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CONSERVATION DITCHING FOR EFFICIENT RESOURCE CONSERVATION AND ENHANCED PRODUCTIVITY OF SEMI ARID VERTISOLS

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FOREWORD

Vertisols and associated soils constitute 22.12% (72 million hectares) of total geographical area of the country. There is enough potential to conserve runoff along with the sediment and periodically recycle the stored water to the fields to overcome the moisture stress in crop growth in semi-arid black soils region. At present, contour *bunding*, graded *bunding* etc. are being adopted for soil and water conservation. But contour *bund*s cause yield reduction in black soils to the tune of 25 to 30% due to water stagnation in about 16% of inter-bund area. On the other hand, graded *bund*s (without properly designed farm pond) drain out the excess rainwater without being recycled for crop production.

For overcoming the structural and functional limitations of contour *bunding*, graded *bunding* and farm pond, Central Soil & Water Conservation Research & Training Institute, Research Centre, Bellary has developed and tested Conservation Ditching technique. This innovation has shown great promise as an effective conservation measure in black soils to improve the water productivity at terrace level.

(V.N.Sharda)
Director
CSWCRTI
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Conservation Ditching: A Substitute to Contour *Bunding* in Vertisols

Introduction

The soil and water conservation measures in vogue, namely, contour *bunding*, graded *bunding* etc. have their inherent structural and functional limitations. Contour *bund*s cause yield reduction to the tune of 25 to 30% due to water stagnation in about 16% of inter-bund area for prolonged periods. On the other hand, graded *bund*s drain out the excess rainwater too far, out of the reach of small farmers.

Vertisols and associated soils occur over an area of 72 million hectares (22.12% of total geographical area) of our country. They are mostly confined to the semi-arid region of the Deccan plateau, spread over the states of Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. Situated in tropics, large part of this area receives low (<750mm) and erratic rainfall. In spite of low rainfall, short but high intensity (32 to 120 mm h^{-1}) rains are common. This causes sheet erosion (an average of 12.5 t $ha^{-1}year^{-1}$ on 1-2 %land slopes) in easily erodible black soils due to low intake rates, poor aggregation and poor vegetation cover.

Conservation ditching technique, developed and tested at Central Soil & Water Conservation Research & Training Institute, Research Centre, Bellary has shown great promise to conserve water resource at field level for increasing the productivity of semi arid black soils.

About the Technology

- Conservation ditching is primarily adaptable in deep black soils with low infiltration rates (<1 mm hr^{-1}) receiving low annual rainfall (< 750 mm).

- Conservation ditch is a shallow trapezoidal dugout, laid on contour to serve the dual purpose of soil conservation and as a water storage structure at the individual field level in low rainfall area of deep black soils. This can also be vaguely described as an 'inverted contour *bund*' with flatter upstream sides and steep downstream sides.

- As a terrace structure, a well designed conservation ditch will store the inter-terrace design runoff within its confines; thus drastically cutting down its potential to initiate/accelerate soil erosion on the downstream of the ditch.

- As a storage structure, due to low infiltration rates in the deep black soils, sufficient volume of the stored water will be available in the ditch for about a week to ten days after the runoff collection in the ditch. The available water at low lifts could be manually lifted and applied to the downstream area to augment the soil profile moisture and stabilize yields of dryland crops.

Design Specifications

Runoff storage capacity

The ditch is designed to store 200 to 300 m^3 of runoff from a hectare of inter terrace land in black soil region of Deccan plateau.

Spacing of ditch

Spacing between ditches is same as that of contour or graded *bund* for similar soil, climatic and topographical conditions. However, for all practical purposes, the spacing is decided as follows for different field slopes in black soils:

Field slope (%)	Horizontal spacing (m)
0.5 – 1.5	50-60
1.5 – 2.5	40-50
2.5 – 3.0	35-40

Depth

The depth of the ditch is made in the range of 0.6 to 0.9 m depending upon the storage volume and soil depth.

Bottom width

Bottom width can be made 0.6 to 0.9 m. However, 0.6 m is considered in view of construction convenience.

Side slopes:
Upstream slope is made 5:1 so as to provide safety against scouring and downstream slope is made 1.5:1 to conform to angle of repose.

Cross section of ditch
=0.5 x [Top width (T) + bottom width (B)] x
Depth (D)
= 0.5 x (4.57+0.6) x 0.6= 1.57 m^2

Hence, design capacity = 1.57 m^3 per running metre of ditch

Length of ditch (L)

About 30 to 300 m long ditch is constructed in segments of 100 m. In case of series of ditches, the unditched stretches (4 to 5 m) should be staggered for effective erosion control.

