Pearl Millet Production System(s) in the Communal Areas of Northern Namibia: Priority Research Foci Arising from a Diagnostic Study

C M Matanyaire[1]

Abstract

Pearl millet is the major crop in northern Namibia where 60% of the population live. Although agricultural research was conducted in these areas during the pre-independence period, the first study to obtain baseline information was conducted in 1993.

The study confirmed the predominance of pearl millet in northern Namibia, with an average sown area per household of 3.5 ha. The farmers identify short duration as the most preferred varietal trait above grain yield, and research needs to be targeted in line with the farmers' preferences. Drought was identified as the major constraint on pearl millet production followed by lack of draft power. Farmers do recognize the importance of a good crop stand, early thinning, and weeding. The use of manure is widespread while the use of chemical fertilizer is very limited.

Research priorities identified in the study include the development of drought-alleviating technologies, development of pearl millet cultivars that meet the farmers' preference, and improvement of soil fertility and crop management strategies.

A large pearl millet grain yield gap was identified with on-farm yields of 0.15 to 0.20 t ha^{1} *compared with on-station yields of 3.63 to 3.87 t ha*^{1} *during the 1992/93 season. The yield gap analysis shows the comparative grain yield gains of improved management to be between 134 and 725% (for the levels of management identified) compared with varietal change yield gains of 6 to 44% at the specified management levels. Based on these findings the Ministry of Agriculture, Water and Rural Development (MAWRD) is requested to put more effort into resource management research as opposed to genetic improvement, with more emphasis on on-farm research.*

1. Research Station Development Officer, ICRISAT-Namibia, PO Box 272, Tsumeb, Namibia.

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Background

The farmers in the northern communal areas of Namibia, namely, Caprivi, Kavango, and the four regions covering the former Owamboland—Oshikoto, Oshana, Ohangwena, and Omusati—practice a mixed farming system. The system is based on crop and livestock production systems that are interdependent.

Pearl millet is the dominant crop. With no formal pearl millet grain markets, household food security is the target for most farmers.

There are very few baseline data on the farming system and little understanding of its component production systems (UNICEF 1989). During the pre-independence period, research on pearl millet and associated production systems was not given attention. The farmers living in these areas know what is good for them; their survival is adequate testimony to their authority. This baseline survey is the first recorded comprehensive attempt to obtain quantitative data on pearl millet-based production system(s) of northern Namibia. The study seeks to identify research priorities and foci based on the knowledge and perceptions of farmers.

Method of Data Collection

A survey, using a structured questionnaire, was conducted between May and April 1993. Agricultural extension officers did the enumeration in their respective areas. A random sample of at least 20 farmers was interviewed around each Agricultural Development Centre (ADC). The ADC is the location of agriculture extension offices within the region and subregions. There was no preselection of respondents and presence at home during time of visit was an important deciding factor in the 'choice' of respondents. Considering the fact that the population densities in these areas are relatively low, the sample size at each ADC makes the respondents representative of the farming communities in northern Namibia. The actual sample sizes were as follows: Caprivi 18; Kavango 107; Omusati 38; Ondangwa 28; and Oshikoto 18.

In an accompanying exercise the areas of pearl millet and sorghum grown by farmers in the 1992/93 season were measured. This was done by extension officers using measuring wheels, with a target of measuring 20 arable holdings per ADC. Two hundred and six family holdings in the Kavango and Owambo regions were measured.

Results

Average size of holding

No national figures are available. The results of the area measurements conducted during the 1992/93 season are presented in Table 1 excluding the extreme values which had fewer than five observations in each class. On the lower end of the data set only four observations were discounted. The average size of area sown to pearl millet

Table 1. Area of pearl millet grown by individual farmers surveyed in 1993.

Class limit (ha)	Class value (ha)	Observed frequency
0.5-1.4	1	20
1.5-2.4	2	37
2.5-3.4	3	42
3.5-4.4	4	38
4.5-5.4	5	17
5.5-6.4	6	10
6.5-7.4	7	9
7.5-8.4	8	6
Mean	3.5	
SD	±1.76	

per household from this data set is 3.5 ha. If classes with 10 or fewer observations are dropped, the mean is reduced to 2.96 ha.

