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WIND EROSION: THE PERSPECTIVE OF GRASS-ROOTS COMMUNITIES IN THE SAHEL

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ABSTRACT

Under the harsh conditions prevailing in the West African Sahel, farmers must deal with a range of environmental and socio-economic issues that constrain agriculture. Although scientific evidence indicates that wind erosion is potentially a major land degradation process, little is known about the Sahelian farmer's perception of the relative importance of wind erosion as a constraint to agricultural production. A village-level survey was therefore undertaken to assess farmers' views about the relative importance of perceived constraints to agricultural production in 41 villages across Niger. During the interviews, the communities' views were also recorded regarding the causes and consequences of wind erosion as well as known wind erosion control measures. Wind erosion ranked eighth overall and was listed by male farmers among the top 10 constraints in 54 per cent of the villages. It was perceived by male farmers to be a moderate to high constraint in 39 per cent of the villages but was not considered important by female farmers. Wind erosion ranked third among environmental constraints, behind drought and soil fertility. Wind erosion related health problems were generally of more concern than crop damage or loss of topsoil by wind erosion. Deforestation, removal of crop residue and land-clearing practices were identified by farmers as major contributors to soil losses by wind. To address this issue, at least 10 different low-cost technologies are currently being implemented by farmers, including leaving crop residue in the field, mulching and natural regeneration of vegetation. The survey results indicate that farmers are well aware of the overriding importance of their management practices, as opposed to climatic factors, on the current extent of wind erosion. Copyright © 2001 John Wiley & Sons, Ltd.

KEY WORDS: gender; land degradation; indigenous knowledge; agriculture; health; soil conservation

INTRODUCTION

In the Sahelian zone of West Africa ongoing land degradation and the resultant loss of the soil's productive capacity constitutes a major concern to the local populations and the international community alike. Current estimates of the extent of land degradation are largely based on subjective expert knowledge (Middleton *et al*., 1997). Although such knowledge may provide a reasonably sound basis for identifying areas most affected by land degradation, quantitative estimates of land degradation derived from expert knowledge may be of limited value in the identification of priority issues to be dealt with in research and development programmes in developing countries. Indeed, such estimates do not properly reflect the priorities of the main target group – the grass-root communities. This is particularly of concern when action programmes require support from and implementation by local communities.

Like expert knowledge, farmers' perceptions of the absolute importance of a given degradation process may also be subjective given the often limited geographic coverage of their knowledge and experience. However, a better understanding of their perceptions of the relative importance of various constraints to agricultural production would greatly add to the value of expert judgement regarding land degradation processes. From an environmental

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protection and education perspective, it is therefore essential to identify the most important land degradation processes both in absolute terms and from the point of view of the rural populations impacted.

Causes of land degradation in the Sahel have been widely discussed and are linked to rapid demographic changes (Mainguet, 1999). The loss of vegetation cover and the conversion of savanna into cropland have led to land degradation processes increasing over time. In particular, wind erosion, which is favoured by the long dry season, coarse-textured soils and low vegetation cover, is often pinpointed as a major factor in the Sahelian zone (Mainguet and Chemin, 1991; Buerkert *et al*., 1996; Sivakumar *et al*., 1998). Although the occurrence of wind erosion is indisputable, the exact extent and impact of this insidious onset, low-grade cumulative process on soil productivity is difficult to quantify at all but the most local scale (Mainguet, 1998).

Sterk and Haigis (1998) have reported results from a survey on farmers' knowledge of wind erosion carried out in 1995 in seven villages in western Niger. Although relevant, the geographical scope of their study was limited and provided no indication about the relative importance of wind erosion compared with other environmental or socio-economic constraints that farmers have to face. The authors also provide little information about farmers' views of the advantages and disadvantages of various techniques for the control of wind erosion. Baidu-Forson and Napier (1998) surveyed 24 villages in 1994 which were all located in the 400 mm average annual rainfall zone of Western Niger. The paper provides valuable insight into farmers' understanding of the causes of wind erosion and clarifies the basic requirements for successful wind-erosion control measures, i.e. they must be low cost, involve farmers at the onset and be based on readily available inputs. However, the survey was focused from the onset on wind-erosion control and also did not provide a means of assessing farmers' perceptions of the importance of wind erosion.

In the present paper, we report on a nationwide survey in the southern Sahelian zone of Niger (400–600 mm annual rainfall), the most important zone for crop production. The survey was carried out in order to identify farmers' perceptions of constraints to agricultural production, in order to prioritize issues that are of most concern to the rural communities. This prioritization was to serve as a basis for identifying urgent research and development activities, and particularly to assess the relevance of current wind-erosion research and control programmes in Niger. The present survey is being complemented by on-farm assessments of wind erosion under current land-use and management practices as well as a field evaluation of wind-erosion control technologies (Bielders *et al*., 2000).

Besides the overview of constraints to agricultural production, farmers were interviewed more specifically about their perceptions of the causes and consequences of wind erosion as well as to assess the nature and extent of wind-erosion control technologies currently implemented by or known to them. Special emphasis was placed on health-related issues and on the advantages and disadvantages of wind-erosion control techniques. This information can be used to adapt existing technologies or to develop new technologies based on a better understanding of the principal advantages and disadvantages of currently known technologies.

