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Innovative Methods...

Establishing orchards in shallow soils

The research initiatives have greatly improved our understanding of biology and management of horticultural plantations under abiotically stressed environments. To overcome the edaphic constraints, the on-site soil and water conservation technologies like trenching, contour/strip planting, graded furrows/ridgesare are being advocated to enhance crop/tree growth while the off-site techniques include storage of run-off, transport of canal/drain water through multi-stage-pumping, water tankers and switching to drip irrigation. But fruit trees suffer the most due to constraint for root proliferation with insufficient soil volume and supply of water and nutrients in required amounts in such shallow soils underlain with hard murrum pans/stones. Therefore, it is generally argued that successful cultivation of fruit trees requires a major shift in planting techniques, site preparation for planting and post-planting management since the initial establishment and growth of fruit tree saplings is the most critical phase for orchards. Thus, the aim should be to create favorable niches in the ambient where their roots are located. Keeping in view, scientists at NIASM, Baramati, have established that subject to changes in planting techniques and the site management; the initial growth of orchards can be boosted in shallow basaltic soils. Therefore, we have collated the available information from our experiences of establishing different orchards crops on a typical basaltic rocky terrain for the benefits of growers.

THE Indian horticulture has registered a phenomenal growth during the past four decades with the overall result that the fruit production has now overtaken the total food production.

The emerging nutrient deficiencies along with acidity, salinity and pollutants are the most common chemical stresses. Among the physical stresses, severe soil erosivity, shallow soil, soil hardening and low water-holding capacity continue to threaten the soil productivity. Latter specifically holds for the most fruit contributing states of Maharashtra and Andhra Pradesh where about 40% of the soils are shallow basaltic/red soils and those are mainly used for rainfed farming since only about one-fifth area is under irrigation. These soils are also inherently low in organic carbon leading to multiple nutrient deficiencies and climate change is further negatively impacting the farming systems. Though unfit for deeper rooted fruit trees since the hard mineral matter provide absolute barriers for root growth and water percolation but with the zeal to get higher economic gains, farmers are increasingly resorting to the orchards under such hostile environment. Nevertheless, the productivity potential of shallow soils continues to be low and these are often frequented by droughts during which a large scale damage even mortality of horticulture orchards is visualized.

Site Characteristics and Development

Large areas of barren and uncultivable terrain as developed from superficially subdued basalt igneous rocks exist in most part of India especially in Peninsular India. These lands are porous, shallow in depth (10-30 cm), gravelly, low in organic matter, high bulk density and poor water retention capacity. NIASM is located at 18° 09' 30.62"N; 74° 30' 03.08"E; MSL 570 m at Malegaon khurd, Baramati in Pune district of Maharashtra which typically represent agro- ecological region Deccan Plateau, hot and semi- arid climate (AER-6) and agro-climatic zone AZ-95, i.e. scarcity zone of Maharashtra. The long-term average annual rainfall is 560mm, and this is restricted to south-west and retreating monsoon. Indeed, site reflected multiple soil edaphic stresses, frequent droughts and its susceptibility to climate changes in an undulating rocky (basalt) terrain, devoid of any vegetation under the rain-shadow environment, developing a research farm for orchards was really an uphill task. Since the site was covered with shallow 0.1–0.3 m murrum soil, the principle of physical (mechanical) along with chemical