Constraints on pearl millet production

A primary objective was to identify the major constraints limiting pearl millet production. The rank order of the constraints was established using a score calculated as the sum of the product of:

(Number of ranking respondents x rank order value)

where first is valued 3, second is valued 2, and third is valued 1.

Drought is the most important constraint recognized by farmers. Next is lack of draft power, with lack of improved seed coming third (Table 2). Viewing the produc-

Table 2. Constraints on pearl millet production in northern Namibia identified by a diagnostic survey: May-Jun 1993.

		Regional rank by score			
Constraint	Score[1]	National	Caprivi	Kavango	Owambo
Drought	409	1	3	1	1
Lack of draft power	321	2	4	2	2
Lack of improved seed	269	3	1	3	3
Lack of grain market	176	4	2	6	-
Lack of fertilizer	173	5	5	5	-
Lack of extension	170	6	-	4	5
Low soil fertility	144	7	-	6	-
Lack of manure	76	8	-	4	-

1. Score = (Number of ranking respondents x rank order value).

tion constraints by region, the major shift from the national pattern is noted in Caprivi where lack of improved seeds and lack of a grain market are classified as the major constraints. This may be due to the wetter environment associated with annual purchase of maize hybrid seed, and the remoteness of the Caprivi region from all urban centers and rail-heads.

Desired traits in pearl millet varieties

It was important to establish reasons for pearl millet cultivar preferences, in order to provide guidelines to the national pearl millet breeding program during its formative phase. The scoring system used for constraint ranking was also applied to rank trait desirability. The results are given in Table 3. Short duration is the most desirable trait followed by grain yield. Drought tolerance and grain size are also top on the list, way above grain storability and insect and disease resistance.

Table 3. Desired traits in improved pearl millet varieties: survey results May-Jun 1993.

Trait	Score[1]	Rank	Respondents ranking first (%)
Short duration	89	1	21.0
Grain yield	72	2	14.6
Drought tolerance	59	3	9.5
Grain size	55	4	12.5
Plant height	44	5	5.7
Head size	41	6	8.8
Insect resistance	39	7	4.8
Grain color	38	8	7.3
Grain storability	34	9	5.3
Disease resistance	27	10	3.0
Bird tolerance	25	11	3.0
Stem thickness	24	12	2.3
Stover yield	22	13	1.5
Milling quality	3	14	0.5

1. Score = (Number of ranking respondents x rank order value).

Crop management

Seedbed preparation. The majority of the farmers use animal power and sow their crop on the flat. However, there are striking regional differences. Ninety-five percent of the farmers in Caprivi, 92% in Kavango, and 67% Oshikoto sow on the flat. On the other hand 81%, 65%, and 33% of the Oshana, Omusati, and Oshikoto farmers sow on the ridge and broadbed.

Mulching is not a common practice. In Kavango 37% of the respondents collect the crop residues and burn them during the process of seedbed preparation. In Owambo, the crop residues are generally grazed down before the onset of the rains.

Sowing and thinning the crop. Fifty percent of the farmers sow their pearl millet crop on hills, in a row pattern, and 34% sow on scattered hills.

Dibbling along rows and broadcasting are not popular, each practice being used by fewer than 10% of the respondents.

The majority of the Caprivi respondents (72%) sow fewer than five seeds per hill (Table 4). A large percentage of the Caprivians (38%) also do not thin their crop (Table 5). The most common reason given for not thinning is shortage of labor. Nationally, 48% of the respondents sow between 5 and 10 seeds per hill.

Table 4. Proportion of farmers (%) sowing the indicated number of seeds per hill: 1993 survey results.

	Number of seeds sown per hill				
	<5	5-10	10-15	15-20	>20
National	27.8	47.8	10.0	5.3	7.7
Caprivi	72.2	16.7	5.6	0	5.6
Kavango	26.2	48.6	9.3	6.5	8.4
Omusati	7.9	78.9	13.9	0	0
Ondangwa	35.7	21.4	17.9	10.7	14.3
Oshikoto	22.2	50.0	0	5.6	11.1

Table 5. Proportion of farmers (%) thinning their pearl millet crop to the levels indicated: 1993 survey results.

