both situations of rainfall in order to achieve the desired crop production in difficult conditions.

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Appropriate Water Management Technologies for Low Rainfall Areas

In low rainfall receiving rainfed regions farmers have to adopt such measures which are not only short term and provide temporary food security but large terms that could affect the micro climate of the place and bring in more productivity along with sustainability of the natural resources. These appropriate water management technologies for such regions have been discussed here. In low rainfall regions it is desired that the available water be used more efficiently. A few such technologies are discussed in detail in the following paragraph.

Checking the Water Losses Due to Evaporation and Evapotranspiration

Water losses due to evapotranspiration could be checked by mulching. Due to mulching the sun rays are not able to penetrate the mulched material and reach the wet surface directly so that the temperature of the surface is not increased thus, the evapotranpiration is checked. With reduced rate of evapotranspiration the losses of water get minimized. For this purpose, two methods are used.

Surface mulching

The crop residues are spread in the field and can be used for covering the land surface. It can be practiced as suggested below.

Application of Biological Mulching Material on the Ground

While harvesting the crops, such practice can be adopted that the stacks of crops can be cut approximately 15 cm above ground. The crops are harvested in such a manner that nearly 6 inches of stacks remain in the field over ground. In this condition these stalks will not only bind the soil but also reduce the rate of evaporation in dry areas. They will also provide resistance to the wind velocity. Similarly, the crop

Surface mulching applied for preventing the moisture losses (From Division of Agri-Physics IARI, New Delhi)

residues can be continuously used for mulching that will not only reduce the evapotranspiration but also get accumulated to increase the organic carbon in the soil. By decomposition and assimilation of these organic carbon in the soil the microbial population in the soil and other beneficial organisms could be increased substantially. Application of biological mulches may alter the structure and texture of the soil if used continuously. By increased organic carbon percentage the number of microbes and soil bacterium could be increased so much so that this may result into changed micro-environs of the soil making unproductive or barren lands, a highly productive one with least moisture.

Plastic Mulching

In certain situations, the polythene or plastic mulches have proved beneficial. The water vapour resulting from the same, get condensed on the inner surface of the mulch that again gets mixed with soil. In rainfed regions, plastic mulches not only conserve the moisture from evaporation but also protect the soil from the direct impact of falling raindrops or high wind speed that could result into reduced soil erosion due to water or wind. Mulching therefore, is helpful in many different ways. Experiments with different coloured mulches are being conducted to see the effect of varying types of radiation on different aspects of crop growth. However, the heat capacity beneath the plastic mulches gets increased so much that can kill the pests and in some cases beneficial microbes too. This process often is termed as solar sterilization. However, this may not be so effective because the insects and pests tend to go to deeper vadose zones to avoid the heating effects of the surface soil and also the beneficial microbes may get destroyed.

Incorporation or mixing the biological materials in the Soil

Different types of biomass are usually available on the farm such as crop residues, leaves of trees, stalks and weeds. By decomposing these biological materials along with the cowdung, leaf manure, FYM, Vermicomposts, vermiwash and other such materials are thoroughly mixed in the fields. The water holding capacity of the soil can also be increased along with the increased organic carbon per cent in the soils. Liter were the rate of infiltration and water distribution in the soil properties get improved with the incorporation of biological materials; soil erosion due to water or wind can also be checked with increased carbon in the soil. If the soil fertility gets improved then the crops as well as weeds also get better growth. The incorporation of such biological materials time and again in the soil multiples the beneficial effects many folds so, the soil productivity can be improved and the soil erosion can also be checked simultaneously.

Incorporation of biological materials in the Soil

Cultivation of low water requiring crops

Low rainfall rainfed zones suffer from the low availability of water while high rainfall rainfed areas are marred with the problem of safe disposal, excessive soil and nutrients loss etc. The problem and remedial measures of rainfed regions in dry or semi-arid zone are being discussed here. In the rainfed regions of acid and remained climate over, those crops provide better results where water requirements are low. It is a basic biological requirement of different crops that may vary substantially. Crops like sorghum, pearl millets, oats, barley, chickpea, peas, basically maize and to certain extent wheat also require less water. These crops cover the land surface very rapidly and are able to provide good yields. During rainfall, the kinetic energy impact on the crop canopy is diverted. soil erosion and land degradation could be checked. Apart from this, the pulse crops absorb the nitrogen in the atmosphere and fix them into the soil. The soils are also protected against soil erosion due to good crop cover. In summer season, if the land surface is allowed to remain covered with crops then wind erosion could also be checked.

Recently, the experiments have concluded that coarse cereals and grain have high nutritive value as well as many anti-oxidants are also in higher amounts as compared to that in grain. These anti-oxidants enhance protection capacity of the human and animals alike.