Steps for establishing a orchard

Ripping and chaining with heavy machineries

Making pits using hole diggers

Trench after blasting below planing sites

Filling pits with different mixture

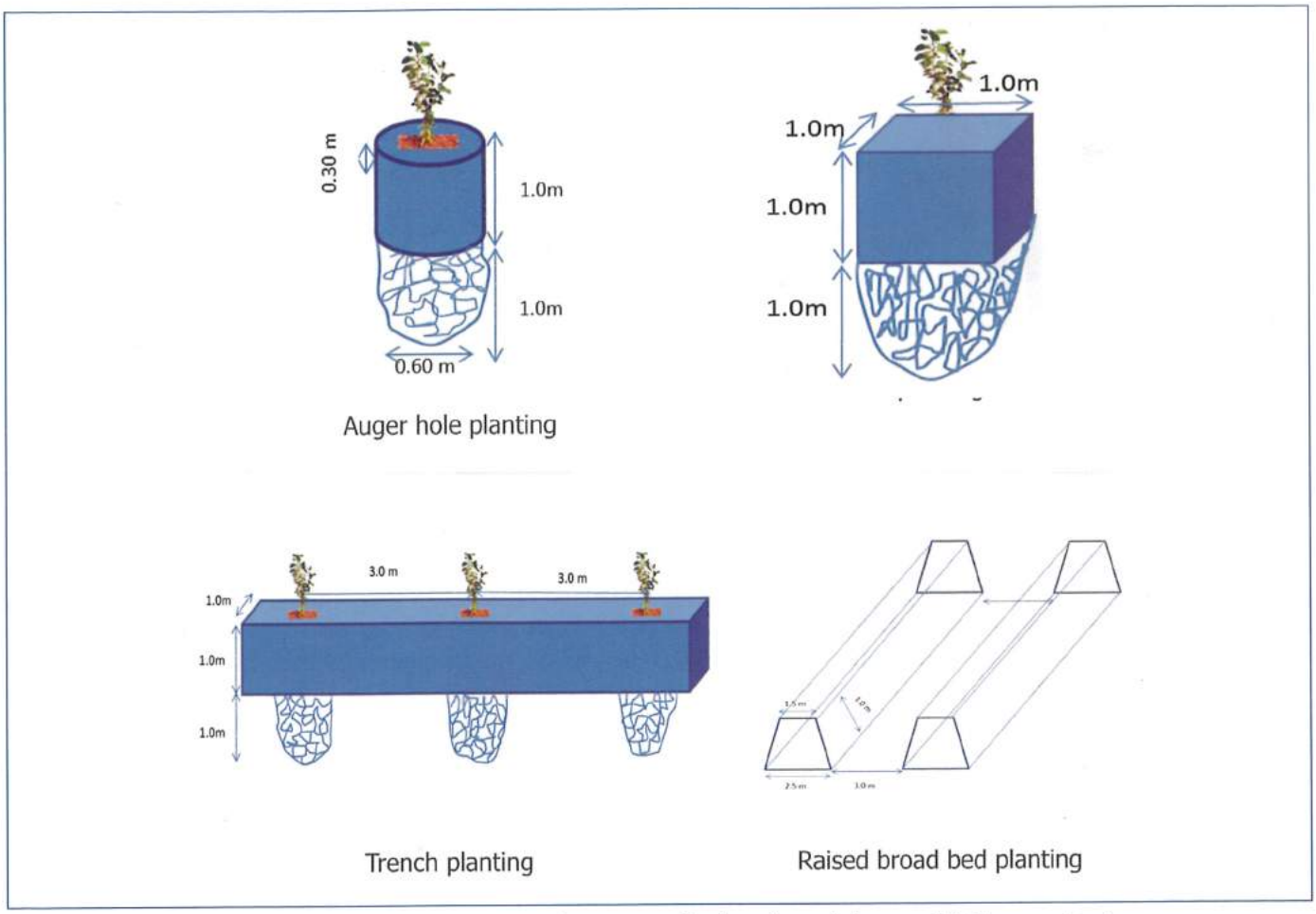
Pomegarate orchard

Nagpur mandarin established on raised beds

weathering processes were adopted to hasten the pace of disintegration and soil development. Ripping and chaining by heavy machineries could target the parental rock blocks and disintegrate them to smaller sized boulder/gravels. The processes of ripping, chaining and pushing were repeated 2 - 3 times in each of the fields till these got almost leveled. Since the distillery raw spent wash, a by-product from sugar industry (pH ~ 4.0, organic carbon ~ 44 g/L addition to macro-and micro-nutrients) is abundantly available in the region; it was used for reaction with parental zeolites and other rocky materials/murrum for augmenting the process of soil development by chemical disintegration. However, the soil fraction (< 2 mm) of the resultant land was still low (< 23 %) and the rest was gravels of different size. The fertility status was very low with mean organic carbon~0.07 % and available N, P and K was 14.7, 0.47, and 18.2 kg/ha, respectively. Various alternative planting methods being tried to overcome edaphic stresses are given below:

Sub-surface Water Harvesting

The most commonly adopted method for planting fruit seedlings is by digging the pits (0.6.mx0.6mx0.6m) and filling these with a mixture of original soil, sand and FYM. But in shallow soils, the orchards established with this method tend to bear much less than their potential as a consequence of regular dry spells, scanty

