Sand Dune Rehabilitation in Thal, Pakistan[1]

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Highlight

Rangeland improvement in Thal, Pakistan through reseeding was started in 1962. These operations were impressively successful on heavy soil valley flats but loose sand dunes defied all efforts of sowings. These dunes have been successfully rehabilitated through planting tufts of *Cenchrus ciliaris* (dhaman) and *Elyonurus hirsutus* (karera). On better sites, grasses seeded in flats are spreading naturally to the dunes. Under "Thal Technique of Planting Trees" more than 100,000 fodder trees have been transplanted successfully since July 1964 in earthen tubes (baked) without watering. Experiments to determine effects of exposure and different competition levels on height growth of *Zizyphus jujuba* (ber) are presented. Southeastern (leeward) exposures have been found to be significantly (highly) better than tops and northwesterly (windward) exposures. The minimum plant competition level gave significantly (highly) more height growth than the other three levels.

Rehabilitacion de las Dunas de Arena en Thal, Pakistan

Resumen

El mejoramiento de los pastizales en Thal, Pakistán por medio de la siembra, fue iniciado en 1962. Se obtuvo un éxito impresionante en las siembras hechas en valles planos con suelos pesados, pero en las dunas de arena suelta todos los esfuerzos por sembrar resultaron fallidos. Sin embargo, dichas dunas han sido rehabilitadas exitosamente por medio del transplante de macollos de *Cenchrus ciliaris* y *Elyonurus hirsutus*. Los zacates sembrados en los valles están invadiendo en forma natural las dunas.

Los pastizales de verano en Thal tienen zacates verdes disponibles por seis meses únicamente; a excepción de *Elysine flagellitera* en general durante su dormancia dichos zacates no mantienen un alto valor nutritivo. Tradicionalmente durante el invierno la principal fuente de alimento es el ramoneo. Los árboles de ramoneo se presentan como fuente esencial de abastecimiento de forraje durante todo el año, su aumento estable por medio de técnicas de plantación es entonces un problema mayor en el área.

Una técnica conocida como "técnica Thal para plantar árboles" ha probado tener mucho éxito en ciertas especies de árboles bajo situaciones específicas. La técnica incluye la construcción de tubos de arcilla cocidos, con una longitud de 30 cm (1 pie) y con un diámetro de 11.25 cm (4.5 pulgadas). Las especies deseadas son plantadas en los tubos en invernaderos para que posteriormente cuando tengan sus raíces y follaje adecuadamente desarrollados sean transplantados en el campo. El propósito del tubo es proporcionar a la planta un medio en el cual pueda sobrevivir hasta que pueda tomar ventaja de la humedad existente en la arena de las dunas, siendo entonces el tiempo de plantación el factor mas determinante. Se encontró que el transplante no se deberá intentar hasta que haya humedad adecuada en 30 cm (1 pie) en el estrato superficial del suelo.

Las plantaciones de *Prosopis spicigera* han sido las de mas éxito, otras especies fueron susceptibles a la destrucción por insectos.

Las plantaciones de exposición sureste fueron significativamente mejores que los realizados en exposición noroeste y en la cima de las dunas. Una mínima competencia con las plantas dio un crecimiento en altura significativamente mayor.

The tract Thal, covering 5 million acres, lies between latitudes 30°–32° N. and longitudes 71°–72° E. It is an alluvial formation with sandy loam to clayey soil in valley flats which are interspersed with loose sand dunes. The region is characterized by an extreme continental desert climate i.e., high temperatures (120 F) meager monsoon rainfall (9 inches) and severe wind storms in summer, low temperatures in winter (less than 32 F). This, a great potential range area, has been depleted due to uncontrolled interference by man and his livestock since very old times. Efforts to reestablish better grass cover through reseeding were started in 1962. The reseeding works on valley flats have already been published (Khan, 1965, 1966). The present paper presents the efforts to establish grasses and trees of fodder value on loose sand dunes where failures followed the usual reseeding operations.

Forty to sixty percent of this tract consists of

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FIG. 1. Tufts of *Elyonurus hirsutus* and tube plants of *Zizyphus jujuba* (fodder tree) planted on active loose sand dunes at D. kotli, Thal. Planted July, 1964; photo August, 1964.

