

# DIRECT SOWING OF ACORNS

**A Low-cost reforestation technique  
for the Himalaya**



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Funded by  
**SIR RATAN TATA TRUST**  
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Mumbai 400001

In partnership with  
**CHIRAG**  
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District Nainital 263 158  
Uttarakhand

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Published by Centre for Ecology, Development and Research (CEDAR)  
A-17, Mayfair Gardens, New Delhi 110016

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Central Himalayan Rural Action Group (Chirag) is a grassroots NGO based in village Orakhan, (block Ramgarh) dist Nainital, Uttarakhand. Chirag works in rural areas across Kumaun in an effort to improve the quality of natural resources and the lives of rural communities.

**The study was funded by the Sir Ratan Tata Trust under the small grant programme (SRTT SGP / 344/ 2005-06).**

## Background:

The degradation of Himalayan forests has been linked to environmental problems in the northern plains of India and Bangladesh, home to over half a billion people. All the major rivers in the northern part of the Indian subcontinent originate in the Himalaya. Forest degradation has been held responsible for increased landslides and soil erosion, leading to the damage of the Himalayan agro-economy, loss of livelihoods and outmigration of the local populace. To counter this problem, several initiatives have looked into reforesting degraded lands, and restoring productivity through a variety of measures aimed at integrated renewal of degraded watersheds.

Reforestation programmes common in the 1980's and early 1990's were replaced by integrated watershed development programmes in the past decade. Watershed development has been carried out on a large scale across the Himalaya by the Central and State Government and various donor agencies. For example, the Sir Ratan Tata Trust alone has been involved in over 25 watershed programmes in the western Himalaya since 2001. While strategies differ, reforestation is usually a key component of watershed development. Millions of trees are planted annually in the Western Himalaya. This is done through a variety of programmes coordinated by the forest department as well as NGOs, citizen groups and village level institutions. In the populated reaches of the central Himalaya, where maximum reforestation has been carried out, oak and in particular banj oak (*Quercus leucotrichophora*) is most often the single most commonly planted species.

Seedlings are typically raised in nurseries for 6-18 months and then transported to the site where reforestation is to be carried out. They are then planted in pits that have been dug specially for the purpose.

While high overheads are responsible for inflating plantation costs per sapling, actual costs of nursery raising and planting are as below:

## Drawbacks of current reforestation techniques:

### Reforestation is expensive:

A major drawback of reforestation programmes is their expense. On average, the total cost of planting a sapling ranges from Rs 14-50 depending on site conditions and the agency involved (see Table 1). Taking a conservative average of Rs 15 and the recommended number of 1600 saplings per hectare, this translates to a total cost of Rs 24,000 per hectare – over five times the average cost per hectare allowed for watershed programmes. After allocation of funds to other critical activities such as community mobilisation, training, and the building of civil measures in critically fragile areas, much of the money is exhausted. Consequently, reforestation rarely covers more than 10% of the watershed area, which may be inadequate. Finding a low cost alternative to nursery raised seedlings would therefore be beneficial.

**Table 1:** Afforestation costs for planting of nursery raised saplings

Catchment	Area (in Hectares)	Cost approved (lakh Rs)	Cost/ ha (Rs)	Cost / sapling (@ 1200/ha)
Parvati (II) HEP CAT Plan	1,509	686	45,443	Rs. 38
Allain Duhangan HEP CAT Plan	300	177	59,162	Rs. 49
Vishnu prayag HEP CAT Plan	188	74	41,267	Rs. 35
Kumaun NGO	300	42	14,000	Rs. 14 (@1000 saplings/ha)
Himachal NGO	100	Integrated watershed	NA	Rs. 19 (@500saplings/ha)

(Source: CAT plans of various Hydroelectric projects; Project proposals of NGOs in Kumaun & Himachal)

**Table 2:** Costs associated with various aspects of nursery raising

Head	Cost/sapling	Details
Nursery raising	Rs. 2-3	polybag cost, filling, seed costs, and maintaining for 1 yr
Planting	Rs. 2.50 – 4	pit digging, transport of seedling, planting
Supervision	Variable, typically > Rs 1.50	cost of monitoring nurseries and plantation activities
Protection	Very variable, typically > Rs 2.00 ; sometimes as high as Rs 10-20	forest guards, fencing, community mobilisation and awareness