Region	Don't thin	Thin to 1	Thin to 2	Thin to 3	Thin to 4	Thin to 5
National	6.2	2.9	17.7	44.5	23.5	5.3
Caprivi	38.9	0	11.1	27.8	11.1	5.6
Kavango	5.6	1.9	12.1	53.3	21.5	5.6
Omusati	0	2.6	21.1	42.1	31.6	2.6
Ondangwa	0	10.7	28.6	32.1	28.1	0
Oshikoto	0	0	33.3	33.3	16.7	16.7

Twenty-eight percent of the respondents sow fewer than 5 seeds per hill. It is interesting to note that close on 8% of the farmers sow over 20 seeds per hill.

Forty-five percent of the farmers thin to three seedlings per hill and 85% thin to between two and four seedlings per hill (Table 5).

A plant population count at two ADCs in Kavango also came up with a mean of three to four plants per hill.

Thinning and weeding time. Timeliness of thinning and weeding was equally of concern to the baseline data collection exercise. Tables 6, 7, and 8 contain the information on thinning time, weeding time, and the number of weedings per crop cycle respectively. Farmers generally forget to thin and weed on time. Seventy-five percent of the farmers planned to thin and 72% to weed their pearl millet crop within 3 weeks of emergence. Only 8% of the respondents thin, and 6% Weed their crops later than 4 weeks after emergence. These figures are consistent, considering the fact that most farmers thin and weed in one operation.

Table 6. Proportion of farmers (%) thinning their crop at the indicated times: 1993 survey results.

		Timing of thinning after emergence (days)			
Region	Thinning	<14	14-20	21-28	>28
National	3.3	30.5	42.1	14.8	7.7
Caprivi	33.3	16.7	27.8	5.6	16.7
Kavango	0.9	22.4	41.0	21.5	10.3
Omusati	0	42.1	55.3	0	2.6
Ondangwa	0	53.6	35.7	10.7	0
Oshikoto	0	27.8	44.4	22.2	5.6

Table 7. Proportion of farmers (%) weeding their pearl millet crop during the indicated period: 1993 survey results.

	Timing of weeding after emergence (weeks)			
Region	<2	2-3	3-4	>4
National	36.7	39.0	18.1	6.2
Caprivi	10.5	31.6	42.1	15.8
Kavango	28.0	42.1	21.5	8.45
Omusati	45.0	55.0	0	0
Ondangwa	71.4	14.3	14.3	0
Oshikoto	43.8	31.3	18.8	6.3

Table 8. Proportion of farmers (%) weeding their pearl millet crop 1-4 times during the season: 1993 survey results.

	Number of weedings per season			
	1	2	3	4
National	32.4	59.5	6.7	1.0
Caprivi	68.4	31.6	0	0
Kavango	30.8	69.2	0	0
Omusati	20.0	47.5	27.5	2.5
Ondangwa	17.9	75.0	7.1	0
Oshikoto	56.3	31.3	6.3	6.3

It may be noted from Table 8 that 60% of the farmers weed their pearl millet crop twice. Over 27% of the Omusati respondents weed their crop thrice, clearly demonstrating that farmers are fully aware of the importance of weeding. However, 68% of respondents in Caprivi and 56% of respondents in Oshikoto weed their pearl millet crop only once.

The majority of the farmers (84%) use the hand-hoe for weed control. The use of animal-drawn cultivators is not common, with 24% of the Kavango, 16% of the Caprivi, and 6% of the Oshikoto farmers making use of animal-drawn implements for weed control.

Fertility management

Another specific purpose of the survey was to establish the regularity of use of kraal manure, fertilizer, rotations, and intercropping. Nationally, 2.8% of the farmers regularly use chemical fertilizers, 21.6% use them sometimes, and 75.5% have never used chemical fertilizer. All respondents in Caprivi sometimes use fertilizer. Seventy-six percent of the respondents in Oshikoto sometimes use fertilizer. In Kavango (21%), Omusati (14%), and Oshana (13%) the farmers sometimes use fertilizer. N-P-K compound fertilizers are the most commonly used chemical fertilizers by the few fertilizer users, followed by straight P fertilizers. The quantities of chemical fertilizers used per farmer are small, being less than 50 kg per farmer (average for all users) during the 1992/93 season.

None of the respondents in Caprivi uses manure. Eighty-four percent of the Kavango respondents never use manure and only 8% use it sometimes. By contrast 40% of the respondents in the former Owamboland regions regularly use manure, and 48% use it sometimes. The quantities used during 1992/93 per farmer (averaged for users only) ranged from 2.5 t in Kavango to 3 t in the former Owamboland regions. The usage of organic and inorganic manure per unit area was not easy to establish because of farmers' difficulties in area estimation.