Nowadays *Sorghum, Pearl millet's, Oats* etc. are increasingly being used to provide better nutrition as high fiber content diet for aged and patients. Hence, the requirements of the coarse cereals and grain, pulses etc. is on the rise, which could be grasped by the farmers of semi and arid region not having irrigation facilities. This is a good sign for increased water availability.

Appropriate water management technologies suitable for highly arid rainfed regions

Highly arid rainfed region can be used for crop production by adopting very specialized package of practices such as life saving irrigation, drip irrigation, fertigation, pot/pitcher irrigation systems, covered cultivation, sub-surface deficit irrigation etc. By adopting these technologies, the vegetables and horticultural crops can also be grown successfully in highly dry conditions on the lines of Israel which has adopted this technology in a big way with very high success rates. By combining the efficient utilization of limited soil water and better management of the soil moisture and cultivation of low water requiring crops these areas can be brought under beneficial agriculture. A few technologies for highly dry conditions are mentioned below.

Deep ploughing of fields before monsoon

The main theme of this technology is to provide high infiltration opportunity time to water to seep in the soil and other deeper zones. Before the onset of monsoon season if the hard pans under the soil surface is broken by deep ploughing then all water that falls on the surface will be absorbed in the soil and run-off build up could be avoided.

Marginal and Peripheral Bunding

In the beginning of the monsoon season all the marginal and peripheral bunds are thoroughly examined for any possible breeding burrows of rats and other animals. New birds can also be created as well as old ones could be repaired to avoid any water loss. All along the borders of big bunds or side by side of the large fields; the peripherals have been constructed. More effective marginal bunds allow more water to be retained behind them that in turn will be seeped into the ground thus enhancing the ground water recharge and future possibilities of ground water exploration for irrigation.

Pot/Pitcher Irrigation System

In dry areas, small and medium sized plants can be successfully grown by providing one life saving irrigation that can be provided with pot/pitches. In the method the earthen pots help in sub surface irrigation. Every drop is precious in semi arid and arid regions, therefore, irrigate the root system of horticultural crops and if possible provide the sub-surface irrigation methods including sub surface drip so as to cut-short the bare soil evaporation. It is advisable that one-low three or four pots/pitchers showed be sunken in the effective not zone area near the trees, depending upon their girth. A small hole made prior to sinking of the pots/pitchers at the bottom will provide the water that will be absorbed by the not zones. The number of pot/pitchers could be increased or decreased depending on the age and development of the trees. In the same continuation, if there is a little more amount of water available then sub-surface ditch irrigation should be drip or sub-surface dip irrigation for providing water and nutrients to trees.

Water and Land Conservation Engineering in very high rainfall areas

Contrary to avidity or no-rainfall, the high rainfall rainfed region are marred with excess water, low sunlight, cloudy sky, high relation humidity and lower temperature related disorders. Due to high rainfall the losses of different nutrients are quite obvious with the soil losses and water along with the nutrient flow down from higher reaches to lower elevations and the valleys suffer from water logging. Low pH (Acid soils) and Al and Fe toxicity are the important characteristics of these regions. Due to this reason, it is

very essential to adopt appropriate land and water management technologies to realize higher agricultural production. The combined engineering and biological measures, could be utilized, for successful land and water conservation in such areas.

Construction of Engineering Structure

Soil and water could be conserved in high rainfall rainfed regions by adopting appropriate engineering, biological or combined measures. In areas having high slopes (>3 to 5%) by construction of engineering structure the heavy soil loss including the mass movement can be prevented. Marginal bunds, peripheral bunds, contour bunds, water harvesting ponds etc. constructed along with biological conservation measures are a few engineering structures recommended in varied condition. Some of the easily adoptable technologies are described below.

Ploughing against the land slope

The land should be ploughed in such a manner that the tillage should take place in appropriate direction to the general slopes of the land. In rainfed regions of north-eastern India usually farmers are found ploughing along the slope which results into excessive soil, water and nutrient losses. The water collected by the farmers in the ploughing against the land slopes, get more time to get accumulated in the areas. This fills the void spaces and saturates the root zone. Also, it is quite likely that this water joins the ground water as sub-surface flows. Thus, by ploughing against the slope it is possible to check soil erosion. Also, this would help in soil accumulation along the bunds that will result in the long run to give a terrace like shape to the land mass without any economic input. Thus, the ploughing against the slopes not only conserves the soil and moisture but also result in slow conversion of slopes into terraces lands. Not only the soil but water also is managed properly in regions of high or excessive rainfalls.

Rain Water Harvesting in Water Harvesting tanks/ponds and proper Reuse

In the rainfed region of high rainfall areas the spatio-temporal distribution is quite uneven. In the last few years; such unevenness has increased possibly due to the effect of changing climate. However, few scientists who support this theory also find it difficult to say for certainty that this may be due to the result of the climate change or global warming. Often due to intense rainfall, run-off gets generated that starts flowing along the slope, frequent soil loss, loss of nutrients and flood like scenarios are created. In such situations collection of excess rainfall, i.e. runoff is a very desirable and appropriate technology. The water collected can be reutilized for providing irrigation to crops.