### Seedling Mortality is High:

While site conditions such as exposure to sun and soil depth; prevailing climate in the weeks after planting; and protection of seedlings in the first year cause very large variations, mortality rates of 25-80% in the first year after plantation are typical. Often it is a combination of factors rather than any single reason that causes seedling mortality, but the most common stressors are:

1. **Drought:** seedlings, particularly in the first year, are susceptible to drought. Nursery grown seedlings that have been raised under favourable conditions often do not have root systems sufficiently well developed to withstand water stress of field conditions. Also fine roots are damaged during the move from the nursery and transplanting, and take some time to regrow. Drought in the first few months after planting kills many seedlings. After the first year, mortality due to drought is lower as seedlings have by then developed sufficiently deep root systems.

2. **Grazing:** planting carried out in areas used by villagers for grazing or programmes where village communities are not involved in reforestation are most impacted by grazing. Overall, repeated grazing and dieback is a major cause of seedling mortality. Grazing of seedlings also prevents them from growing more than a foot or two tall and hence prevents them, almost indefinitely, from forming a forest canopy.
3. **Fire:** some sites are highly susceptible to fire, particularly those with a canopy of conifers such as chir pine (*Pinus roxburghii*). Fires occur in the dry season and are correlated to dry conditions. While oak saplings can survive light ground fires, the aboveground portion is killed and there is fresh growth from the root the following monsoon. In effect the seedling has to start growth from the beginning. Strong forest fires kill oak seedlings.

## DIRECT SEEDING: A LOW COST ALTERNATIVE TO NURSERY RAISING

Direct seeding can be done at under 5% the cost of nursery raising. There is no need for growing seedlings in nurseries for a year, and nor do these seedlings have to be transported to plantation sites – an expensive operation given that seedlings are usually transported by humans over rugged terrain.

Oaks have large seeds known as acorns, and these carry considerable stored reserves enabling them to germinate and grow in a variety of sites. The first year is always the most susceptible year for a seedling. Germinating seeds in nurseries increases their chances of surviving this critical first year. However, in large seeded species, such as oaks which have substantial stored reserves, seedlings are larger than in the case of small seeded trees. Hence they are more able to withstand a variety of environmental stresses. While mortality in field conditions will be higher than mortality under controlled nursery conditions, at the end of the first year the field grown seedling will be better adapted to the local site conditions and have a higher chance of success than a nursery

grown seedling thereby, to an extent, equalising mortality rates. Nursery grown seedlings are larger than those grown directly from acorn at site. However, after a years growth in the field, differences in size were not found to be significant.

## Direct Seeding: Methodology & Techniques

While the acorns of the two primary oak species, banj oak (*Quercus leucotrichophora*) and tilonj oak (*Quercus floribunda*) show some important differences, they are similar enough to be considered together. As banj oak is more commonly used for reforestation, it has been considered here. Wherever differences between the two species exist they are specifically pointed out. Overall, the two species differ in ways pointed out in Table 3.

Trait	Banj ( <i>Quercus leucotrichophora</i> )	Tilonj ( <i>Quercus floribunda</i> )
Acorn size	smaller (1.5-2.5 g fresh wt.)	larger (2-6 g fresh wt.)
Pollination to dispersal	~22 months	~17 months
Time of acorn dispersal	winter – dry and cold	monsoon – wet and warm
Dormancy	2-5 months	nil – few weeks
Importance of microsite	high, will not germinate in unsuitable environs. Susceptible to drying in direct sunlight	low, cloudy conditions and high humidity at dispersal time allow germination almost anywhere
Early allocation	high allocation to leaves	higher allocation to roots
Masting strategy (Heavy production of acorns that occurs every few years)	fairly regular masts, moderate year to year fluctuation.	uneven masts, difference in acorn production >1000 fold between high and low acorn production years
Seedling tolerance to shade	Moderate: can survive deep shade for the first few years but thereafter needs some sun.	High: A high proportion of photosynthetic tissue allows seedlings to withstand considerable shade for many years.