Bottom level (bed slope)

The bed slope of the ditch must be maintained at zero level throughout. In valley portions, a small embankment is to be raised suitably to constantly maintain the depth of storage. The layout, dimensions of typical size of a ditch are shown in Fig 1&2.

Technology Implementation

Ditch layout

The following steps are followed for laying out a conservation ditch:

- Collect the cadastral map from revenue office/village secretary. Do the reconnaissance survey of the field along with farmer. Draw a rough sketch showing the survey no., field boundaries on upstream and downstream, waterways, valleys portions across the slope, soil depth, etc.

- Difference in elevation of the field is to be determined by using Hydro marker or Abney level. One of the spacing mentioned earlier is selected depending upon the field slope.

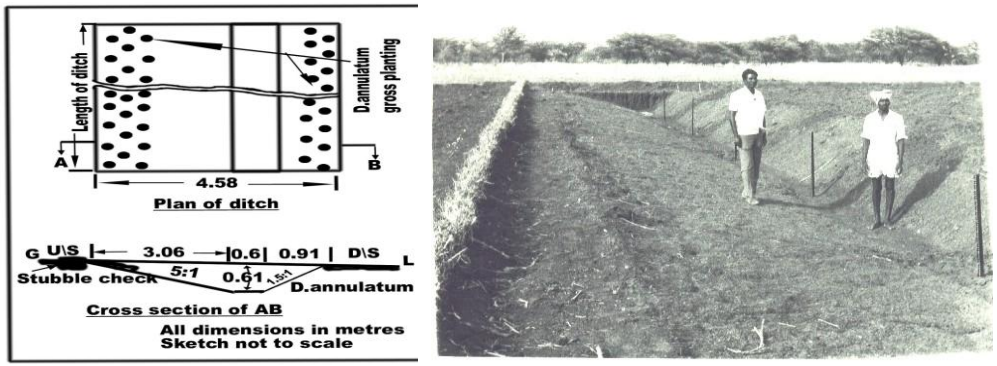

Fig. 1. Dimensions of conservation ditch

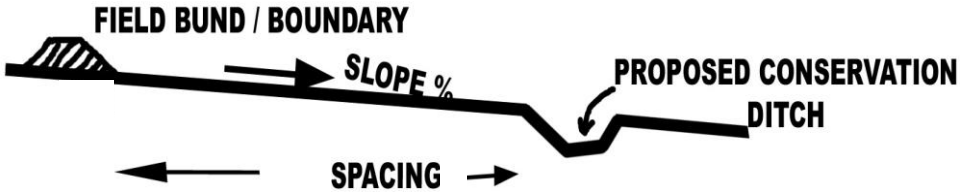

Fig. 2. Ditch spacing

- For the alignment of ditch on watershed/sub-watershed scale, professional surveyors may prepare contour maps, which are then super-imposed on cadastral/village map. Slope and drainage pattern are found out from this map for the purpose of making the alignment on the map and to transfer to the ground with permissible deviation.

- Theoretically, conservation ditches are to be laid out along exact contour points. However, permissible deviations need to be applied to negotiate local valley / depression or ridge so that excessive curvature is avoided. In places where straightening/smoothening of ditch is required, it is suggested that in the valley portions, the ditch sidewall height is suitably raised by filling the valley line. For this purpose, dug out soil could be used. But care should be taken to see that such filled-up portions are raised slightly (15-20 cm) above the adjoining portions of bed of ditch to prevent surplus water from flowing over such filled-up (made-up) soil.

In black soils, overland flow transforms into rill erosion. Left unchecked, the rill head at the entry to the ditch with a fall of about 0.6 m has a tendency to work upwards into the catchment area simultaneously damaging the ditch shape. Hence, a vegetative barrier, which mechanically filters out the soil allowing runoff water to flow down into the ditch and checking effectively the rill head advancement, is quite necessary. For creating the barrier, two rows of *Agave* species with spacing of 60 cm x 60 cm are planted in staggered manner (Fig. 3).