MATERIALS AND METHODS

The survey was carried out from October to December 1998 in 41 villages from seven districts across the southern Sahelian zone of Niger (400–600 mm annual rainfall), West Africa (Figure 1). The villages were selected along two transects across Niger: a north–south transect in western Niger, ranging from 395–610 mm long-term average annual rainfall, and an east–west transect between 400 and 500 mm rainfall isohyets (Table I). Because the results of the survey were in part intended to serve as a means to identify priority activities for the Peace Corps NGO, all surveyed villages were Peace Corps project villages, which implies that a Peace Corps volunteer was at the time working with the village in activities of environmental protection, agricultural production or health education.

Group interviews were carried out with male farmers in 41 villages (Table I). Care was taken to exclude the village leaders from the group meetings to avoid possible dominance by these leaders in the discussion. In addition to the interviews with male farmers, separate groups of women were interviewed in two villages in each of four districts (Table I). The number of female group interviews was limited because of time and financial constraints. Women were interviewed separately to avoid dominance by male farmers in the discussions. The survey was carried out in each village in the Djerma or Haoussa languages by one Peace Corps volunteer and an experienced animator.

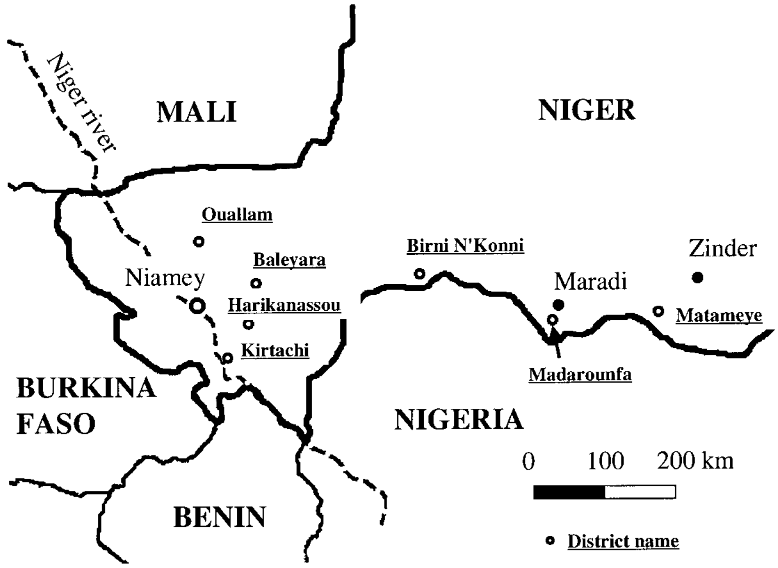

Figure 1. Location of the seven surveyed districts in Niger.

Table I. Location and main characteristics of surveyed villages in Niger

District	Villages[1]	Location[2]	Population of villages	Main ethnic groups	Annual rainfall (mm)
Baleyara	Hayni Simorou, Zouragan, Maourey (M/F), Zourgo Koara, Holo, Winde (M/F)	13°53′N; 2°57′E	450–500	Djerma, Bella	410
Birni N'Konni	Aroki, Goumbi, Sakouda, Baoune, Yelwa, Doumbou	13°54′N; 5°10′E	325–1700	Haoussa, Bouzou	480
Harikanassou	Harikanassou, Gam Dey (M/F), Niabere Moulay, Naibere Kaina, Drouel, Boktili (M/F)	13°16′N; 2°47′E	650–3000	Djerma	550
Kirtachi	Balaga, Bani Zoumbou, Soungame, Goungou Gorou, Farey Dey, Darey Bangou (M/F), Zarmaganda (F)	12°44′N; 2°27′E	200–900	Djerma, Haoussa	610
Madarounfa	Harounawa Nare, Saounaoua, Dan gaya, Takoude, Banché	13°07′N; 7°07′E	270–1000	Haoussa	500
Matameye	Gomba Haoussa, Ganoua, Kaori, Kourni Bougaje Ban-dawa, Koufourna, Amsoudou Awaki	13°29′N; 8°31′E	300–2000	Haoussa, Fulani	430
Ouallam	Fondouberi, Dey (M/F), Diginasa, Mondolo, Fefandou, Tiala, Fooy Gorou (F)	14°20′N; 1°60′E	300–1600	Djerma	395

[1]M, males; F, females. Unless specifically mentioned, only male groups were interviewed.
[2]Approximate location of villages in district.

In each village, an average of 18 ± 4 (mean $\pm$ SD) male farmers and 17 ± 3 female farmers were interviewed in a group meeting. The Djerma ethnic group dominated in western Niger, whereas the Haoussa ethnic group dominated in the Birni N'Konni, Madarounfa and Matameye districts in central and eastern Niger (Table I). Of all the participating male farmers, 6 per cent were under 20 years of age, 41 per cent between 20 and 40 years old, 35 per cent between 40 and 60 years old and 18 per cent older than 60. Of the participating female farmers, 3 per cent were under 20 years of age, 62 per cent between 20 and 40 years old, 29 per cent between 40 and 60 years old, and 7 per cent older than 60. Because the animators endeavoured to keep all age groups involved in the discussions and the interviews did not relate to a socially sensitive topic, dominance by specific age groups was not considered a problem.

Millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata*) and sorrel (*Hibiscus sabdarifa*) were cropped to some extent in all surveyed villages. Millet was the dominant cereal crop, and cowpea the dominant legume in the cropping systems. Additional important crops included groundnut (*Arachis hypogaea*), Maize (*Zea mays*), Rice (*Oriza* sp.), Cassava (*Manihot esculenta*), and Sesame (*Sesamum indicum*). Millet and sorghum were never cultivated specifically by female farmers whereas bambara groundnut (*Vigna subterranea*), okra (*Abelmuschus esculentus*) as well as other local small garden crops were specifically grown by them.

