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Farmers' Perception Towards Shelterbelts in Hot Arid Regions of Rajasthan: an Analysis by Garrett's Ranking Technique

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ABSTRACT

Shelterbelt plantations are one of the biggest ecofriendly technologies to address wind erosion, control sand movement and related problems in the arid areas, which cover 12 per cent of India and more than half of Rajasthan. However, the role of shelterbelts in arid agriculture is changing. A survey was undertaken to investigate the farmers' perception toward field shelterbelts/windbreaks and its impact in farmers' fields in the arid district of Bikaner, Rajasthan. Questionnaire, group discussion and observations were used for data collection. The respondents of the study were the farmers having already established shelterbelts in their farms. The study revealed that farmers were using windbreaks on agricultural lands mainly to protect crops from strong winds, provide shade to livestock, reduce crop damage from frost and cold winds, reduce soil erosion etc.; while the biggest challenge was the competition by trees to the crops growing below them. The farmers' preference for tree species was also noted to have changed over the years. Though old shelterbelts were mainly of Acacia tortilis, farmers now prefer Dalbergia sissoo (45 per cent prevalence), since it does not affect crop growth and for its economic timber value. Other species like Zizyphus sp., Eucalyptus sp., Cordia myxa etc. when used as shelterbelts provide fruits and fuelwood which provide additional income to farmers.

Keywords: Arid regions, erosion control, farmers' perception, garrett ranking, shelterbelts,

INTRODUCTION

The arid zone covers about 12 per cent of India's total area, with nearly 62 per cent in Rajasthan. Western Rajasthan's hot arid region, including Bikaner, is a delicate ecosystem resulting from continued effects of intense heat, low rainfall, high evaporation and wind speeds, low humidity, poor soil conditions, high biotic pressure, etc. The un-conducive environment limits agricultural activities. Sand dunes, mainly of transverse and parabolic types occur in 57.9 per cent area and much of the transverse dunes are cultivated (Moharana *et al.,* 2013). Having plant and crop cover in most tropical arid lands without afforestation and trees support is almost impractical. Several interventions have been undertaken to control the direct and indirect impacts of wind erosion. Afforestation through shelterbelt techniques is one of the best methods developed for this purpose in the arid regions of Bikaner in Rajasthan. Shelterbelts are plantations with single or multiple trees and shrubs, established in rangelands, cropland, roadside, etc. in order to reduce the velocity of wind. The planting of shelterbelts in uniform rows perpendicular to the direction of the prevailing winds, act as windbreak and protect vegetation and soils on the lee side against wind damages. Their efficiency depends on height, density, width, length, canopy, tree species and nature of wind (Santra *et al.,* 2016). Selection of tree species is also an important criterion while establishing shelterbelts. Those species with faster growth rate are preferred for establishing shelterbelts. Apart from lowering air temperatures and increasing humidity, shelterbelts have also been reported

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to improve soil organic carbon and reduce evaporation (Mertia *et al.* 2006, Alemu, 2016). All these factors have been reported to improve and sustain agricultural production near these plantations. Recent years have seen changes in the perception about these shelterbelts or farm windbreaks. In the past, shelterbelts have been promoted and adopted to reduce soil erosion, for sand dune stabilization and to shelter farms and livestock from harsh climates. Changes in production techniques accompanied with increased access to irrigation and changes in government policies have contributed to a shift in how shelterbelts are considered within the field by farmers.

Extreme temperatures accompanied by high wind velocity, make shelterbelts essential to reduce sand movement and crop establishment in the hyper arid region of Bikaner, Rajasthan. Shelterbelt plantations have been an age-old practice in Bikaner district for sand dune stabilisation and afforestation. Several shelterbelts can be seen in and around Bikaner with different tree species and characters. The slow growing nature of indigenous tree species (such as Dalbergia sissoo, Tecomella undulata, Azadirachta indica) required the use of exotic tree species such as Eucalyptus, Acacia and other genera in past for faster control of sand movement and wind erosion. In the future, these windbreaks are expected to become ever more vital as the regional impacts of global warming become more known, both for sequestering carbon and to suppress the negative agricultural impacts relating to reduced soil moisture and increased likelihood of erosion.

In this study, a survey was undertaken in Bikaner district of Rajasthan, with the objective of identifying the existing shelterbelts, assessing the trends in establishment, as well as the farmer's perception on the benefits and drawbacks from adoption and retention of shelterbelts on their fields and crops.