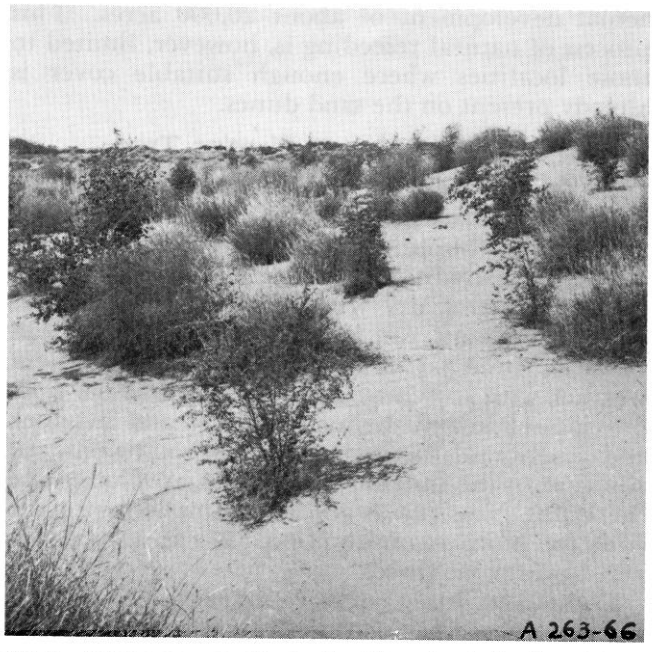

FIG. 2. Same area as in Fig. 1, after 85 weeks of planting. Photo, March, 1966.

loose sand dunes with inadequate vegetal cover of species of low forage value. Not only the grasses of good forage value have disappeared but the trees of fodder value have also been continuously browsed by camel and lopped heavily to feed sheep and goats in winter. The social economic conditions of the population resulted in ruthless cutting of trees for firewood. The traditional rain-fed cultivation has been responsible for much of the blowing sands and shifting sand dunes. Khan (1966) reporting on the effect of site on success of reseeding in Thal, observed that slopes and dunes could not be reseeded properly with the available practices. He concluded that reseeding operations in Thal should be confined to flats.

In order to rehabilitate these loose sand dunes a two-pronged attack was made. Where better grasses were established through "tuft planting," a new technique called "Thal Technique of Planting" was evolved to establish trees of range value on the sand dunes.

Tuft Planting and Reseeding

Grasses dug with at least a 9-inch root system and 6 inches above the collar were termed "tufted." This operation was specially needed to cover sand dunes where sowings had not been successful. In order to tackle the problem of severe winds and loose textured sands, the tufts of *Cenchrus ciliaris* (dhaman) and *Elyonurus hirsutus* (karera) were planted. Plantings (since 1963) have been made successfully during spring as well as monsoon showers. Spacings of 5 × 5, 10 × 5, and 10 × 10 ft have been tried. Where the success percentage has varied from 10% to 80% "time elapsed between uprooting and planting of these tufts" and "the time of planting with respect to rainfall" have been the determining factors for its success (Khan, 1966). Tufts planted in rainfall or within 24 hours after rainfall gave 80% success. Areas where the tufts received the second shower soon after the planting gave a very high percentage of success. The very fact that the success of this operation depends upon the most opportune time and rainfall, which is often very short, renders this operation of limited application. Tuft planting has been extended on larger and extensive areas. If labor and the tuft sources would be managed and rainfall could be duly predicted, the operation can be adopted with success. By 1966, this operation had been attempted on about 2,000 acres (Figs. 1 and 2).

The tufts which had been overgrazed did not give a high survival percentage as compared to the tufts with greater aerial parts dug out from our pastures.

Topography lends a peculiar aspect to Thal ranges. Shrubby vegetal cover on sand dunes renders natural reseeding possible. Actual seeding is done on flats covering 40 to 60% of the total area. Seed disseminated by wind from such reseeded areas lodges in bushy and shrubby growth on sand dunes. They provide not only the much needed protection but underneath a good seed bed where humus mixes with loose soil. Thus dhaman and karera are coming up naturally on such dunes. So seeding of 10,000 acres of Thal ranges means the

actual development of about 20,000 acres. This process of natural reseeding is, however, limited to those localities where enough suitable cover is already present on the sand dunes.