Fallowing as a fertility management strategy is not common; only 1.6% of the farmers regularly do it. Eighteen percent of the farmers sometimes leave their lands fallow to restore fertility while 79% never do it.

Intercropping is a common practice with 45% of the respondents' cereal crop lands being regularly intercropped while 34% are sometimes intercropped (Table 9).

Table 9. Proportion of farmers (%) using legumes for intercropping: 1993 survey results.

Region	Never intercrop	Sometimes intercrop	Regularly intercrop
National	17.1	34.2	45.2
Caprivi	33.3	48.6	15.2
Kavango	12.9	33.6	51.1
Omusati	20.9	36.3	43.4
Ondangwa	14.3	28.6	47.6
Oshikoto	5.6	11.8	70.6

Cowpea is the dominant legume used for intercropping with 98% of the farmers using it. It is the sole legume used in the intercropping system of the Oshikoto and Oshana regions. The cowpea densities used are generally low and the pearl millet to cowpea ratio was not easy to quantify. Crop rotation is not common, with 74% of the lands being under continuous pearl millet. Only 5% of the lands are regularly rotated and 17% of the lands are sometimes rotated.

Discussion: Implications for Research

The pearl millet area in Namibia

The area sown to sorghum and pearl millet nationally during the 1992/93 season is given by the Namibian Early Warning and Food Information System as 171 200 ha. This is made up of 143 000 ha in Owambo, 17 000 in Kavango and 11 200 in Caprivi. These figures are not based on any known measurements.

The 1991 population census by the Ministry of Home Affairs established that the population of the pearl millet growing areas of the north is 829 000, which is 60% of the national population. The regional figures were as follows:

Owambo 601 000, Kavango 157 000, and Caprivi 71 000.

The average family sizes were established to be 4.6 (Caprivi), 6.0 (Owambo), and 6.2 (Kavango). The census figures also indicate that 80% of the population in Owambo is rural. Of the 140 000 households in the pearl millet growing areas of northern Namibia, 112 000 are estimated to be rural cultivators.

A MAWRD/ICRISAT Millet subsector study (Keyler 1993) estimated the average household hectarages during the 1993 harvest to be 3.5 ha for Owambo and 2.9 ha for Kavango. This is in agreement with the area measurements we conducted during the 1992/93 season (Table 1). Our survey results also indicated that the sorghum area per cultivator was less than 0.1 ha and the maize area was negligible. The Namibian Early Warning and Food Information System reports a maize area of 14 800 ha in Caprivi during the 1992/93 season, and no maize in Kavango and Owambo.

From the above information the national area sown to pearl millet has been re-estimated. Using the lower mean pearl millet hectarage per cultivar of 2.96 ha, it is estimated that the area under pearl millet during the 1992/93 season in northern Namibia was 331 500 ha. It is unlikely that this area varies greatly from year to year. Thus any Namibian research effort targeted to the small-scale crop growers has to be on pearl millet and its associated production systems.

Drought: the major constraint

The pearl millet-growing communal areas of northern Namibia are characterized by low, erratic rainfall ranging from 300 mm y^{-1} in the west to 600 mm y^{-1} in the east. Season length ranges from 80 to 100 days (Hutchinson 1993). The high potential evapotranspiration and the low water-holding capacity of the predominantly sandy soils with a low organic content further destabilizes the already precarious soil moisture balance potential for successful cropping.

The farmers' knowledge of their environment is good; and they do recognize this soil moisture limitation (drought) as the major constraint on pearl millet production. While no data are available the yields are known to be very variable from year to year and to be totally dependent on season quality. The production estimates from the Namibian Early Warning and Information System between 1990/91 and 1992/93 clearly indicate this trend. Research priorities are the development and adaptation of technologies that minimize the detrimental effects of drought on rainfed pearl millet production. The technology must raise yields and increase yield stability.

Draft power constraint

The human population and livestock numbers in the northern communal areas do not reflect an obvious scarcity of animal draft power. However, the results of the survey come up with lack of draft power as the number two constraint.