METHODOLOGY

An exploratory survey was conducted of shelterbelts or field windbreaks in farmers' fields in Bikaner district of Rajasthan during 2017-2019. All respondent farmers (71 farmers) from the surveyed areas were having established shelterbelts in their farms. For the purpose of this manuscript, data gathered during survey included the respondents' demographic details (age, education level, land holding size, experience in farming), shelterbelt characteristics (tree species preferred, plantation age) and the farmers' perceptions towards benefits and drawbacks due to adoption of shelterbelts. Data was analyzed, tabulated and interpreted for drawing the conclusion of the study. Statistical measures like frequency, percentage and rank were used to draw meaningful inferences.

The Garrett ranking method was used to study the opinions of the farmers regarding the benefits and drawbacks from the shelterbelts or field windbreaks. The percent position of each rank was found out by the formula:

$$\text{Percent position} \quad \frac{100\ (R_{ij}-05)}{N_j}$$

where, R_{ij} = Rank given for the ith items by the jth individual,

N_j = Number of items ranked by the jth individual

The percent position of each rank was converted into scores referring to the Garrett Ranking Conversion table. For each factor, the scores of individual respondents were added together and divided by the total number of the respondents. The obtained mean scores for all factors were arranged in descending order, ranks were assigned and most important factors were identified.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

The demographic details of the farmers from the surveyed area are given in Table 1. The demographic details can provide insight into the reasons behind the perceptions of benefits and challenges from shelterbelts/windbreaks. The data showed that majority of the respondents (59.2 %) belonged to the middle age group 41-60 years, followed by old age group (61 years and above) to the extent of 25.4 per cent. Younger participants (up to 40 years) constituted only 15.5 per cent of the total. The table also shows that 74.6 per cent of the participants had some form of education, with majority being educated up to secondary school (31 %) and 16.9 per cent being graduate. Greater part of the farmers had land holding above 5 and up to 10 ha (63.4 %), followed by 31.0 per cent having up to 5 ha, and 5.6 per cent having land holding over 10 ha. Also majority of the farmers (76.1 %) had been engaged in farming for 11 to 40 yrs. It can be observed that those farmers having more land were likely to plant trees as windbreaks in the farm. These results may indicate the changing role and importance of shelterbelts or field windbreaks in current times. Promoted and adopted in earlier times for managing the major problems like sand dune stabilization, wind erosion control and protection from harsh weather elements; however, advances in production technology and irrigation facilities and changes in landscape features over time, have changed the perception of farmers to these windbreaks in their fields. This change in farmers' preferences can be observed better from the change in tree species preferences as explained in later section.

Table 1: Demographic profile of respondents

n=71

Variable	Category	Frequency	Percentage
Age (years)	Up to 40	11	15.49
	41-60	42	59.15
	61 and above	18	25.35
Education	Illiterate	18	25.35
	Primary	19	26.76
	Secondary	22	30.99
	Graduate and above	12	16.90
Average land holding (ha)	Up to 5	22	30.99
	5-10	45	63.38
	More than 10	4	5.63
Experience in farming	Up to 10	10	14.08
(years)	11-25	30	42.25
	26-40	24	33.80
	More than 40	7	9.86

Farmer reported shelterbelt benefits and challenges

Benefits from shelterbelts

The benefits of shelterbelts as reported by farmers are abundant. For field windbreaks, farmers have reported the following benefits: protection from wind, crop protection, yield improvement, control of sand movement, provision of shade and wood, protection from stray animals (biofence), demarcation of land boundary, provision of fruits, fuel wood, fodder *etc.*

Farmers were asked to rank the benefits from the shelterbelts using the questionnaire, which was then analyzed by Garrett ranking technique (Table 2-4). A key finding from this analysis is that farmers in this arid region use windbreaks on agricultural lands mostly for indirect economic benefits (crop protection from hot or cold winds, livestock protection, soil erosion control). This is followed by direct economic benefits from forestry (timber, fruits, fuel wood). As per the table, protection of crops from strong winds was the most cited benefit with a Garrett score of 76.93, followed by protection of livestock from harsh climates, protection of crops from cold winds in winter and reduction of soil erosion. Adesina and Gadiga (2014) also cited shelterbelts as a necessary tool in vegetation development in semi-arid areas, protecting the soil against wind erosion, thus fighting desertification.