Thal Technique of Planting Trees

In summer ranges of Thal, green grasses are available for six months only. Except for *Eleusine flagellifera* (chhimber) grasses do not cure well. People have traditionally been depending on fodder trees during dry winters. Trees, being more drought resistant, can better face the years of lean rainfall. In Thal, a tract marked by inclement weather with scorching and stormy summers, trees provide shade and shelter to grazier and livestock and ameliorate the general living conditions. In addition to the nutritious fodder, *Zizyphus jujuba* (ber) and *Zizyphus nummularis* (mallah) provide fruit for human consumption. Ber is also a suitable host for lac insect.

Loose sand dunes conserve moisture. Even after six months of the monsoon rainfall (in July and August), moisture in sand dunes is available at 10 to 12-inch depth. The technique, therefore, aimed at the effective utilization of this moisture. After planting, no watering was done. The technique was first tried in July 1964 and by 1967 more than 100,000 transplants have successfully been made.

Earthen Tubes.—One foot long, 4.5 inches in diameter, open on both ends, earthen (baked) tubes are used to raise plants in the nursery. The tube tapers slightly towards the bottom, and ensures holding the soil. Four holes 0.25-inch in diameter are made in the tube shell to provide drainage and aeration. The tube shell is 0.5 inch thick. The length of the tube ensures one-foot long root system of the plant before transplanting.

Tree Species.—Ber, mallah and *Prosopis spicigera* (jand) have been successfully tried. Jand, being a relatively slow growing species, large scale planting has been done with the former species only. Similarly transplanted rooted cuttings of *Tamarix articulata* could not survive. They are invariably attacked by white ants.

Planting Season.—As absolutely no watering is done after planting, rainfall is obviously the limiting factor. Monsoon season (July and August) has been found to be the best. Planting was also tried in spring (March–April) showers of 1965. Even unusually good spring rains did not give a survival of more than 5%. Subsequent drought and high soil temperatures of summer (May and June) killed the survivals.

Planting Time.—Time of planting is one of the most important factors. Every effort must be made to complete planting within 48 hours and preferably within 24 hours of a real good rainfall. However, if nursery beds be irrigated prior to the transfer of tube plants, the period of planting can safely be extended up to 72 hours. Unless the top one-foot sand layer is wet, planting must not be undertaken. This is to ensure proper soil moisture and humidity conditions for the plants newly transferred from nursery conditions. Also, the root system of the tube-plant can utilize moisture only if it be available at a one foot depth.

FIG. 3. Close up of ber transplant after planting. Note "shelter" provided against blowing sands. Planted and photo, July, 1964.

Planting Site.—Flats with heavy soil are unsuitable; only loose sandy sites should be selected for planting. The more sandy the site the better it is.

Planting Technique.—Survival of plants in the earthen tubes was compared with the success of those whose tubes were broken immediately before planting. The observations were continued for 20 months i.e., July, 1964 to April, 1965. The higher survival under the former technique was highly significant. Careful planting under the former technique may give a survival 95%. The former technique has therefore been generally adopted with great success. Vertical narrow holes are dug out at a point preferably clear from bush growth and grass clumps. The tube plant is then carefully placed in it. The soil (sand) is then refilled and pressed. Top of the tube should be at least four inches below the dune surface. The transplants should preferably be 1.5 to 2 ft high before transferring from the nursery.

Shelters.—The desiccating impact and abrasive action of sand-laden summer storms seriously damage the tender leaves of the young plants. The plants already being under moisture stress, may often succumb to the onslaught of wind storms.

FIG. 4. Windward exposure of sand dune (same as Fig. 5). Winds have blown away sand layers; also note stunted fodder plants (*Zizyphus jujuba*). Planted July, 1964; photo March, 1966.