Of the surveyed villages 52 per cent had collaborated with one or more of 22 different development projects in the past, in addition to being Peace Corps project villages. Less than 10 per cent of the respondents had access to external credit, fertilizer or animal-drawn tillage implements.

The survey was structured in two main parts, and took place in two half-day (2 hour) sessions for parts I and II respectively. Part I dealt with the perception of the rural communities of constraints to agricultural production. Part II was specifically related to their perception of wind erosion. Prior to its full-scale implementation, the survey was tested in one village and subsequently adjusted.

Survey Part I: Constraints to Agricultural Production

Part I of the survey was carried out using the principles of Participatory Rural Appraisal (Chambers, 1994a and b). The communities were first asked to list the main constraints to agricultural production, without any restrictions. The participants were subsequently asked to perform a pair-wise comparison of the 10 most important constraints. The constraints were later ranked by counting the number of times a given answer was given as more important than another. The most important constraint was given a score of 9, the second most important a score of 8, and so on. If a given community listed less than 10 constraints, the ranking was performed in the same way, starting with a score of 9 for the most important constraint. Although it is sometimes recommended to restrict pair-wise ranking to a maximum of six factors, the apparent consistency of the survey results was indicative of the farmers' ability to remain concentrated during the entire ranking process.

In some cases, answers were grouped a posteriori into categories to facilitate comparison between villages, and the relative rankings were adjusted accordingly. Grouping of answers was done as described below.

(1) All damage by insects other than locusts was grouped into a single category.
(2) All damage by birds and/or rodents was grouped into a single category.
(3) All products having to do with pest control were placed in a single category.
(4) The constraints of 'famine', 'poverty' and 'lack of purchasing power' were frequently mentioned by farmers during the survey. Though they underline real problems, these three very general constraints are not particularly helpful for identifying remedial actions or priority research thrusts, which was one of the aims of the survey. The three constraints were therefore grouped into a single category.
(5) For those villages where several constraints were to be combined into a single category, as explained in points 1 to 4, the ranking of the highest ranking constraint was used for that particular category.
(6) In some villages hardpan problems were associated with lack of appropriate tools for tillage, whereas in others these two constraints were identified separately. Whenever two such items of a very different nature were associated, two categories were created and given the same rank to enable comparison with villages where these had been ranked separately.

Results of part I are reported either in terms of the percentage of villages reporting a given constraint or as a weighted score. A weighted score is the product of the average score for all villages reporting a given constraint and the percentage of villages reporting that constraint. The use of weighted scores was preferred over the average score because it avoided giving undue importance to very site specific problems.

Villages were classified on the basis of the relative importance of individual constraints, as measured by the village level scores. A low importance corresponds to a score of 0 to 2, moderate from 3 to 6 and high from 7 to 9. 'Unimportant' was attributed to all villages not reporting a given constraint in the top 10 list of constraints.

Survey Part II: Perception of Wind Erosion

Because wind erosion constituted a very low-ranking constraint for all surveyed female farmer groups, part II of the survey was restricted to the male groups and was structured into four main sections: (1) consequences of sand storms, (2) causes of sand storms, (3) technologies for wind-erosion control and (4) general perception of specific wind-erosion issues. The latter included specific questions about the health impact of wind erosion. For the first two sections, the answers by the villagers were first listed. This was followed by pair-wise ranking of a limited number of imposed answers. For section 3, farmers were asked to provide a list of wind-erosion control technologies either currently in use or known to them but not used. For those currently in use, farmers were asked to provide the advantages and disadvantages, as well as the origin of the technology (indigenous, development project, etc.). For those technologies that were known but not used, farmers were asked the reasons for not using them. Section 4 consisted of a number of structured questions. Where appropriate, the communities were asked to rank imposed answers by pair-wise comparison.

The results of part II are given in terms of the percentage of villages spontaneously reporting a given cause, consequence or technology, or as an average score. In addition, for section 3, the percentage of farmers claiming to use a given technology is also reported. Results of Part I and II are presented on a country basis, unless large differences across districts warranted a separate analysis.

RESULTS AND DISCUSSION

Part I: Constraints to Agricultural Production

Male farmers

At the national level, male farmers perceived drought as the single most important constraint to agriculture (Table II), a key climatic characteristic of the Sahelian zone (Sivakumar *et al*., 1993). At the district level, drought is perceived as the main constraint to agricultural production in only four out of seven districts, and all of these districts are located in western Niger (Table II). For those four districts, the weighted score for drought is roughly inversely related to the average annual rainfall. For eastern and central Niger, insect pests are considered the most important constraint in the Birni N'Konni and Matameye districts, and soil fertility in the Madarounfa area. These observed regional differences in perceptions may to some extent be influenced by year-specific crop growth conditions. In August 1997 a fairly prolonged drought was observed in Niger, and resulted in low cereal yields and severe food shortages during the 1997–98 dry season. The shortages were more pronounced in the western than in the eastern part of the country, which may explain why drought was ranked higher overall in western Niger than in the eastern part of the country for villages located in approximately the same rainfall zone. The effects of the 1997 drought were exacerbated in 1998 by late maturing of millet due to poor growth conditions early in the season, and by poor yields in the Ouallam and Baleyara districts in particular.