In a study carried out on similar lines in Sudan, El Amain and El Madina (2014) observed that farmers in the study area held positive attitudes towards the establishment of shelterbelts and were aware of their protective role. Also, the major benefits of shelterbelts given by respondents included reduction of crop damage due to winds, crop productivity increase and income generation. A review of the studies done on windbreaks in the United States (Smith *et al.,* 2021) also concluded from the work that producers use windbreaks on agricultural lands mostly for indirect economic benefits, followed by agricultural benefits (increased crop and livestock production) and intrinsic values (aesthetics and wildlife habitat).

However, a study done on the shelterbelts in Jaisalmer district of Rajasthan (Mertia *et al.* 2006), the economic benefits that can be gained from the sale of timber was cited as the main reason for farmers planting shelterbelts in their field boundaries. They also noted the availability of additional fodder for cattle, and improvement of surrounding micro-climate, as other advantages of these plantations.

Table 2: Ranking of benefits from shelterbelts as perceived by farmers

Benefits perceived by farmers	Ranking by respondents (n=71)									
	1	2	3	4	5	6	7	8	9	10
Reduce damage to crops from heat in summers	0	11	0	0	9	6	26	19	0	0
Extra income to the famers through selling of timber, fruits *etc.*	0	16	1	36	0	1	0	0	17	0
Provide fire wood	0	0	0	1	0	9	8	15	0	38
Protect fertile top soil from blowing away	11	0	16	1	7	10	17	9	0	0
Add litter to soil improving fertility and soil quality	0	0	17	0	0	27	1	15	11	0
Increase productivity of agricultural crops by temperature and moisture regulation	0	0	0	0	11	0	0	0	27	33
Provide shade to crops and livestock	8	26	10	16	0	0	11	0	0	0
Reduce damage to crops from strong winds	52	8	0	11	0	0	0	0	0	0
Protect the field from stray animals	0	0	9	6	11	17	0	11	16	1
Protect crops from damage due to frost and cold winds	0	10	18	0	34	0	9	0	0	0

Table 3: Computation of Garrett value

	Rank									
	1	2	3	4	5	6	7	8	9	10
Percent position $[100(R_{ij} - 0.5)/N_j]$	5	15	25	35	45	55	65	75	85	95
Garrett Value	82	70	63	58	52	48	42	37	29	18
Factors	Rank 1 *82	Rank 2*70	Rank 3*63	Rank 4*58	Rank 5*52	Rank 6*48	Rank 7*42	Rank 8*37	Rank 9*29	Rank 10*18
Reduce damage to crops from heat in summers	0	770	0	0	468	288	1092	703	0	0
Extra income to the famers through selling of timber, fruits etc	0	1120	63	2088	0	48	0	0	493	0
Provide fire wood	0	0	0	58	0	432	336	555	0	684
Protect fertile top soil from blowing away	902	0	1008	58	364	480	714	333	0	0
Add litter to soil improving fertility and soil quality	0	0	1071	0	0	1296	42	555	493	0
Increase productivity of agricultural crops by temperature and moisture regulation	0	0	0	0	572	0	0	0	783	594
Provide shade to crops and livestock	656	1820	630	928	0	0	462	0	0	0
Reduce damage to crops from strong winds	4264	560	0	638	0	0	0	0	0	0
Protect the field from stray animals	0	0	567	348	572	816	0	407	464	18
Protect crops from damage due to frost and cold winds	0	700	1134	0	1248	0	378	0	0	0

Table 4: Ranking of shelterbelts' benefits as per Garrett ranking technique

Benefits perceived by farmers	Total score	Mean Garrett score	Garrett Rank
Reduce damage to crops from heat in summers	3321	46.77	VI
Extra income to the famers through selling of timber, fruits *etc*.	3812	53.69	V
Provide fire wood	2065	29.08	IX
Protect fertile top soil from blowing away	3859	54.35	IV
Add litter to soil improving fertility and soil quality	3283	46.24	VII
Increase productivity of agricultural crops by temperature and moisture regulation	1949	27.45	X
Provide shade to livestock and crops	4496	63.32	II
Reduce damage to crops from strong winds	5462	76.93	I
Protect the field from stray animals	3192	44.96	VIII
Protect crops from damage due to frost and cold winds	3980	56.06	III

Challenges due to shelterbelts

A ranking was done through Garrett method (Table 5-7) of the constraints or difficulties faced by farmers due to the windbreaks on crop and farm. The major drawback was crop losses due to competition from the trees and due to damage by bird that nest on these plantations, with a mean Garrett score of 68.24 and 62.54, respectively.