## Storage of acorns:

Acorns must be stored under damp, cool and shaded conditions. While tilonj oak acorns can be planted almost directly after dispersal, in the case of banj oak, acorns must be stored for about three months. The following protocol has been shown to be effective and had the highest germination rates:

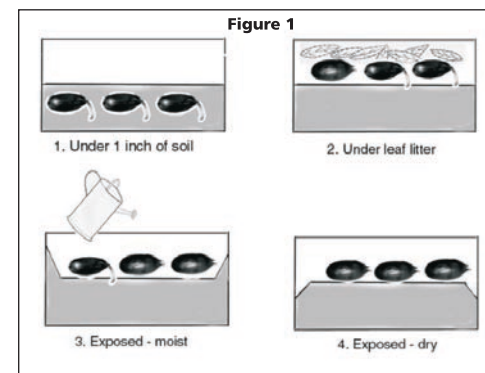
1. Collect acorns freshly fallen from a tree, or collect directly from the tree by spreading a sheet under the tree and vigorously shaking its branches. While acorn ripening time will vary depending on the altitude and seasonality, typically December – January is the time to collect. Start collection about a week after acorns start maturing and falling to the ground. The cap (calyptra) will remain on the tree. Greenish acorns that have a calyptra attached and have fallen might have been broken by monkeys and are not mature.
2. Float these acorns in a bucket of water. Acorns that float are to be discarded as they are typically infested with weevil larvae. Keep only the acorns that sink in water.
3. Mix these acorns with an equal amount of sand or coarse soil, dampen and store in a porous bag. Jute bags or loosely woven plastic bags are suitable. The bags should be porous. Used pesticide / fertiliser bags are often used and are suitable. The strong smell of such bags also helps keep away rodents.
4. Bury these bags under a few inches of soil in a shaded place. If the area has a high rodent population surrounding the bag with chicken wire might help.
5. If the winter is very dry then wet the earth where the bags have been placed about once every 3-4 weeks so that the acorns do not dry out.
6. During spring, typically in early to mid April dig out the bags and float the acorns once again to test for viability. Acorns that float should be discarded.
7. Plant the acorns that sink in water. Care must be taken to avoid exposure to excessive sun or drying conditions. Exposure to sun for even a day can lead to heavy loss of viability.



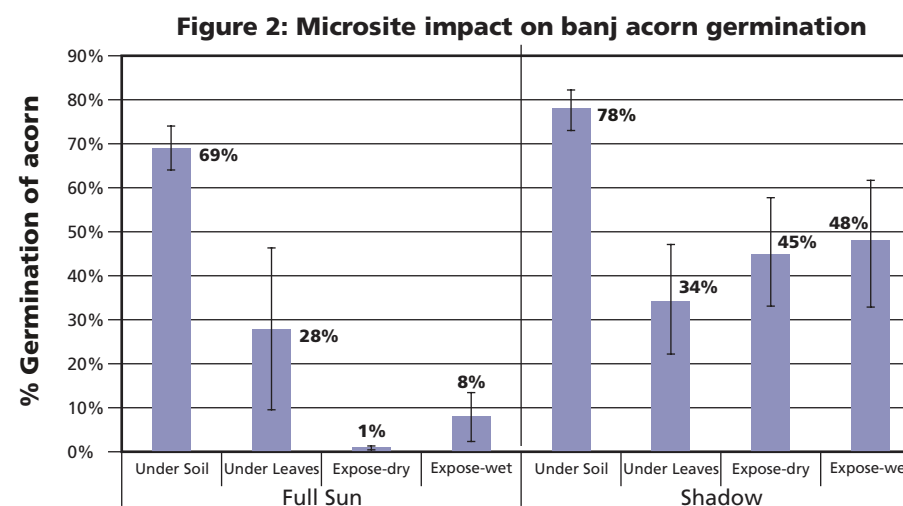
## Impact of Microsite:

The protection of acorns from sun and predation by birds and rodents through burying of acorns is important to ensure successful germination. Experiments show that less than 1% of the acorns of banj that fall from the tree germinate if left undisturbed under a variety of sites. Acorns that were protected and buried under soil showed an approximately hundred fold higher germination rate (over 80% germination).

Acorns were germinated under four different conditions as shown in figure 1. One group was buried under about an inch (2.5cm) of soil; a second group was covered with a layer of leaves approx to the same depth (2.5cm) while two groups were left exposed on the soil surface. One of these was watered on alternate days



while no watering was done in the second group. These experiments were carried out in both shaded and sunny conditions and was replicated five times over a two year period. The results in the case of banj oak are shown in the graph (figure 2) below:



This clearly demonstrates the adverse impacts of sun and desiccation (drying) on banj acorn germination. Under sunny conditions germination was very poor unless acorns were buried in soil, though acorns covered by leaves showed moderate germination in some cases. Under shaded conditions the differences in microsite were less apparent. Tilonj acorns also showed similar trends though the differences were less significant.