On a countrywide basis, famine/poverty/low purchasing power were viewed by male farmers as the second most important constraint, limiting access to inputs such as fertilizers and seed, and reducing the opportunity to buy food in bad production years (Table II). Again, this constraint was more important in the three lowest rainfall districts of western Niger. Insect pests and low soil fertility further limit agricultural production in Niger (Table II). Although they have lower average weighted scores, these latter two constraints were more widespread (76–80 per cent of villages) than drought (68 per cent) or poverty (59 per cent).

Table II. Weighted score (maximum = 9) of the top 10 constraints to agricultural production at the national level as perceived by male farmers in seven districts of Niger, and total percentage of villages mentioning a given constraint (high score indicates severity of the constraint)

Constraints	District[1]							All villages	
	Ba	Bi	Ha	Ki	Md	Mt	Ou		(%)
Drought	8.3	4.5	6.8	5.7	*	4.5	8.2	5.6	68
Famine/poverty	7.8	4.0	5.7	1.3	1.6	2.0	7.2	4.3	59
Insect pests	3.8	6.7	1.5	2.5	2.8	6.7	5.0	4.2	80
Soil fertility	3.7	1.3	4.3	4.7	5.6	5.7	1.0	3.7	76
Lack of improved variety seed	3.8	2.0	3.2	1.0	4.8	3.3	4.8	3.2	56
Lack of fertilizer	0.7	2.2	5.2	4.8	5.6	2.8	1.7	3.2	71
Lack of appropriate tools	1.7	1.7	1.8	1.5	4.6	2.7	3.7	2.5	54
Wind erosion	1.7	1.5	2.3	4.3	4.6	1.0	1.7	2.4	54
Lack of pesticide	1.0	1.3	1.5	2.8	3.4	1.0	4.7	2.2	54
Land/population pressure	0.7	2.8	2.0	2.3	*	3.0	*	1.6	29

[1]Ba, Baleyara; Bi, Birni N'Konni; Ha, Harikanassou; Ki, Kirtachi; Md, Madarounfa; Mt, Matameye; Ou, Ouallam.
*Not mentioned.

Wind erosion was ranked eighth overall by male farmers and was mentioned among the top 10 constraints in 54 per cent of the villages (Table II). Male farmers in 66, 61 and 39 per cent of the surveyed villages perceived drought, soil fertility and wind erosion, respectively, to be of moderate to high importance as a constraint to agricultural production across the southern Sahelian zone of Niger (Figure 2).

On a countrywide basis, wind erosion ranked third among the environmental constraints, behind drought and soil fertility problems (Table II), and ahead of deforestation, soil compaction/hardpan formation, water erosion, overgrazing, inundation and salinization (not shown). The extent of soil fertility decline in the Sahel is well documented (Smaling *et al*., 1993; Stoorvogel *et al*., 1993). Water erosion, referring to both sheet and gully erosion, was ranked higher than wind erosion only in the Birni N'Konni district where somewhat finer textured soils which are prone to sealing and runoff dominate. Soil compaction and hardpan formation were also most important in the Birni N'Konni district, and could be linked to the greater sensitivity of the soils in that area to surface sealing and hardsetting.

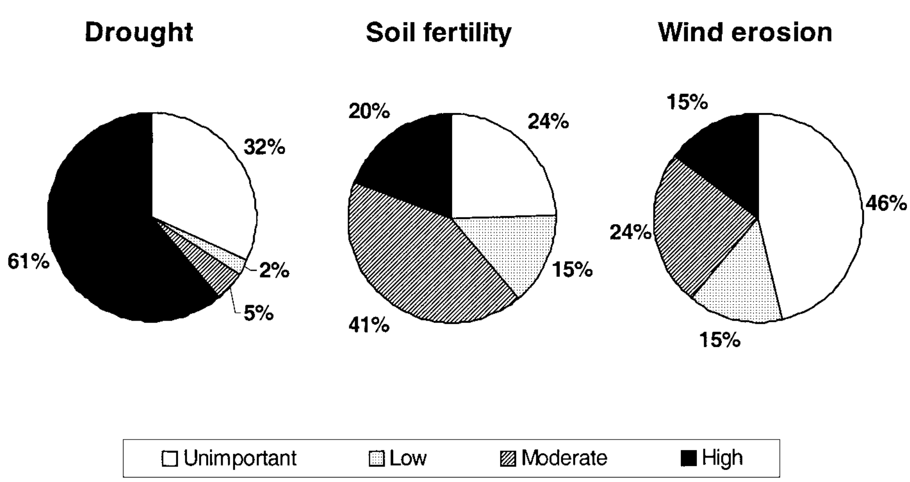

Figure 2. Distribution of surveyed villages (per cent of villages) according to the importance of drought, soil fertility or wind erosion as a perceived constraint to agricultural production.

Table III. Consequences of wind erosion as identified by male farmers in Niger (percentage of villages reporting a given consequence and score within each of the three categories)

Consequence	%	Score
Human health problems[1]	*10*	
Fever	NI	1.3
Coughing	NI	1.0
Eye sores	NI	0.7
Crop damage[2]	*93*	
Seedling burial	93	0.93
Sand blasting	61	0.07
Soil problems[2]	*90*	
Crusting/hardpan	78	0.54
Loss of soil fertility	68	0.46
Loss of fertilizer/manure	20	NR
Sedimentation	10	NR

[1]Maximum score = 2.
[2]Maximum score = 1.
NI, not identified spontaneously by farmers; NR, not ranked.

