the boundary wall plantation. At present different horticultural crop *viz.,* koronda, acid lime, sweet orange, dragon fruit, mango, grapes, custard apple, date palm, pomegranate, guava, alona, figs, coconut, jamun, bael, sandal wood and sapota etc. were planted and known to get successful economic yields under abiotic stressed environment.

Step 9: Irrigation, drainage and farm road networks development

Irrigation and drainage network was designed considering the topography, crop and soil types, rainfall pattern and source of irrigation (Nira Left Canal). At present two water balancing tanks i.e. one at the end of south side and another in mid of north-side supplying irrigation water to the whole developed site. Provision of automated irrigation system is also kept. Farm roads network for smoothing farm was developed as per standards.

Benefits/Utility

Using this technology, shallow basaltic rocky land in Deccan plateau includes the state like Maharashtra, Madhya Pradesh and Karnataka in India can be brought under cultivation so that the cultivable area of the country can be increased. Substantial area out of 26.5 M ha of similar basaltic uncultivable area (8% of our geographical area) can be brought into cultivation. For developing 1 ha rocky basaltic terrain into productive land, the cost will vary from ₹55,000-80,000 depending upon the nature of slope and extent of hardiness. Farmers can generate income of Rs 60,000 from the second year only and this income will gradually increase with the time as a result of increase in yield due to better soil content.

Precaution with the Technology

- Confirm the availability of electricity, water and transportation facilities for developing such barren rocky degraded lands.
- Blasting releases energy in the form of fragmentation and displacement of rock, vibration of ground and air blast. Hence confirm permission from local competent authorities is essential and need to be performed very carefully.
- Need to be careful about spent wash application since it percolates down into and contaminate the ground water.
- Financial supports from the Central/State Government/NGO is highly essential while developing such sites and suitable for community level program.
- Need multidisciplinary expertise technical team from agriculture, horticulture and agricultural engineering disciplines.

How to Use

Research, development and extension activities: Well-developed rocky basaltic lands can be used by central/state government/scientists /extension functionary/post graduate students for abiotic research/ extension in agriculture, livestock and fisheries based on concept of climate smart integrated farming approach. Further, it acts as centre of excellence for demonstrating/ imparting trainings and skill development to farmers from the degraded lands.

Commercial agriculture: In India, there is about 8 million ha of degraded land similar to the one chosen for transformation through the demonstrated technology. Much of it in semi-arid region like Maharashtra. The transformed basaltic rocky lands can be used commercial agriculture for enhancing the livelihood, income and net profit of debt ridden farming community from degraded regions. The use of advance techniques of water saving, nutrients management, insect and pest control can help to maintain the yields and quality of produce from these degraded lands which are otherwise left unattended and subjected to further degradation.

Crop diversification and Agro-tourism: Transformed rocky basaltic sites can creates new avenues for crop intensification and diversification through cultivation of promising dryland crops such as dragon fruit and medicinal plants in addition to a variety of traditional dryland fruit crops. Hence the transformed degraded land will also play a vital role in extending agro-tourism in degraded land regions.

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

Technical Folder No. 50 (2022)

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Transforming Barren Rocky Basaltic Terrain into Productive Land for Field and Horticultural Crops

भाकृअनुप
ICAR

Model Research Farm for Alleviation of Abiotic Stresses

राअस्ट्रैप्रसं
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Introduction

Indian agriculture is confronted with dichotomous challenges of food security and sustainability within limited land and water resources in impending climate change situations. Thus, for providing vistas from science of land-water-environment continuum suiting to societal needs for food security remains a plausible option. This arises need of establishing sustainable agriculture over degraded land (~120 Mha) of India with suitable abiotic stress adaptation and mitigation strategies. Particularly in those 6 Mha degraded areas mainly suffered with hard pan and having shallow soil depth. Here, scanty precipitation, frequent droughts, ill drained soils and improper technology for agriculture, ground water recession and high temperature are the major driving forces for the poorly developed soil formation from basaltic igneous rocks. These areas often covered with shallow 0.1-0.3 m *murrum* soil made with parental basaltic rock shield exposed due to slow physical, chemical and biological weathering process. Therefore, an attempt was made to convert these type of barren rocky land (56.5 ha) at ICAR-NIASM, Baramati into cultivation depending upon the investment power, risk taking ability and availability of irrigation water.

Various scientific considerations viz., watersheds, natural drainage pattern, topography, counter map and layout of buildings were taken into account while designing and developing site. The entire site was initially divided into three watersheds i.e. south (18 ha), north eastern (16 ha) and north western (22.5 ha) block. The rocky terrain devoid of any vegetation blasted, ripped and levelled with help of heavy machinery support from Irrigation Dept., Maharashtra. Then site was subdivided into terraces and subplots. Further, locally available spent wash and spent mushroom substrate/FYM were applied each plot for pulverizing the gravelly *murrum* and enriching soil organic carbon. In addition, 2.7 ha in south side have been filled-in by transporting black/tank silt soils for field crop cultivation. Unutilized boulders and stones were dumped into road site while preparing farm roads. Research activities to evolve long lasting solutions for the adverse impacts of abiotic stresses on crop production, livestock and fisheries, integrated farming system have been initiated, tested and validated on south side. Both the northeast and northwest farms have been put under fruit orchards, medicinal garden and agro-forestry research to address edaphic stress and drought related issues. Two (north and south side) water balancing tanks have been developed for supplying irrigation water to field and orchard crops. Presently, ICAR-NIASM is successful to provide sound techniques for bringing uncultivable rocky barren lands under cultivation both for arable and horticultural crops.