Vegetative water way or drainage channels

To safely discharge the surface run-off, downhill it has been found that vegetative water ways are more safe. Side stages of such water ways are covered with biomass or made stable by sodding or planting trees/shrubs. At appropriate places, temporary check dams are constructed in a series. Vegetative water way is one of the emerging means to protect the water and land reserves by ensuring safe passage to the excess water from any area.

Cover management

The biological material available on earth green or grey (meaning thereby either the plants, shrubs, trees and/or dead wood and other biomass) is beneficial to check the soil loss because these act like washing material or filters. Also such material gets accumulated and mixed up in the soil to increase its organic carbon per cent for the season, the cover management of the earth surface is highly desirable either by dry grass mulching or range lands of afforestation.

Afforestation

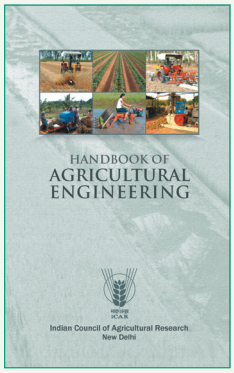
Although, it takes long time yet in all such places which act as highly undulating and not suitable for agriculture, afforestation is highly workable often for conservation.

Afforestation is able to solve many water related practices too. It is also essential to explain the possibilities of social forestry as well as timber and industrial plantation opportunities. The experiment undertaken in the country and abroad have confirmed the fact that biological, energy or combined land and water reserves conservation and management technologies have given promising results with varying success in various places. To make the regions more usable farmers shall have to make more efforts that will not only bring short-term food and social security to individuals but also long term changes in environment and the micro-climates of places as well as by the earth. It is possible that such affairs will be rewarded positively by the nature to the human kinds.

SUMMARY

For diverse agroclimatic regions, different but appropriate technologies are available which could be suitably adopted depending upon the local agro-climatic settings and the problem of soil and water management can be suitably addressed. In some of these places, the adoption of suitable water and land management technologies require rising above the petty interests of individuals, geographical boundaries or even countries. Much more success can be envisaged in agricultural, social and climatic sectors by adopting these technologies.

HANDBOOK OF AGRICULTURAL ENGINEERING



Agricultural Engineering interventions have led to significant improvement in agricultural productivity by timeliness of operations, reduction in drudgery, prevention of post-harvest losses and achieving higher cultivation intensity. Timely farm operations with efficient use of inputs, post-harvest processing and value addition to agricultural produce and conservation and sustainable use of natural resources are essential for ensuring higher returns to the cultivators. This is the maiden attempt of the Indian Council of Agricultural Research to publish the *Handbook of Agricultural Engineering*. The handbook comprises 50 chapters under four sections, namely Farm Machinery and Power, Soil and Water Engineering, Energy in Agriculture and Agro-Process Engineering. This publication would be useful to farmers, students, researchers, extension workers, policy makers, entrepreneurs and other stakeholders.

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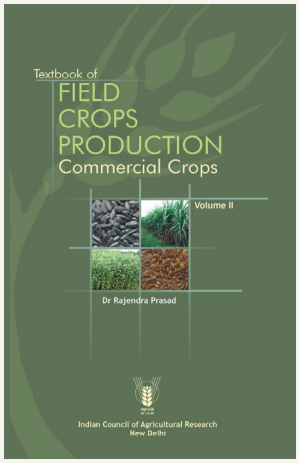
Textbook of Field Crops Production – Commercial Crops



Availability of high-yielding varieties/hybrids and increased irrigated facilities have resulted in the development of production-intensive cropping systems in several parts of India, and this has catalyzed further agronomic research based on the cropping-system approach. Many changes have also taken place in the crop-production technologies. And this necessitated the revision of the earlier publication brought out in 2002. The revised textbook is in two volumes: First is covering Foodgrains and second is on Commercial Crops.

The discipline of Agronomy has no longer remained mere field trials without application of discoveries emanating from the related disciplines of Genetics, Soil Science and Agricultural Chemistry, Plant Biochemistry, etc. The future Agronomy Landscape will face challenges of climate change, transboundary issues, TRIPS and other trade-related barriers, biotic and abiotic stresses, consequences of biotechnology and genetic engineering and increased market demands in terms of quality assurance, customized food crops, global competition, ecosystem services on land and social equities etc. The Agronomy must measure up to these futuristic challenges with well-defined metrics and methodologies for performance. The advent of hydroponics, precision farming, bio-sensors, fertigation, landscaping, application of ICT, GPS and GIS tools and micro-irrigation is in the horizon. This revised edition in two volumes covers fundamentals of the subject and at the same time will inspire and prepare teachers and students for the emerging frontiers.

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