Although wind erosion was consistently ranked by male farmers as being between the second and fourth most important environmental constraint across the various districts (Table II), this land degradation process appeared to be of more concern in the Kirtachi and Madarounfa districts, which are also the higher rainfall districts. This apparent contradiction may result from the use of the pair-wise ranking methodology applied in this survey. In the drier areas where wind erosion should theoretically be more pronounced, other perceived constraints such as drought, famine and poverty, insect pests, soil fertility and lack of improved seeds were of such overriding importance that wind erosion got a low overall weighted score. This result does not invalidate the use of pair-wise ranking, however, as the use of the weighted scores gives an appropriate estimate of the relative importance of various constraints to agricultural production as perceived by the farmers. One may therefore deduce from Table II that it may be more relevant to work with farmers on wind-erosion control measures in the wetter areas of the Sahelian zone simply because farmers in these areas perceive it as a high priority. However, wind erosion probably is a more important land degradation process in the lower rainfall areas of the Sahel even though farmers may have other immediate concerns. Baidu-Forson and Napier (1998) also suggested in their survey that farmer participation in wind-erosion control programmes may be hampered by the low perceived importance of wind erosion compared to drought alleviation, pest control or food security. Thus action programmes with mandates on the control of land degradation and desertification may initially need to address these and other constraints in order to foster farmer participation in land rehabilitation or desertification control activities.

Female farmers

Famine/poverty, drought, insect pests, lack of improved variety seed and lack of fertilizer were the top five constraints identified by female farmers in the eight surveyed villages (not shown). With a weighted score of 8.0 and 6.4, respectively, famine/poverty and drought appear to be of overriding concern for women in the rural communities. As opposed to male farmers who were more immediately concerned by the low fertility of their fields, female farmers were more concerned by the lack of fertilizer. Soil fertility *per se* was ranked only eighth by female farmers, though it was mentioned in five villages out of eight. This difference in attitude may in part relate to the fact that women generally cultivate higher value crops, e.g. groundnut, bambara nut, cowpea, sorrel, okra and sesame, for which the use of fertilizer may provide a higher return. As opposed to male farmers, wind erosion was identified by female farmers in only one village out of eight where it ranked fifth out of eight identified constraints. This may be due to the fact that crops typically grown by females are generally sown later in the rainy season when the intensity of sand storms and the risk of crop damage from sand storms is reduced (Bielders *et al.*, 2000).

Generally, women's crops are planted on much smaller plots of land, involve more tillage, expensive seed, later planting, are more susceptible to pests and require division of labour among many other activities. It is therefore not surprising with the socio-economic constraints on the production of crops by women that an environmental constraint such as wind erosion would not be viewed as important. Although the number of villages surveyed for women may be insufficiently representative to draw general conclusions, it appears that wind erosion was of little concern to female farmers in Niger.

It is well known that survey results in developing countries may be biased because the interviewees may adjust their answers as a function of the interviewer in the hope of reaping certain benefits in the future, something that is often referred to as 'project mentality'. Project mentality is by no means restricted to villages that have known projects in the past, and although a certain bias may have been introduced in the present analysis by restricting the survey to Peace Corps villages, this bias is likely to be small, especially for Part I. Indeed, from being familiar with Peace Corps activities, the surveyed villages clearly understood that they had little to gain from conducting the interview other than through an improved understanding of their own problems. Furthermore, in Sahelian countries such as Niger that depend heavily on international aid the selection of villages free of 'project mentality' could prove to be an impossible task.

Part II: Perception of Wind Erosion

The period of occurrence of the most erosive storms was perceived to be predominantly during the late dry season and early rainy season (March–July; 78 per cent of villages), which is in accordance with past experimental results (Michels *et al*., 1995b). In 93 per cent of the villages, farmers felt that wind erosion was increasing over time as compared to the past. In 76 per cent of the villages it was reported that wind erosion affected mostly small surfaces within their fields, while the remaining villages reported wind erosion damage at the field scale. The perception of increasing wind erosion is in agreement with the results obtained by Sterk and Haigis (1998) for villages where large-scale wind-erosion control measures had not been implemented previously, as well as with some meteorological evidence of increasing numbers of dusty days over the last decades (Coudé-Gaussen, 1994; Valentin, 1994). Since wind erosion is strongly dependent on the extent of ground cover, farmers' perceptions of increased wind erosion probably reflects the slow but steady loss of vegetation cover that can be observed in large parts of the Nigerien Sahel as a result of deforestation, overgrazing and decreasing rainfall in certain parts of the country during the last few decades (Sivakumar *et al*., 1993).

Consequences of wind erosion

Farmers identified the following major consequences of wind erosion: seedling burial, soil crusting/hardpan formation, loss of topsoil and fertility and sandblasting damage, among others (Table III).

Consequences on crops. Among the consequences on crops, seedling burial was considered a more important issue than sand blasting in 95 per cent of the villages, irrespective of the district (not shown). The greater importance of seedling burial is also supported by its higher score (Table III). The present results are consistent with the findings of Sterk and Haigis (1998) and with past experimental results which have shown that millet, which is the crop most likely to be affected by wind erosion, is rather resistant to sandblasting but is sensitive to burial at the seedling stage as a result of it being sown in small planting holes (Michels *et al*., 1995a).