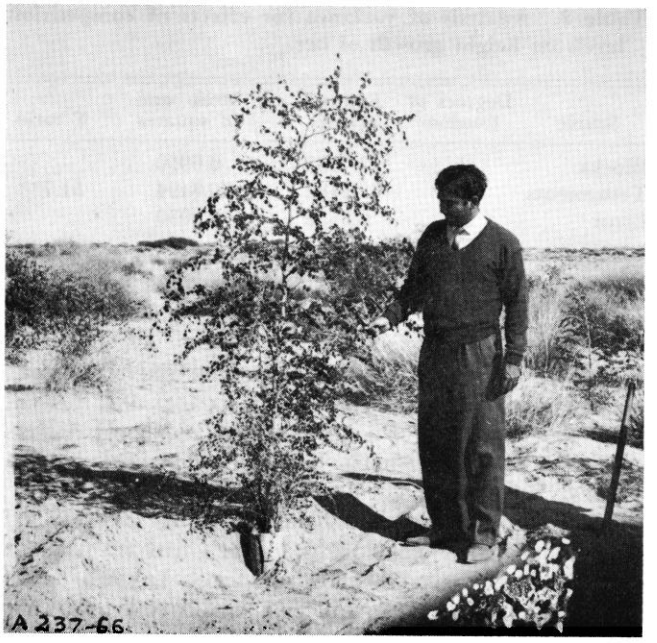

FIG. 5. Leeward exposure of the same dune as in Fig. 4. Tree height 9.5 ft. Planted July, 1964; photo January, 1966.

Plants without guard shelters showed high mortality. The shelter is also known to at least reduce the frost effect usually experienced in Thal. They also cut the moisture losses. The shelters are therefore provided during the first year (Fig. 3). The shelters are made of local vegetal material, conical in shape with a vertical opening facing east. This not only ensures sufficient sunlight but also protects the young plant from severe northwestern wind storms.

Growth of Transplants

Moisture is the limiting factor in these desert ranges. There is a characteristic rainfall gradient within Thal. There is a linear increase from the southern most apex (at M. Garh) towards the northern base (foot of salt range) of the great triangle of Thal. Other site conditions remaining the same, environmental factors are more favorable in the northern half than those of the southern half. Where ber plants grew to the maximum height of 4.5 ft in Shergarh, maximum heights attained in 20 months at Chubara and Dagarkotli were 9.5 and 10 ft, respectively.

Effects of Exposure on Height Growth of Ber.— Corresponding to the prevalent direction of wind storms in Thal the sand dunes form a regular pattern from NNE to SSW. The study was conducted to determine the effects of three typical exposures i.e., northwestern, top, and southeastern, on height growth of ber transplants. The experiment was laid out as a completely randomized design with three treatments and ten replications. The experimental sites (in Dagarkotli project) were cleared of all the vegetal cover with a D-4 dozer. The natural form of dunes was not disturbed. Slopes on northern and eastern exposures averaged 10 and 18%, respectively. The area was fenced. To ensure uniform planting stock, the ber plants were grouped into one-inch height classes of 18, 19, 20, and 21 inches. They were so grouped that each plot had a comparable group of 12 plants. Allocations of such groups of tube plants to each plot was made at random. The planting was done at 15 × 15 ft spacings. Each plot had an area of 90 × 30 ft. The planting was made on July 15, 1964. Final height measurements were made on March 1, 1966 i.e., 85 weeks after planting. Height was measured from the collar of the tube to the top of the leading shoot and measurements recorded were to the nearest half inch. The mean heights on northwestern, top and southeastern exposures were 3.08, 3.89, and 6.33 ft, respectively (Figs. 4 and 5).

The analysis of variance (Table 1) showed that

Table 1. Analysis of variance for effects of exposure on height of growth of ber.

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F ratio
Treatments	2	25.813475	12.906737	8.896**
Error	27	39.169138	1.6507	
Total	29	64.982613		

** P = 0.01.

Table 2. Analysis of variance for effects of competition levels on height growth of ber.

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F ratio
Blocks	5	3.4753	0.6950	
Treatments	3	62.5482	20.8494	51.7**
Error	15	6.0558	0.4030	
Total	23	72.0793		

** P = 0.01.

increased height growth on eastern exposure was highly significant as compared to top and northwestern exposure. There was no significant difference in height growth between top and northwestern exposure.

Effects of Competition on Height Growth of Ber.—This study was conducted at Chubara project of Thal from July 22, 1964 to March 1, 1966. The randomized block design was employed to block the sites at different exposures of the sand dunes. Twenty tube plants grouped as mentioned before, were planted in each experimental plot of 200 × 40 ft. Planting spacings were 20 × 20 ft. The entire area was fenced. The four competition levels applied as four treatments were:

U. Dune untouched. Old grass clumps of fitsain (*Pennisetum* spp.) were present within 5-ft radius of the tube plant.

U5. Dune untouched. Old clumps of fitsain were stubbed out from within 5-ft radius of the tube plant.