Rapid rural appraisals conducted in Kavango during 1993 also identified lack of draft power as one of the major constraints on crop production (Morrow 1993). There is a need to establish the livestock ownership patterns in these communal areas, which the study did not do. The data on manure use, however, suggest a more widespread cattle ownership pattern in former Owamboland and may be a sharper skew in Kavango.

In the former Owamboland regions there is extreme grazing pressure around the villages. Cattle are moved away from home during the dry season only to return when the grazing has recovered following the onset of the rains. There is no supplementary feeding for the livestock, though farmers attach little importance to crop residues.

Thus, at the start of the season there are no animals in the village to provide the needed draft power. The few that may be present are usually too weak to plow. Livestock management strategies thus aggravate the draft power scarcity constraint on crop production. Technologies that would extend the areas worked by the few draft animals available and/or make the available animal draft power more productive from the onset of the rains should be developed and adapted.

Lack of improved seed

The lack of improved pearl millet seed is a result of pre-independence neglect of research on the crop (UNICEF 1989). The post-independence release of Okashana 1 and provision of seed for the variety by Government has generated a large interest in the use of improved pearl millet seed. The Caprivi farmers have had pre-independence exposure to improved maize and sorghum seed due to the comparatively higher agricultural potential of their region; hence their greater appreciation of improved seed. This demand for improved seed needs to be addressed within the framework of the desirable cultivar traits as identified by farmers. The fact that farmers put more emphasis on variety earliness over grain yield may indicate their concern for grain yield stability and/or the need for an early harvest.

Farmers associate varietal earliness with grain yield stability. There is, however, no scientific research data to back the assumption that varietal earliness improves grain yield stability.

Furthermore, farmers still consider drought tolerance as an important trait requirement in improved cultivars, clearly showing their concern about the aridity of their environment. Grain and head size are also placed high on the farmers' priority list of desirable cultivar traits. The fact that disease and pest tolerance are not ranked high may indicate their low incidence in the existing pearl millet production systems.

The farmers indicate that Okashana 1 meets their expectations for desirable traits in improved pearl millet varieties. To avoid putting all their eggs in one 'unknown' basket the farmers do wisely continue to grow their landrace cultivars.

The cultivars to be developed in the short-term would thus have to take into consideration these clearly defined farmers' varietal trait preferences. Thus, development and adaptation of improved pearl millet cultivars that do satisfy the farmers' desirable traits, i.e., earliness, grain yield, and drought tolerance, are the research priorities.

Use of fertilizer

The recognition of constraints such as lack of fertilizer and manure indicates the farmers' sensitivity to the problems of poor soil fertility. The high risks of failure that go with cropping in the semi-arid zones result in very limited use of externally purchased inputs. The lack of a guaranteed formal grain market also discourages the use of costly purchased inputs. Consequently less than 3% of the farmers regularly use fertilizer and over 75% never use it. However, the fact that some fertilizer is used on pearl millet indicates that the crop is of great importance in the Namibian farming system, unlike the situation in other SADC countries. For example, no farmer in Zimbabwe is known to apply fertilizer on pearl millet.

The majority of farmers in the former Owamboland regions also apply manure on pearl millet. The limited use of manure in Kavango and Caprivi may be related to the low human population pressure allowing for some shifting cultivation.

There are, however, no fertilizer or manure use recommendations for the farmers in the northern communal areas of Namibia. Research priorities should, therefore, be the development and adaptation of low-cost soil fertility maintenance strategies based on a combination of organic and inorganic fertilizers.

Intercropping and crop rotations

Pearl millet/cowpea intercropping is a very common practice, with 98% of the pearl millet farmers using the system. However, the pearl millet/cowpea ratio in the cropped lands varies from farmer to farmer. There is no optimum spatial arrangement known for Namibian conditions which extension staff can recommend to farmers. The use of intercropping as drought insurance is widely used in similar regions, and research elsewhere has demonstrated increased and more stable yields from intercrops compared with sole crops (Willey 1979). The economic returns in Niger under traditional farming conditions have been reported to be substantially higher for intercropped pearl millet than sole-cropped millet (Spencer and Sivakumar 1986). Therefore, the research priorities are to develop and adapt pearl millet/cowpea intercropping technologies that enhance the production systems' grain yield and yield stability, and use cultivars of both pearl millet and cowpeas that are acceptable to the farmers.