Consequences on soils. Hardpan formation and surface crusting were considered the most important consequence on soils in 51 per cent of the villages, whereas loss of soil fertility was considered the most important in 39 per cent of the villages (not shown). The remaining villages (10 per cent) considered both equally important. The almost equal importance of these two processes was also apparent in their scores which are relatively similar (Table III). Regional differences were small, except for Kirtachi where hardpan and crust formation dominated over fertility issues, and the Madarounfa area where loss of soil fertility scored much higher than hardpan formation.

Sedimentation – the deposition of wind-blown sediment – appeared to be a problem in only 10 per cent of the surveyed villages (Table III). This is probably due to the fact that the surveyed villages were located in the southern Sahelian zone where the occurrence of moving sand dunes and sanding up of roads or other infrastructure is indeed very limited and site specific.

Consequences on health. Although wind-erosion related health problems were mentioned spontaneously in only 10 per cent of the villages (Table III), health problems were considered more important than soil and crop problems in 78 per cent of the villages (not shown). It cannot be excluded that because the survey was focused on agriculture, farmers did not consider mentioning health issues when asked to list the consequences of wind erosion. The consequences of wind erosion on soil, crops and health were rated at 0.8, 0.6 and 1.6, respectively (not shown; maximum possible score = 2), confirming the greater concern of the rural communities for human health over environmental health.

Eighty per cent of villages reported health problems to be most severe during the Harmattan period, during which people are exposed for several consecutive days to high levels of dust. Only 15 per cent reported the most severe health problems during the period of convective storms. The principle health problems were fever (46 per cent), coughing (41 per cent) and sore eyes (13 per cent). The health risk associated with prolonged exposure to fine dust particles have been well documented (Coudé-Gaussen, 1992; Prospero, 1999).

Causes of wind erosion

Farmers identified a range of factors that favour wind erosion (Table IV). Deforestation, which includes the cutting of trees in both savanna areas and cultivated fields, was mentioned by 98 per cent of the villages. Farmers were also well aware of the impact of crop residue removal from their fields (68 per cent of villages) as well as of the land-clearing method used (59 per cent of villages) on wind erosion. The latter refers to the clearing of fallow land for cultivation and also to the cleaning of cropland prior to each cropping season. The cleaning involves uprooting of millet stubble, cutting down of bushes, and sometimes the burning of branches, weeds or millet stalks. It was specifically recognised by 37 per cent of the villages that the practice of burning fields increased wind erosion. Land clearing had the highest score of all the factors that were identified by the farmers, indicating that this factor is perceived as being a major cause of wind erosion.

In the southern Sahelian zone, fallow land is fairly insensitive to wind erosion as a result of the sufficient vegetation and litter cover throughout the year. Consequently, the extent of wind erosion should be strongly affected by the area of cultivated land, a fact that is recognized by 21 per cent of the villages (Table IV). Only 20 per cent of the villages attributed wind erosion to (over)grazing by livestock, and 10 per cent to drought. Lack of inorganic and organic amendments (Table IV) refers to farmers inability to improve soil fertility and thereby crop growth. Bad crop development, which results in a lower mulch cover after harvest, may be perceived as a factor that enhances wind erosion.

The results obtained here are generally consistent with those of Baidu-Forson and Napier (1998) who also observed that farmers considered deforestation and bush fires as important factors contributing to wind erosion. Similarly, (over)grazing by livestock was not perceived as a serious cause in their study, which Baidu-Forson and Napier (1998) attributed to the high value that farmers attach to livestock, not recognizing the adverse effects of livestock on soil cover. However, population pressure was reported by Baidu-Forson and Napier (1998) as a very

Table IV. Factors favouring wind erosion, as identified by male farmers in Niger (percentage of villages reporting a given factor and score of the top five factors)

Factor	%	Score[1]
Deforestation	98	2.3
Removal of crop residue	68	2.4
Land clearing (burning of fields)	59 (37)	3.3
Increase in cropland	21	0.8
(Over)grazing	20	1.2
Lack of (in)organic amendments	20	NR
Drought	10	NR
Tillage	5	NR

[1]Maximum score = 4.
NR, not ranked.

Table V. Wind-erosion control technologies, and their origin, currently in use by male farmers in Niger (percentage of farmers implementing a given technology per district, and percentage of villages where a technology is being implemented)

Technology in use	District[1]							All villages	Origin[2]
	Ba	Bi	Ha	Ki	Md	Mt	Ou	(%)	
Natural regeneration/ improved land clearing	28	73	58	25	49	100	30	68	P > A > S > L
Mulching with straw or branches	87	81	58	67	16	14	84	68	A > > P,L
Leaving millet straw in the fields	42	0	68	78	0	68	12	44	A > > S,L
Manure application	55	17	33	41	65	34	32	41	A > > L
Planting of trees	9	49	11	0	29	18	1	34	P > > A,S,L
Partial second weeding	0	0	0	0	0	0	27	2	L
Dead fencing	0	6	0	0	0	0	0	2	A
Live fencing	0	0	0	0	0	0	1	2	P
Andropogon windbreak	0	23	0	0	0	0	0	2	A
Delayed weeding	0	0	0	0	0	14	0	2	P

[1]Ba, Baleyara; Bi, Birni N'Konni; Ha, Harikanassou; Ki, Kirtachi; Md, Madarounfa; Mt, Matameye; Ou, Ouallam.
[2]A, ancestral; P, development project; S, agricultural or forestry services; L, locally developed or adopted following exchange of information among farmers.

important factor. This factor, which can probably be linked to 'increase in cropland' (Table IV), was not given much importance by farmers in the present survey. This may indicate that, on the whole, farmers considered management practices to contribute more to wind erosion than the actual extent of cropland. Though recent trends in climate change may enhance the extent of wind erosion (Coudé-Gaussen, 1994), it appears that farmers are well aware of the overriding influence of their land management practices rather than climatic factors on this land degradation process.