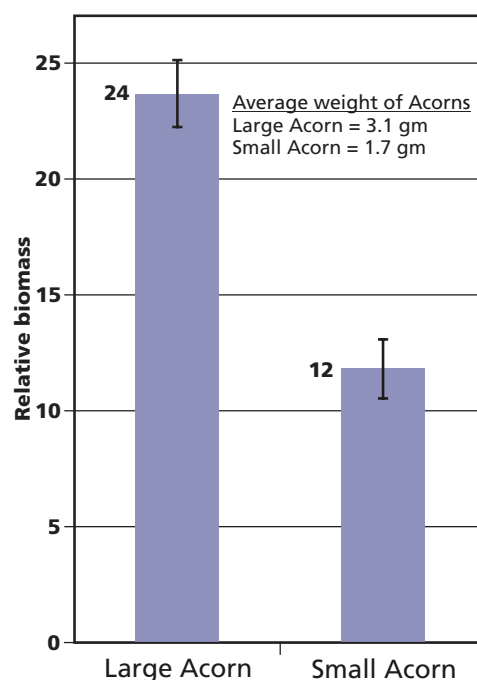
**Learning: For good germination rates, acorns must be buried under soil and not left exposed.**

### Impact of Acorn Size:

In both banj and tilonj there was a slight, though not significant impact of acorn size on germination. While larger and heavier acorns showed a slightly higher germination rate (approximately 10% higher), the difference was not statistically significant when repeated across several trials.

However, early growth was significantly influenced by acorn size. In both oaks after 6-8 months growth, seedlings originating from larger acorns were almost twice the size of seedlings that originated from smaller acorns.

**Figure 3: Relative biomass of banj seedlings (grown in full sun for 6 months)**



**Learning: Choosing larger acorns is beneficial as the more abundant food reserves allow for faster growth rates of the seedling.**

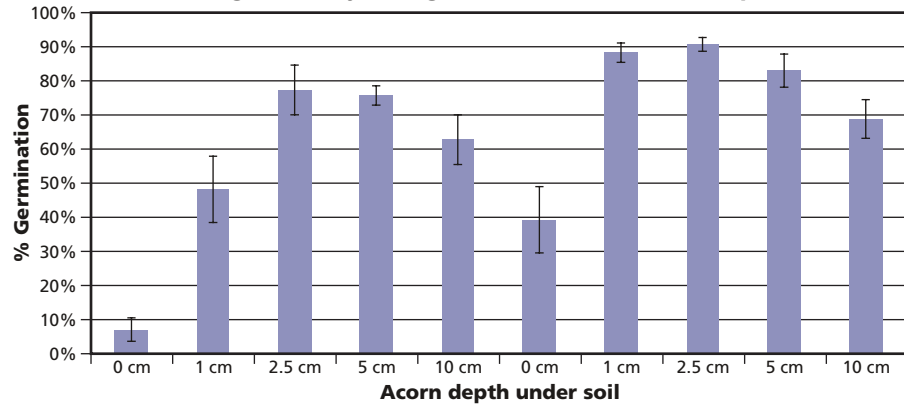
### Impact of Planting Depth:

In nurseries, acorns are typically planted about 1-2cm under the soil surface. However under field conditions a planting depth that is slightly greater is recommended. In exposed conditions (sunny sites) acorns of banj show highest germination and survival at slightly greater planting depths, viz about 2.5 cm (1 inch) below the soil surface. At shallow burial depths, in exposed conditions, acorns are susceptible to drying out. It was also found that planting depth does not need to be very exact. A depth of between 2cm – 8 cm below the soil surface is suitable for banj acorns with 2.5-5cm (1-2") being optimal. In shady or protected sites, a planting depth of 1cm is suitable.



Tilonj acorns do best when planted at slightly shallower depths than banj, and between 1-5cm under the soil surface is optimal.

**Figure 4: Banj acorn germination % at different depths**



In all cases, acorns buried at greater depths emerge later than those buried at shallow depths. Acorns buried at 10cm depth take on average three weeks longer than those buried at 2.5cm depth to germinate and for the plumule to emerge from the ground.