Seedbed configuration. The use of flat seedbeds is associated with sandy soils of high infiltration and good drainage. On the other hand, the use of ridges and broadbeds is associated with soils of poor drainage situated on very flat terrain. Ridging is reported to improve seedling establishment (Fussel et al. 1986), especially during over-wet periods. There is, however, no follow-up to link these drainage measures with moisture conservation technologies later in the season when the crop water demands are higher and the potential benefits of minimizing runoff greater. The research priorities are thus the development and adaptation of technologies that minimize runoff during the latter half of the crop cycle by transforming or manipulating the surface water drainage technologies currently in use.

Use of crop residues. Farmers who use the hand-hoe for primary land preparation burn crop residues at the time of land preparation. The farmers say this reduces weeds and pests.

However, the practice of burning crop residues in an environment where soils are devoid of organic matter and have a very low nitrogen status needs reviewing.

There is merit, therefore, in developing technologies that will enable the farming system to benefit from the crop residues irrespective of the method of primary cultivation. Experiments in India have shown that use of organic mulches, for example, can increase pearl millet yield by 25%, especially in years of poorly distributed rainfall (Spencer and Sivakumar 1986).

The practicalities and economics of mulching in the situation of the small farmer remains questionable. Where crop residues are available, there is merit in using them to possible advantage. Thus, the development and adaptation of technologies that exploit the soil improvement capabilities of crop residues, whilst addressing the farmers' requirement to minimize carryover of weeds and pests, are the research priorities.

Crop thinning and weeding. Farmers know the importance of good seedling establishment, early thinning and weeding, including the potential benefits of keeping the crop clean throughout its growth cycle. Early thinning and weeding are known to contribute to good yields (Gautam and Kaushik 1980a), and yield reductions of between 25 and 50% due to weed completion have been estimated (Spencer and

Sivakumar 1986). In the former Owamboland regions and in Kavango, where pearl millet is the dominant cereal, weeding is done 2 to 3 times during the season.

The finding that the majority of Caprivi respondents only weed once may be explained by the fact that in this comparatively high agricultural potential area, pearl millet becomes a cereal of tertiary importance to maize and sorghum. The reason why the majority of Oshikoto farmers weed only once is not clear. It may be related to low weed pressures. This needs verification.

The limited use of animal-drawn, interrow weeders may be due to the farmers' and extension officers' limited exposure to the technology due to pre-independence human movement restrictions. Since farmers are aware of the importance of timely weeding, any failure to control weeds is associated with labor shortages. Consequently, the use of technologies that would make weed control easier would be beneficial to crop production. The research priorities are therefore to develop, introduce, and adapt animal-based weed-control technologies that fit into the pearl millet production systems used in northern Namibia.

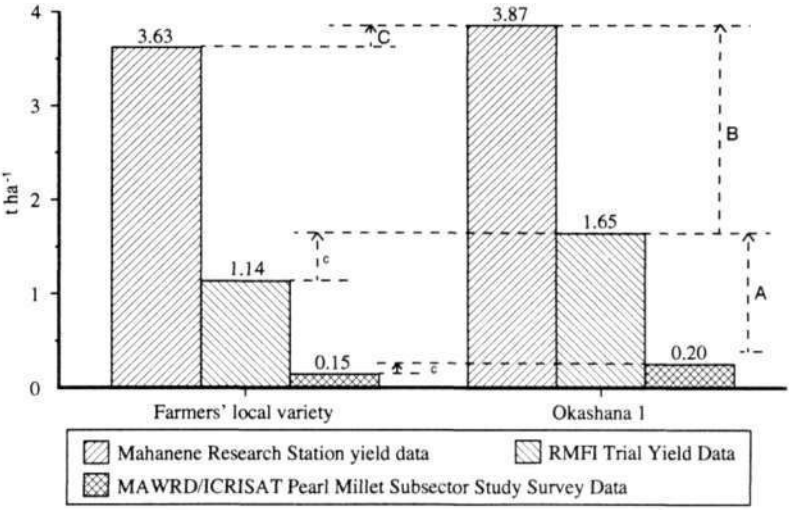
The pearl millet yield gap

The Namibian Early Warning and Food Information System, the only source of national statistics, estimated the 1992/93 pearl millet and sorghum grain yields to be between 0.24 t ha^{-1} and 0.26 t ha^{-1}. During the 1991/92 drought season, yields were estimated to be 0.1 t ha^{-1} for the main pearl millet growing areas of Owambo and Kavango.