Wind-erosion control technologies

Farmers identified 10 technologies currently in use that aim, at least partially, at wind-erosion control (Table V). The primary purpose of some or all of the listed technologies may, however, not be wind-erosion control, and it is apparent from Table VI that the listed technologies have many benefits other than that one. This is consistent with earlier findings that farmers are unlikely to adopt soil conservation measures unless these techniques have immediate benefits for crop production or household consumption.

Natural regeneration of vegetation in cropland (i.e. leaving some young tree or shrub seedlings in the field) and improved land-clearing methods (not burning crop residue, not cutting bushes to the ground, not burning weeds and bushes) were practised to some extent in 68 per cent of the villages. Depending on the district, between 25 and 100 per cent of the interviewed farmers practised this technique in the previous year, which was largely being reintroduced through development projects, although some villages reported the technique to be indigenous. Besides the reduction in wind speed, this practice was appreciated by farmers for its positive impact on soil fertility and the production of by-products from the trees, such as fruits, wood and traditional medicine (Table VI). The disadvantages included the protection requirement of young trees against livestock, a reduction in cropping area resulting from competition with crops for light, water and nutrients, and the shelter it offers to granivorous birds around harvest time.

Mulching with straw or woody branches was practised to some extent in 68 per cent of the villages, and by more farmers than natural regeneration/improved land-clearing methods, except in the Madarounfa and Matameye areas. Besides the soil protection afforded by mulches, mulching is largely practised for its positive impact on soil fertility and for rehabilitation of hardpans. All these positive effects have been largely documented in the scientific literature (Bielders *et al*., 2000; Chase and Boudouresque, 1987; Michels *et al*., 1995b,c). However, the use of straw or branches reduces their availability for alternative uses, such as forage for livestock, fire wood or building material, which was a concern to farmers in 21 per cent of the villages. Allocation of millet stover to multiple

Table VI. Farmers' perceptions of the advantages and disadvantages of the five main wind-erosion control technologies currently used by male farmers in Niger (percentage refers to the ratio of the number of villages mentioning a given advantage or disadvantage to the number of villages where the technology is being used)

Technology	Advantages	%	Disadvantages	%
Natural regeneration/ improved land clearing	Reduces wind speed	93	Requires protection from livestock	18
	Improves soil fertility	50	Reduces cropping area	11
	By-products (wood, medicine, fruits, ...)	39	Harbours granivorous birds	11
			Harbours insect pests	7
	Shade	25	Requires maintenance	4
	Forage	11		
Mulching using straw or woody material	Protects the soil	79	Reduces alternative uses of residue	21
	Improves soil fertility	79	Labour requirement	13
	Improves soil structure/ reduces hardpans	25	Hinders tillage	4
	Captures sand	21		
Leaving straw in the field	Protects the soil	87	Harbours pests	20
	Improves soil fertility	73	Reduces forage availability	20
	Improves soil structure/ reduces hardpans	27	Reduces options for alternate uses	20
			Hinders weeding	7
Manure application	Improves soil fertility	94	Labour requirement	24
	Protects the soil	65	Increases risk of crop failure in drought years	24
	Improves soil structure	18		
	Low cost	6		
Planting of trees	Reduces wind speed	100	Harbours bird pests	17
	Shade	17	Reduces cropping area	17
	Wood production	8	Requires protection from livestock	8
	Forage production	8	Harbours insect pests	8
			Seedling availability	8

purposes has been shown to be an optimal means of exploiting this resource (Lamers and Bruentrup, 1996). In addition, mulching can be fairly labour intensive, and under conditions of limited availability, precision application of mulches to low productivity sites within fields can be considered optimal (Lamers *et al*., 1998). Mulching is essentially a traditional practice well known to farmers (Table V), even though in a few instances it has been encouraged by development projects or adopted by farmers after observing it in someone else's field.

Leaving straw in the field, a form of 'passive' mulching, was practised to a variable extent in 44 per cent of the villages (Table V). Like mulching, it is a traditional practice, occasionally reintroduced through government services, NGOs or by self-learning (Table VI). Its benefits included increased soil protection and improved soil fertility, as well as a reduced occurrence of hardpans. Besides the reduction in forage availability and other by-products that this practice entails, farmers in 20 per cent of the villages applying this practice felt that it favours the occurrence of pests. That this disadvantage was not mentioned for mulching is probably related to the fact that mulching is commonly practised only on small areas within cropped fields – typically hardpan or very low fertility spots – rather than at the field scale (Lamers and Feil, 1995).

The inclusion of manure application, an indigenous practice, as a wind-erosion control measure is somewhat surprising (Table V). However, the physical protection that it affords seemed to be appreciated by farmers, even if the main effect is clearly soil fertility improvement. Field experiments have shown that the application of $5\,t\,ha^{-1}$ of manure effectively reduces the occurrence of bare, unproductive erosion crusts and, to a lesser extent, favours sand trapping in the vicinity of the faeces (de Rouw *et al*., 1998). Additionally one cannot exclude that the improved crop growth resulting from the manure application would improve the mulch cover and mask any negative impact of wind erosion on the intrinsically low fertility aeolian soils. Farmers may therefore overestimate the value of this practice as a wind-erosion control method. The planting of trees to reduce wind speed and to provide for shade and by-products was generally a practice introduced by development projects. It requires access to seedlings and some form of protection against free-ranging livestock, and was perceived as harbouring bird and insect pests in addition to reducing the cropping area. This practice was therefore implemented in only one-third of the villages, and generally by few farmers except in Birni N'Konni and Madarounfa.