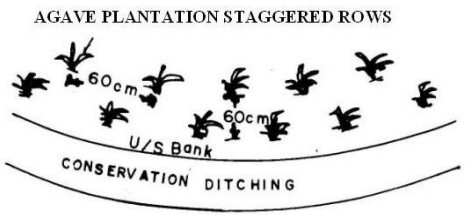

Fig. 3.Agave barrier for protection

Construction Procedure

Step 1: As shown Fig 4, the square pits of side 'a' equal to the bottom width of the ditch and depth equal to the design depth are dug at 20 m intervals along the aligned line. The bottom width 'a' is kept at 0.6-0.9 m to facilitate easy execution with the cutting of central box portion with permissible deviations on alignment. Pegs are driven into these pits such that their tops correspond to the bottom level of the ditch, which is constant. Since the ditch is on contour, it can be laid out to any length limited to field borders. However, a maximum length of 300 m is appropriate.

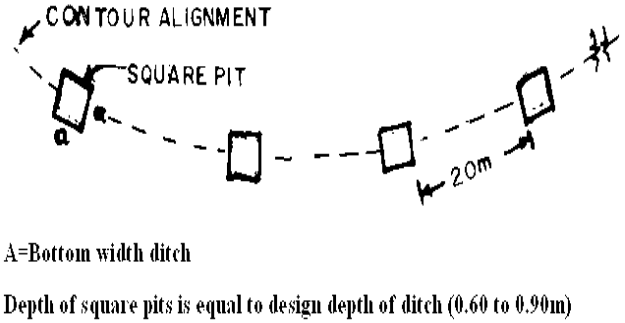

Fig. 4. Digging of square pits along alignment

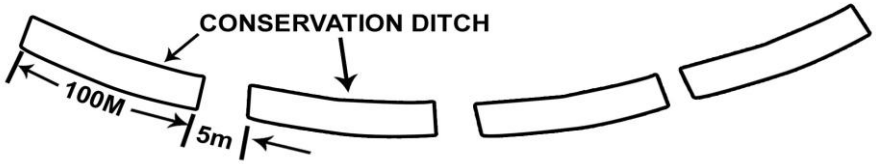

Fig.5. Ditching in multiple lengths with gaps

It is preferred to construct ditches in multiple lengths of 100 m, by leaving 4 to 5 m lengths unditched in between for free passage of human beings, cattle and farm implements from field to field. Then, a trench (box portion) joining all the square pits are dug (Fig 5).

Step 2: From the central line, borders marking the edges of the square pits are made and also the upstream and downstream edges

of the ditch are marked using the side slope ratios. The upstream side slope of the ditch is kept flat, i.e. 5:1 (Horizontal: Vertical) to avoid scouring due to the action of incoming runoff. The downstream side is kept at 1.5:1 conforming to the angle of repose of the soil so that caving in of the soil after saturation does not take place.

Step 3: To start with, the full sections of the ditch are dug near the already existing box trench 20 m apart. A template made of GI/PVC pipe/bamboo conforming to the cross section of the ditch is used for maintaining the design shape of the ditch. The trench covering upstream and downstream sides is dug with reference to aligned line, by periodically checking the shape of ditch so formed with the template.

Step 4: The soil could, preferably, be spread safely over low-lying areas and depressions to make them nearly level. Bullock drawn level blade/buck scrapper, commonly available in black soil region, can be used for spreading the spoil.

In the same manner along downstream bank horticulture plants such as mango, *sapota*, *ber*, *anjura*, orange, drumstick etc. can be grown as shown in Fig 6.

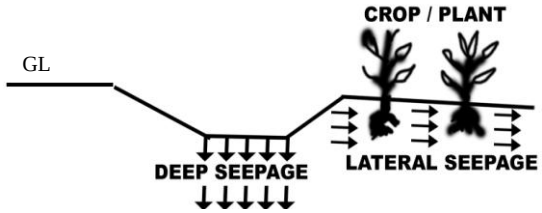

Fig 6. Ditch bank plantation

Step 5: Rooted slips of the *Dichantium annulatum* can be planted on side surfaces of ditch, which not only thrives well under the prolonged submergence condition but also produces fodder grass. The survival percentage of grass is more than 90% requiring 10% mortality replacement. Leguminous species used as green manure are also preferred for growing on downstream bank for utilizing the built up moisture regime (Box 1)

Maintenance / Management

In some cases, the ditch may come across the waterway. At the meeting point of waterway and ditch, the waste weir should be constructed on the upstream side of ditch for protection against scouring. The waste weir should also be constructed on the downstream bank at lowest vulnerable point or depression of the ditch to prevent gully formation. The gaps in Agave rows should be replanted periodically till the vegetative barrier is established. The grass on ditch side slopes should be maintained. Disilting of ditch may be done once in three years.