Brief Description of Technology Including Salient Features

Brief about steps involved in technology of transforming shallow basaltic rocky land to productive land are described as follows:

Step 1: Geo-hydrological survey and schematic layout of site

The site is basaltic subdued plateau (18°09'30.62''N; 74°30'03.08''E) having an elevation ranging from 565 to 547 m with slope being towards south. Geo-morphologically the landscape is divided into summit with side and back slopes. Electrical Resistivity Method (ERM) was employed to conduct geo-hydrological survey and the delineation of potential/ suitable/ favourable zones for sinking of water abstraction structures for water supply to farm land, plots and other utilities. The subsoil strata along the periphery of the site boundary of 3.6 km to a depth of 100-150 cm were also surveyed to know the nature of exposure and their orientation, geo-morphological/ topographical and structural control, likely mineralogical make up, development of weathering profiles and relation with soil. Layout was designed for demonstrating soil and water conservation technologies suited to the semi-arid climate of the region.

Step 2: Ripping and chaining by heavy machineries

In mechanical process, parental rock blocks were targeted to be disintegrated into smaller sized boulder/gravels/granular forms either by blasting or ripening. The land was subdivided into terraces and subplots based on the topography across the slopes. The top 0.1-0.3 m *murrum* soil was scrapped and separately collected by front dozer before levelling terrace/plots with the aim of reusing this soil for top filling of terrace/subplot. Ripping operation was performed using heavy dozer with ripper (Model No. D355). It breaks the weathered and non-weathered rock/*murrum* fragments down to the 0.9 m depth through its tines. Finer grades of the primary and secondary zeolite materials were further induced through chaining with the same dozers. The processes of ripping, chaining and pushing were repeated 2-3 times till the terrace/plots got uniformly levelled. After each ripping operation, big hardy stones got crushed by chaining with the dozers. The hard stones remaining even after chaining were collected physically and transported for their utilization in filling the base of the roads.

Step 3: Blasting

After scrapping/removing the shallow top *murrum* soil, the exposed hard rocky portions left in patches after chaining and ripping by the heavy dozers were shattered by blasting. For this purpose series of holes of approx. 50 mm diameter were drilled using semi-automated tractor operated drill machine at spacing 0.5-1 m and 0.6-0.9 m depth depending upon the hardness of the rock along a line defining where the rock should split. The heavy stones during the blasting were collected and used for road filling. The remaining material thus generated was again chained, ripped and pushed for levelling.

Step 4: Application of spent wash

The sugarcane is the major crop of this region and distillery spent wash, a by-product from sugar industries is available in large quantities. Since the raw spent wash is acidic and having pH 4.0, it was used for reaction with parental rocky materials/*murrum* and thus augmenting the process of soil development by chemical disintegration. Moreover, being a rich source of organic matter (OC 43.8 g/l) in addition to macro-and micro-nutrients, it helps the microbes to flourish and induces the reactions of their by-products e.g. organic acids with zeolites and other materials and subsequently resulting in their dissolution. The raw spent wash (acidic nature) from Malegaon Bk Corporative sugar factory was applied two times with an interval of 6-12 months in all the farm terraces/fields in furrows or on beds with effluent pipes from tankers. The impacts of acids in spent wash and those generated with decomposition of organic matter could be visualized in terms of resultant smaller sized stones/*murrum* so generated. The rocky basaltic/ zeolitic boulders/stones also got so softened and vulnerable after treatment with spent wash that these further disintegrated into smaller pieces of sand and gravels of different sizes when the fields were later ploughed.

Step 5: Levelling of fields

Uneven *murrum* surface of the farm plots prepared after ripping, chaining and rough levelling operation done by heavy dozer was fine levelled using tractor operated front dozer(75 hp). For economic development of graded/plane surface, each plot was divided to sub-plots by performing grid survey of 15 m x 15 m to find out the centroid. Thereafter average elevation of all sub-plots was determined so that plane passing through the centroid at this elevation will produce equal volumes of cut and fill. Recommended safe limit of the slope 0.1-0.4% based on soil condition in the direction of irrigation was considered for levelling each plot.

Step 6: Green manuring for enrichment with organic carbon and application of SMS

Once the field plots were ready after ripping/blasting, chaining, spent wash application, removal of boulders and levelling, uniformity test was conducted for each field by growing *Dhaincha* and also using it for green manuring. It helped to add the organic matter, nutrients etc. in the soil. The analysis of surface soils showed that these were still gravelly (70-90% gravels of various sizes and rest 10-30% less than 2 mm) and low in fertility (organic carbon ~ 0.04% and available N and P ~ 14 and 1.4 kg/ha, respectively). Thus further attempts were made to enrich the soil fertility status through addition of organic manures. It was decided to add 20-25 Mg of FYM per hectare. However, due to scattered dairies and utilization of FYM by the farmers of the area mainly for sugarcane, only 340 m^3 of FYM (N, P, K 0.45, 0.19 and 0.42 %; bulk density 0.72 Mg/m^3) could be procured. Therefore, the alternate sources of organic i.e. spent mushroom substrate (SMS) based upon the cheaper supplies considering its organic carbon and nutrient content (C: N 30:1, N, P, K 2.35, 0.32, 0.17 %) were used.

Step 7: Development of black soil plots

In order to compare the impact edaphic and water stresses, total of 20,381 m^3 of good quality black soil was transported and about 6000 brass (16,990 m^3) was applied to 2.7 ha areas in south side and the rest was utilized for mixing with original soil/murrum dug out of pits for establishing orchards and boundary/ roadside plantations.

Step 8: Orchards and boundary wall plantation

After completing above mentioned 1 to 5 steps, various horticultural, agroforestry and medicinal crops were planted in north side block using different soil filling mixtures and planting (pit and trench) methods over an area of 22 ha i.e. exclusively for managing edaphic and water stress in orchard. Same method has implemented for establishing