These challenges may be addressed to some extent with proper irrigation management to avoid competition for moisture and pruning of trees so that birds may not nest on these trees, respectively. Some changes in forest laws and policy which allow farmers to sell mature trees, with the assurance that the cut trees will be replaced, may provide further incentive to promote this system of windbreak plantation in fields. In the study by El Amain and El Madina (2014), farmers showed interest in planting shelterbelts in their farms, despite the negative attitudes toward the notion that shelterbelts bring birds, insects and rodents, which damage crops. Kowalchuk and de Jong (1995) also reported competition for water to be the main reason for the reduced yields at the edge of the fields. A study by Kidanu *et al.* (2005) concluded that the Eucalyptus boundary plantation compensated for crop yield reduction, in financial terms, by provision of fuel wood. Bhardwaj *et al.* (2017) have also reported crop yield loss near Eucalyptus bund planting due to shading effect and competition for moisture and nutrients.

Table 5: Challenges from shelterbelt as reported by farmers n=71

Challenges from shelterbelt	Ranking by respondents				
	1	2	3	4	5
Shelterbelts harbor birds that damage crops	20	39	12	0	0
Compete with crops for moisture and nutrients, reducing crop yields	51	11	0	9	0
Cost of planting and protecting shelter belts is more than their monetary benefits	0	9	14	32	16
Administrative problems in harvesting and selling timber trees	0	0	44	15	12
Competition for light, thus affecting crop stand	0	12	1	15	43

Table 6: Computation of Garrett value

	Rank				
	1	2	3	4	5
Percent position [$100(R_{ij} - 0.5)/N_j$]	10	30	50	70	90
Garrett Value	75	60	50	40	25
Factors	Rank 1*	Rank 2*	Rank 3*	Rank 4*	Rank
	75	60	50	40	5* 25
Shelterbelts harbor birds that damage crops	0	770	0	0	468
Compete with crops for moisture and nutrients, reducing crop yields	0	1120	63	2088	0
Cost of planting and protecting shelter belts is more than their monetary benefits	0	0	0	58	0
Administrative problems in harvesting and selling timber trees	902	0	1008	58	364
Competition for light, thus affecting crop stand	0	0	1071	0	0

Table 7: Ranking of shelterbelts' drawbacks as per Garrett ranking technique

Challenges from shelterbelt	Total score	Mean Garrett score	Garrett Rank
Shelterbelts harbor birds that damage crops	4440	62.54	II
Compete with crops for moisture and nutrients, reducing crop yields	4845	68.24	I
Cost of planting and protecting shelter belts is more than their monetary benefits	2920	41.13	IV
Administrative problems in harvesting and selling timber trees	3100	43.66	III
Competition for light, thus affecting crop stand	2445	34.44	V

Farmers' preference for tree species in shelterbelts

Wood providing trees were most preferred by farmers for plantation in the farms, followed by fruit trees (Table 8). Wood can be obtained from many trees but certain species are more preferred. Market values and higher income potential are the main reasons for preferring timber species. Dalbergia sisoo was observed to be preferred by farmers for plantations around their fields in this study (Fig 1). Although it takes longer period for a timber species to mature, farmers viewed timber trees as long–term investment. Before they reach maturity, the branches are used as fuelwood.

These trees thus constitute a form of family insurance, with occasional bonus of fuelwood. Farmers also opined that shisham does not effect on crop growth. Other trees observed include like Azadiracta indica, Acacia tortilis, Cordia myxa, Zizyphus sp., Prosopis cineraria, Tecomella undulata etc (Table 8).

Mertia *et al.* (2006) suggested trees like P. cineraria, T. undulata, Acacia senegal, Salvadora oleoides and Acacia leucophloea, among woody plants, to be more suitable for shelterbelts in arid region. Sale and John (2014) in a study conducted in Nigeria reported that fruit trees were farmer's first preference (40%), followed by timber trees (30%), fuel wood trees (12%) and ornamental trees (10%).