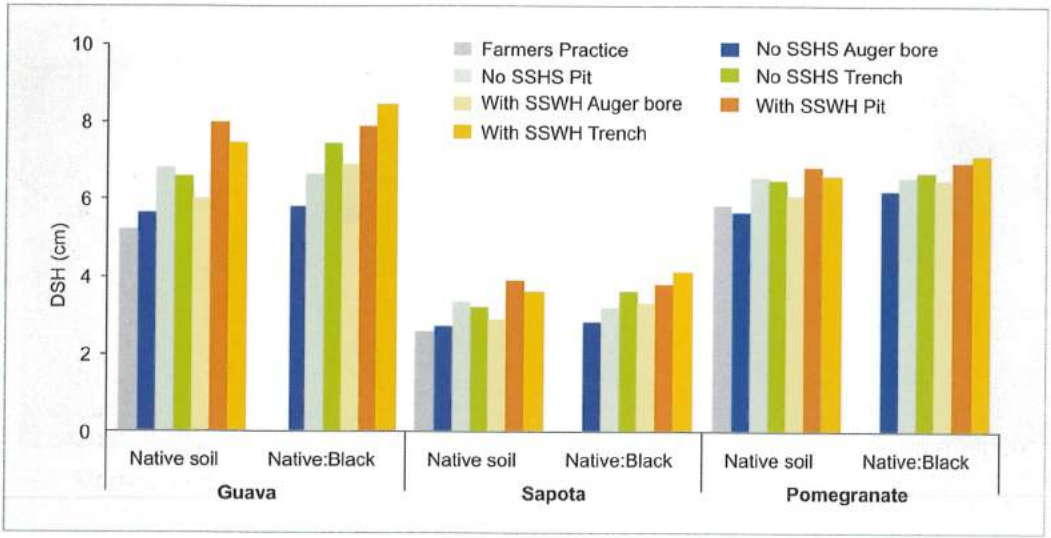


Schematic diagram of various planting methods adopted for establishing orchards

rainfall, recurring droughts combined with shallow and gravelly rhizosphere exposing the plants to severe moisture stress. Therefore, to increase the accessible water storage capacity from these soils and for better root proliferation, it is advised to take up larger pits or trenches. This kind of planting is mainly suitable for shallow rooted fruit tree like pomegranate. In grapes, as the spacing is very closer, digging of longer trenches is desirable. However, the underlying murrum/rock often hinders the growth for deep rooted plants like sapota, ber and guava even when planted with larger pits/trenches. Moreover, being the tap root system, the main root has the tendency to align vertically when it penetrates to deeper layers. Therefore, to provide for greater and deeper soil volumes for root growth, about 1.0 m^3 murrum below the planting site was shattered and fragmented by site specific controlled micro-blasting. Blasting releases energy to crush the rock in the form of smaller fragments and also displaces it. Since these soils are highly porous, the rainwater infiltrates rapidly and penetrates into blasted site from where it is unable to percolate further due to impervious surrounding of murrum/rock. Thus the crushed sites could further facilitate the deeper root penetration and provide for sufficient access to water storage and thereby allow the trees root to carry over during critical summer period/drought. Therefore, the blasted site having cracked murrum/rocks pieces not only facilitates in subsurface water harvesting (SSWH) and its uptake by fruit trees, this techniques seems to have advantage over storage of run-off harvested water in farm ponds where the significant losses through evaporation and seepage continue to be the cause of low water use efficiencies. All the above methods viz. auger bore hole (0.3m ID, 1.0m deep), larger pits (1.0mx1.0mx1.0m) and trenches (1.0mx1.0mxLength of row) are being tried along with SSWH (blasting below the planting site) for three different fruit trees with variable rooting patterns i.e. pomegranate, guava and sapota. To further improve the soil water and nutrient regimes these were either refilled with mixture of native soil with FYM (as recommended) or the equal ratios of native soil, black soil and FYM. The observation on soil water storage has shown considerable benefits of SSWH system. This technique in fact created niches of better water regimes and soil volume for proliferation of roots and thus resulting in better establishment and growth of transplanted fruit seedlings. The performance is still better when the planting sites were refilled with a mixture of native and black soils.

Raised Bed Planting

Another alternative for enlargement of the rooting volume on shallow soils is to create raised bed by scrapping the surface soil. Normally raised beds of about 0.5 m height are recommended for planting fruit trees. But under arid, basaltic conditions, the broad raised beds of 1.5 m width with the minimum height



Effect of planting methods and filling mixures on growth of orchards

of 0.8-1.0 m seem better to provide sufficient loose and friable soil for root growth. To increase the soil volume for creating ridges, scrapping may be preceded by ripping. The wide furrows formed in between the two raised beds can be used for *in situ* conservation of run-off rain water. This structure is highly suitable for fruit trees like mandarin and lime which are surface feeder and their active roots reside in surface about 1.0m soil depth. Such beds have an advantage over cumbersome trench/deeper pits that require heavy machinery to pierce into underlain murrum/basaltic rock and its fragmentation. Nevertheless, the disadvantage may be the higher exposed surfaces which are prone to high water losses in terms of evaporation/ run-off. To overcome this, application of mulch may reduce both the evaporation and weed growth. Due to non-availability of crop residues, pitching of gravels and covering with thin black polythene sheet are being tried. So far the results are encouraging since the mandarin that was transplanted about a year back, has picked up very good growth.

SUMMARY

In the end it is stated that the climate change induced rainfall aberrations resulting in decreased number of rainy days and increase in the frequency of high intensity rainfall have started showing immediate impacts on fruit productivity and shallow soils continue to be the most vulnerable. Therefore, for resilience of horticulture, the innovative techniques for planting site development as described above are required to be tested for their viability on large scale.

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