D. Dune cleared of all grass clumps with bulldozer (D-4). Tufts of *Elyonurus hirsutus* (karera) were planted at 10 × 10 ft spacings with tufts within 5-ft radius of the tube plants.

D5. After preparation as in D., tufts were planted so as to leave a clear space of 5-ft radius around the tube plant.

The mean height of ber plants under treatments U, U5, D, and D5 were 2.4, 2.61, 5.05, and 6.20 ft, respectively. The analysis of variance (Table 2) shows that D5 was the most effective and highly significant. D was highly significant as compared to U5 and U. There was no significant difference in height growth between U5 and U.

Discussion

Due to severe microclimatic factors and blowing sands on these active sand dunes of Thal ranges of Pakistan, sowings and seedings of grasses did not succeed. Such areas when planted with tufts of dhaman and karera were successfully covered by better grasses of great forage value. Proper time and season of planting, proper amount of rainfall and technique of planting is the key to the success of this operation.

FIG. 6. Earthen tube (baked) broken by growth pressure of *Zizyphus jujuba*. Planted July 15, 1964; photo March, 1966.

The establishment of seeded grasses from windblown seed depends on the site factors of the sand dunes. If dunes are relatively stable and there is enough of shrubby cover over them the natural propagation may be satisfactory. On other places, however, seed may not get protection from blowing sands. On such active spots, tuft planting is the answer.

Tube planting seems to have some advantages over planting without tubes. In the former case the root system remains undisturbed and intact. As the tube plant, with one-foot root system already developed, has moisture available only on the downward open end of the tube, it is not unlikely that roots in search of moisture should have a stimulus to elongate only downward. This might help in development of a deeper root system and ensuring better survival conditions. The top 10 to 12 inches of dry soil in sand dunes during drought may not have any appreciable effect on tube plant. By the time the plant grows higher and the critical period has been successfully overcome, the growth pressure has been observed to break the earthen tubes automatically (Fig. 6). The plants with collar girth of five to six inches usually break the tube more or less vertically.

After 12 months, a tube plant with 10 inches of bare tube standing above the dune surface is not uncommon (Fig. 4). This is specially true on northwestern (windward) exposures. Thus an earthen tube by providing mechanical support enables the plant to face the moving sand blows.

The impact of sand-laden winds seems to be the main factor in reducing growth rates on northwestern exposures as well as on the tops. The direct impact of desiccating winds not only blows off top soil but also results in quicker loss of moisture conserved in sand dunes. Under desert conditions of Thal even a little loss of moisture may make a great difference. That is why eastern exposures are relatively safer and better sites for height growth of ber.

The study of four different competition levels suggests moisture to be a critical factor. The massive root system of old clumps of fitsain seem to use most of the moisture. New tufts even planted within 5-ft radius of tube plant did not offer as much competition for moisture as the old well-established clumps. However, the lowest competition level represented by complete removal of old clumps and no new tufts within 5-ft radius gave the maximum height growth of ber.

Conclusions

Where sand dunes are active, sowings of grasses may not be successful. Alternative practices of surface stabilization may be too costly to apply over extensive desert ranges of Pakistan.

If done properly, tuft planting is a reasonably sure method of establishing vegetal cover on active sand dunes. The operation is relatively economical. Under Thal conditions, its cost is Rs. 12.00/acre.[3]

Ten to 25 fodder trees/acre of dunes will not only ameliorate the general environment but also be a dependable fodder source in winter. As no watering is done after planting, the operation is extremely economical. Under Thal conditions the total cost of planting fodder trees does not exceed Rs. 75.00/hundred plants.

For better height growth, ber should be transplanted on southeastern (leeward) exposures. Even tops may be slightly better than northwestern exposures. If possible, the 5-ft radius around the ber plant should be cleared of all vegetation. To avoid wind erosion on sensitive spots, tufts of karera or dhaman may be planted without much harmful effects on height growth of ber plants. Ber, being a fast growing species, should be able to check wind erosion within two years.

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[3] $1.00 U. S. = Rs. 4.76. Labor cost under Thal conditions is Rs. 0.50/man hour.