Additional techniques were sometimes practised by farmers in specific localities. These included a partial second weeding in Ouallam, a locally developed technique whereby only small areas around millet pockets are weeded. This is feasible as a result of the very low planting densities practised in Sahelian agriculture and the often high spatial variability in crop growth within fields. Unproductive areas are thereby not weeded, which may increase soil cover during the subsequent dry season and help reduce erosion and trap sediment from adjacent unprotected areas. In the Matameye area, 14 per cent of the farmers practised a delayed first weeding which helps to maintain a higher soil cover during the early phase of crop growth. This practice can indeed be expected to reduce wind erosion, and especially seedling burial, but may also have negative impact on crop development through competition for water and nutrients and it should therefore be practised with much care.

Andropogon windbreaks growing along plot boundaries are traditionally practised by 23 per cent of the farmers in the Birni N'Konni area. Because of the generally large size of cropped fields (1 or more hectares) and limited height of *Andropogon* plants ($\sim$2.5 m), the protection afforded by this type of windbreak is probably limited in practice, but its value as a source of construction material and fodder for livestock cannot be ignored.

In addition to the techniques currently in use (Table V), farmers were aware of additional techniques not being implemented. Windbreaks were mentioned in 39 per cent of the villages. Reasons for non-adoption were lack of plant material, lack of training and development project support, reduction in cropping area, land tenure problems (ownership of trees), and protection against grazing cattle. The need for external financial support to cover the initial heavy investments that are required for windbreak establishment was also emphasized by Lamers *et al.* (1998). The use of artificial windbreaks made of millet straw was mentioned in 7 per cent of the villages, but suffers from limitations in the availability of straw. Furthermore, this technique is only applicable on small wind-erosion susceptible areas, such as for sand dune control.

Two villages mentioned alternative residue management techniques, namely leaving crop residue standing or cutting it to pieces and leaving it as mulch. It is well known that standing residue is more effective than mulching for reducing wind speed for uniformly spaced straw (Lyles and Allison, 1976). However, standing residue is more easily browsed by cattle than lying residue, which is the reason for lying it down. Cutting the residue into pieces ensures that it will not be collected by others for use as construction material.

Because the survey was restricted to Peace Corps villages, it may be that farmers enjoyed a greater than average awareness regarding specific technologies. However, because of the type of activities that the Peace Corps is usually involved in, the number of surveyed villages having been briefed or trained specifically about wind erosion in the past is likely to be very small. In addition, the Peace Corps rarely demonstrates technologies other than those already recommended by the local agriculture and livestock extension services. The main bias in the present survey may therefore lie in the number of villages or farmers being aware of wind-erosion control technologies. On the other hand, farmers' experience with a broader range of technologies may potentially be advantageous in the present case in so far as this provides them with a better understanding of the advantages and disadvantages of the various technologies.

CONCLUSIONS

The present survey provides clear indications that, contrary to female farmers, Sahelian male farmers perceive wind erosion to be a major constraint to agricultural production, though it is frequently subordinate to other environmental (soil fertility and drought), biotic (insect pests) and socio-economic (poverty, access to inputs) constraints. Although in absolute terms wind erosion can be expected to be more severe in the northern half of the survey area, the survey suggests that wind-erosion control measures may be more successfully promoted by projects and extension services in the wetter areas of the southern Sahelian zone because it constitutes a higher priority to local populations in those areas. In the drier areas, issues such as drought alleviation, pest control and food security need first to be addressed in order to secure farmer participation in wind erosion control activities.

Farmers perceived wind erosion as increasing, which they attributed to deforestation, land-clearing practices, bush fires and the removal of crop residue from their fields for alternative uses. Drought was mentioned as a factor contributing to wind erosion in only 10 per cent of the villages. This clearly indicates that farmers are aware of the potential impact of their land management practices on wind erosion and that they realize that wind erosion is mostly related to human activities rather than the result of climate change.

The rural communities were most concerned with the impact of wind erosion on their health, followed by seedling burial, hardpan formation and loss of soil fertility. Health problems such as fever and coughing are most acute during the early dry season period, a problem which may not be easily managed locally because of the remote origin of the Harmattan dust. Current trends in the degradation of vegetation cover in the southern Sahelian zone may, however, exacerbate this problem.

The large number of practices currently implemented by farmers to control wind erosion attest to the feasibility of controlling wind erosion damage at the local scale. Within desertification control programmes, wind erosion can best be addressed through improvements of existing crop residue or vegetation management practices. Such technologies are simple and often scientifically sound, rely on local skills and materials, and provide short-term benefits other than wind-erosion control. Although known to many rural communities, more sophisticated techniques such as tree windbreaks are less attractive to farmers because of the high level of skills required, limited access to basic inputs and absence of external financial and technical support. In collaboration with farmers, extension services and development projects, it is recommended to gear research activities in the short term towards the evaluation and adaptation of those wind-erosion control measures currently used by farmers. In the medium and long term, the results of the present survey could usefully be complemented with quantitative estimates of the extent of wind erosion and its impact on health, soil fertility and crop production at various locations in the Sahel.

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