**Learning: Bury banj acorns 2-8cm (optimal 2.5-5cm) below the ground surface in sunny sites. In shady sites for banj, and for all sites for tilonj a depth of 1-5cm is suitable. Acorns buried more deeply take longer to emerge. Burying slightly deeper is advised if direct sowing of banj is carried out much before the monsoon as this helps delay emergence of seedlings.**

### Impact of Orientation:

It is commonly believed that acorns should be planted flat to maximise germination. It is thought that acorns planted in an inverted position (with apex pointed downwards) do not germinate. Experiments to test this hypothesis showed that orientation has no impact on germination and inverted acorns germinate with as much success as acorns that are planted straight. However inverted acorns germinate a few weeks late compared to those planted flat or with their apex upwards. Acorns planted with their apex pointed upwards are more susceptible to drying out if they are not planted at sufficient depth.

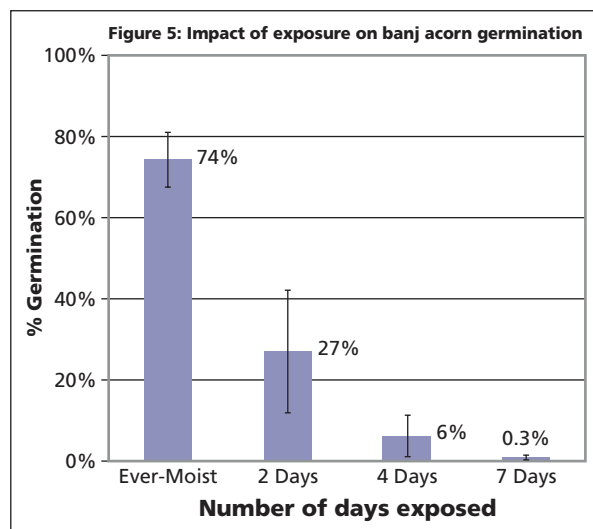


**Learning: If acorns are buried at the correct depth there is very little impact of acorn orientation on germination and early survival.**

## Impact of Exposure:

Acorns are susceptible to drying when left exposed in the sun. Acorns exposed to sunny conditions for even a few days show greatly depressed germination rates. After a weeks exposure to sunny conditions, acorns almost completely lose their viability and will not germinate.

Learning: **Acorns must be protected from prolonged exposure to direct sunlight and should be kept moist. Drying out of acorns will result in lowered germination rates.**



## Impact of site quality on early growth:

While depth, orientation, temperatures etc have a lot of impact on germination time and success of acorns, equally important in any reforestation project is the growth rate of the seedlings. Overall, it was found that:

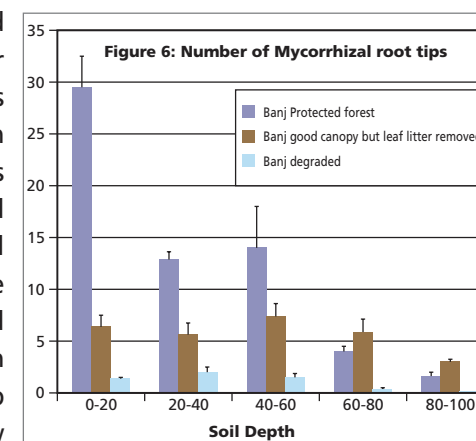
1. Light and moisture are the two main limiting factors to growth. In degraded conditions, where reforestation programmes are usually carried out, the forest understory is sufficiently exposed and light is not a constraint. Shortage of moisture in the dry season is thus usually the main factor limiting growth. While some nutrients, in particular phosphorus, were found to be in short supply, it was the lack of water that had the most impact on growth.

2. Early growth of seedlings is better when soils are less compacted and moisture and nutrient regimes are better. For a given light condition, forest soils lead to better growth than soils in degraded plots where grazing has resulted in soil compaction.
3. Oaks are associated with certain fungi in a mutually beneficial relationship. This association, known as mycorrhizae, help seedlings in the gathering of moisture and nutrients (such as phosphorus). Studies show that disturbed plots had reduced levels of mycorrhizal root tips. The number of mycorrhizal root tips and the ratio of mycorrhizal / non-mycorrhizal roots decreased from a protected forest to one where leaf litter removal occurred and was minimal in degraded oak forests.

Lowered mycorrhizae in disturbed conditions is indicative of greater susceptibility to water stress as these fungi help the plant in water absorption. Degraded sites are also usually more exposed and hence water stress in surficial layers is likely to be even more acute. This supports the need for soil and water conservation works in sites being taken up for reforestation. Shallow

pits; narrow, low cost contour trenching; and small scale bunding are likely to be effective in enhancing soil water while being relatively inexpensive (albeit short lived measures). These are likely to help raise seedling survival and early growth over the initial few years and allow for the oak root system to penetrate deeper soil layers after which drought stress is less likely to be a problem.