Table 8: Trees commonly planted by farmers in field windbreaks

Botanical Name	Common/Local Name	Uses	Frequency
Dalbergia sisoo	Shisham/Tali	Timber, fuelwood	33
Azadiracta indica	Neem	Medicinal, timber, fuelwood	10
T.undulata	Rohida	Timber	3
Prosopis cineraria	Khejri	Edible fruits, leaf fodder	2
Cordiamyxa	Gonda	Edible fruits	7
Zizyphus sp.	Ber	Edible fruits	4
Acacia sp.	Acacia	Fuelwood	8
Ailanthus excelsa	Ardu	Matchwood, leaf fodder	2
Eucalyptus sp.	Eucalyptus/ Safeda	Pulp and paper, fuelwood	2
Citrus sp.	Lemon	Edible fruits	1
Phoenix dactylifera	Date palm	Edible fruits	1

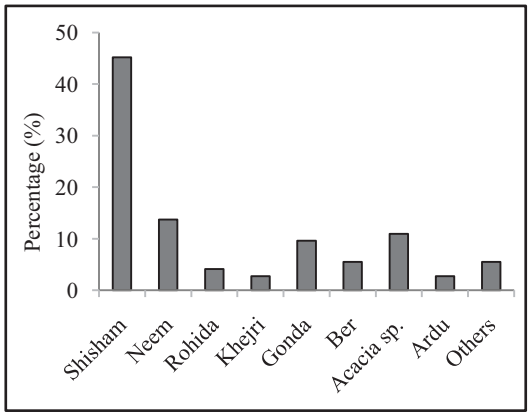

Fig 1. Prevalence of tree species in shelterbelts

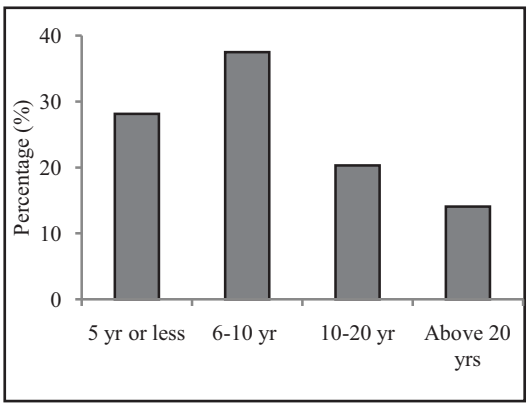

Fig 2. Age class of shelterbelts

The age trend analysis (Fig.2) showed that more than twenty year old shelterbelts were observed mostly of Acacia, while the lesser age group trees were those of shisham, neem, etc. With time, a shift was observed from Acacia sp. plantations to other trees. Fast growing trees were used earlier as immediate solutions for afforestation, sand dune stabilization and to reduce wind velocities. However, seeing the negative competitive effects of these trees on crops and considering economical benefits, farmers have started planting other trees. In some areas, cutting of existing Acacia trees were also observed as they were reducing crop growth nearby.

Effect of shelter belts on the productivity of agricultural crops

The effect of plantation on crops varied with the tree species. Some trees exerted more negative effects on the crop compared to others. Farmers opined that some trees like khejri improve crop growth and yield when grown with it, while others in general affect crop growth up to some distance from the tree line. Trees like shisham, gonda, ber, ardu do not have much effect on crop yields, while others like rohida, eucalyptus, acacia do not let crop growth under it. Farmers also noted that the effect depends on water availability. This might again justify the reasoning that it is the competition for moisture between trees and crops, which mainly affects crop growth.

CONCLUSION

From the study, it can be seen that the majority of the farmers having shelterbelts were above middle age, which might indicate that the concept of shelterbelts has changed in importance from earlier times, when they were essential for sand movement control and vegetation development. Few farmers have only planted new plantations in fields understanding their intrinsic and other values. The tree preference also is observed to have shifted to include trees which do not hamper crop production, at the same time, providing economical by-products. The study also indicated that farmers valued the benefits like crop protection from hot and cold winds, shading effect, soil erosion control ability of shelterbelts on agricultural lands more. The timber/wood value was also valued by farmers, who considered wood yielding trees as a long term investment, which explains the higher preference for shisham. The major challenges faced by farmers include competition by trees with crops for moisture and harboring bird, both of which affect crop yields. These can be addressed to some extent with proper irrigation management and pruning. Some changes in forest laws and policy which allow farmers to sell mature trees, with replacing the removed trees, may provide further incentive to promote this system of windbreak plantation in fields.

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