Box 1: Usage of seepage water

While a part of seepage water in ditch becomes available to the adjacent crops, the other part may go below the reach of the annual crop roots. To utilize the deep percolated water within an individual farmer's field, deep-rooted drought hardy fruit/fodder/oilseed plantations can be grown along downstream bank of ditch. Naturally, the spacing and architecture of the selected species is symbiotic with adjacent crops.

Cost

Work	Top width (T) (m)	Bottom width (B) (m)	Depth (D) (m)	Quantity per running metre {0.5 x (T+B) x D} (Cum)	Rate (Rs.)	L (m)	Total cost (Rs.)
Earth work	4.57	0.61	0.6	1.57	55 (per cum)	200	17270
Plantation on banks	-	-	-	-	15 (per RM*)	200	3000

*RM = running meter

Recycling of Stored Runoff Water

The ditches are designed to store 90% of 10 year 24 hour maximum runoff. The ditch holds entire runoff during below normal years and 70 – 90 % of annual runoff during normal rainfall year. It is advantageous to use the stored water at the earliest opportunity for irrigating the downstream land whenever the ditch is full with runoff water. This technique prevents unproductive storage losses. After every ditch-filling rainfall, the water stays for about a week to ten days (Photo 1). Since the water is available at low lifts (0.6-0.9 m), traditional low-lift and low-cost hand operated lifting devices such as swing basket and Archimedean screw can be used for lifting the water. The downstream area can easily be irrigated by gravity. The water is available for irrigation at different stages of crop growth and also for pre-sowing irrigation. Horticulture or agro-horticulture system is to be preferred in the downstream area as more area (about 40% of catchment area) could be irrigated from ditch as against the limited area (15-20% of catchment area) under annual crops.

Photo 1. Ditch with stored water

Resource Conservation Benefits

Besides harvesting and use of runoff, the nutrient rich silt deposited on the bed of the ditch can be harvested back to the cultivated land @ 4.5 t $ha^{-1}yr^{-1}$ in the first year, 2.6 t ha^{-1} yr^{-1} in next 4 years and 1.8 t ha^{-1} yr^{-1} after 4 years. The harvested soil is clay-to-clay loam in texture. The nutrients @ 357 kg ha^{-1} of N, 38.5 kg ha^{-1} of P_2O_5 and 851 kg ha^{-1} of K_2O are retained along with silt in the ditch

.

Production / Output

Conservation ditching is effective in mitigating the drought condition. Continuous charging of downstream land with ditch water can help to realize 5 to 7 times more yield as compared to the situation of withering crops in drought years. Ditch irrigation can produce additional yields of 650-850 kg ha^{-1} in *jowar* and 298 kg ha^{-1} in safflower, which works out to 35-48% increase over unirrigated condition. The water use efficiency in *jowar* can be around 124 kg ha^{-1} cm^{-1}. Under normal rainfall condition the maximum grass yield (*Dichantium annulatum*) of 16 t ha^{-1} $year^{-1}$ is obtained by the second year. Two cuttings, the first one in October and the second one in December, can be taken. This serves as an incentive to the farmer for proper maintenance of ditch. Other potential uses are reflected in Box 2.

Box 2: Potential for water recycling

10-year rainfall runoff analysis indicated that during May and June, a total of 30 mm runoff occurred in the Bellary region. This can be stored in ditch and recycled for horticulture block or to grow summer *moong*. Yields of about 6 q ha^{-1} of *moong* grain can be realized, which by dry land standards are bonus income to farmer. With an electric/diesel pump set, even upstream side crops could be irrigated. Land smoothening may be required in this case for uniform application of water.

Economics

On an average the additional sorghum grain yield expected due to ditching is 628 kg ha^{-1}. The net present value of additional net benefits is Rs. 2843 ha^{-1} $year^{-1}$ at 10% discount rate considering a 10 year life span with sorghum as the test crop.

Scope of Application

This technology has the potential for application in black soil region of Karnataka, Andhra Pradesh, Maharashtra and Tamilnadu. The technology is becoming popular in Akola region of Maharashtra where it is being promoted by Dr. Panjabrao Deshmukh Krishi Vishvavidyalaya, Akola.

Agave plantation on ditch banks helps in protecting conservation ditch and generates additional income