Learning: **Degraded sites are likely to be dryer and seedling growth is impacted due to this lack of moisture. Lowered beneficial association known as mycorrhizae further accentuate the drought stress. This makes soil and moisture conservation works such as contour trenches, terraces and bunding important measures to help reduce seedling mortality and enhance early growth.**



## DIRECT SOWING OF OAK ACORNS:

Two common techniques of direct sowing were tried out and found to be suitable. These are described below:

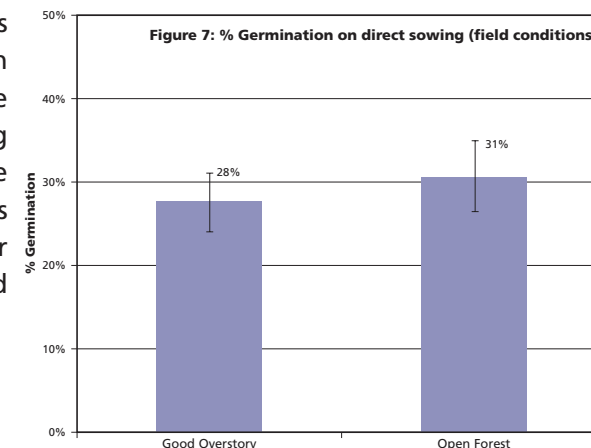
1. Direct sowing through dibbling: Direct sowing of acorns was carried out in a crude way by dibbling acorns approx 3-6 cm below the soil surface using a sabbal (essentially a heavy iron rod with a tapered end) to make this hole. This method is not optimal as it results in soil compaction around the



acorn and it is also difficult to control for depth of planting. However, such conditions do replicate actual field conditions. The sabbal is rammed into the ground with a very light force so as to make a pit approx 3-7 cm deep. As sabbals are typically used to make much deeper holes in the ground, care must be taken not to use excessive force but rather let the weight of the sabbal create the pit. Force required varies with soil conditions but most locals, having used this tool, have no problems making a pit of the right depth. 2-3 acorns are lightly dibbled into each hole and covered loosely with soil.

Germination rates of approx 30% were observed which are satisfactory. When two acorns are planted per pit, it can be expected that over 50% of the pits will show seedlings. A planting density of approximately 3,000 pits per hectare is appropriate. Given the very low cost of each pit made

in this manner, this method of reforestation costs well below 10% the costs of nursery raising and planting. While the graph below shows results for banj, similar results were observed for Tilonj oak as well.



NGO's such as HIMCON have tested direct sowing through making of small pits approximately 1 foot across and 1 foot deep. While the time taken to make such pits is much greater, the reforestation cost would still be approx 10-15% that of nursery raising and these pits result in much better growing conditions for the young seedling.

A sample of tilonj acorns were also tested under field conditions. Germination was found to be between 20-40%.



**Direct seeding through making of a pit:  
This results in better early growth of seedlings**

**Key findings and recommendations:**

Direct sowing is a low cost technique that can be used to afforest degraded land when species with large seeds, such as oaks are to be used. The main advantage over nursery raising is the savings in cost as this method is about a tenth as expensive as nursery raising and planting.

Direct sowing also helps focus the attention of the community on the geographical area or plot which is to be protected. It can be used as a tool for gathering the community and can be an effective community motivation technique comparable to nursery raising and planting.

The essential points while carrying out direct sowing of acorns are:

1. Select large and healthy acorns that have been properly stored and are free of weevil infestation.
2. Cover the acorns with soil so as to protect them from drying out. Banj acorns planted in exposed sites should be covered by 2.5-5cm (1-2") soil while under shady conditions and for tilonj acorns even 1cm soil cover is adequate.
3. Orientation of acorns does not matter as long as sufficient soil is used to cover the acorns.
4. Plant 2-3 acorns per pit to ensure adequate germination.
5. Protect acorns from prolonged exposure to sun and keep them moist.
6. Water conservation measures such as contour trenches, percolation pits and bunds, which help increase soil moisture will also increase survival and growth of seedlings and such measures should be given due attention.

For further information or access to the complete study report please  
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