The on-station and on-farm research data collected during the 1992/93 and 1993/94 seasons are used separately in Figures 1 and 2 to illustrate the pearl millet yield gap with respect to both the farmers' local landrace varieties (LLVs)and the improved released cultivar Okashana 1. The MAWRD/ICRISAT pearl millet subsector study yield figures used in the 1992/93 yield gap illustration are of similar magnitude to the estimates used by the Namibian Early Warning and Food Information System. By contrast, the on-station yields are about 20 times higher than the farmers' estimated pearl millet grain yields.

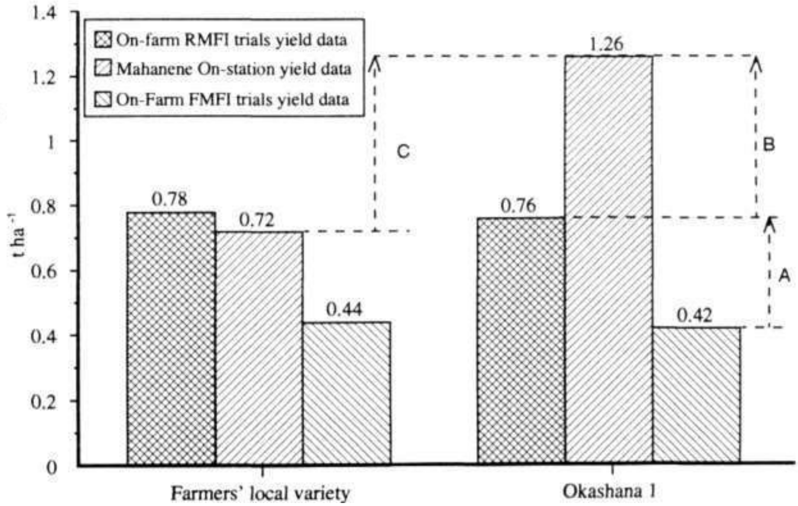
Both Figures 1 and 2 also show the yield gains due to cultivar change and management change. Using the 1992/93 data, it is interesting to note that the change in cultivar results in grain yield gains of between 6 and 44% at the three identified levels of management, while the grain yield gains by moving from one management level to the other are 134% and 725% for Okashana 1, and 218% and 660% for the farmers' LLV.

The 1993/94 pearl millet grain yield gains are less spectacular but the relative magnitude of management versus cultivar change gains is maintained.



A and B = management change yield gain C = variety change yield gain

Figure 1. The 1992/93 yield gap of Okashana 1 and the farmers' LLVs in Namibia.



A and B - management change yield gain C - variety change yield gain

Figure 2. The 1993/94 yield gap of Okashana 1 and the farmers' LLVs.

Short-term options for the Namibian NARS

The human resource capacity of the Namibian NARS for crop research is very limited. Consequently, not all the priorities enumerated above can be addressed in the short term. This calls for some stringent, hard choices and reprioritization.

The yield gain indications in Figures 1 and 2 suggest that the largest potential returns to investment in research would come from crop/soil/moisture management research as compared with crop genetic improvement. The MAWRD is, therefore, requested to seriously consider the strengthening of the national capacity for the development of management technologies in line with the priorities identified above using the available resources in order to maximize potential short-term research benefits.

Considering the limited NARS research capacity and the Division of Agricultural Extension's adoption of on-farm trials and demonstrations as an extension strategy, the returns on research may be further increased by emphasizing on-farm research in collaboration with extension. Research should therefore consider scaling down on-station research. Moreover, management-related technologies tend to be location-specific and on-farm research provides a cost-effective and time-efficient strategy to address location-specific technology adaptation and development requirements. Preliminary indications from the on-farm trials results seem to indicate that blanket, national cultivar and/or management recommendations would not be appropriate. Extension recommendations may have to be stratified on the basis of rainfall zones, with within-zone modifications for soil type. Broadly, technology development at this stage may be targeted at five zones: Owambo West, Owambo East, Kavango West, Kavango East, and Caprivi.

Prospects for technology adoption

The well-known aversion to risk and the limited resources of small-scale farmers make it necessary to review prospects for technology adoption. The Namibian pearl millet farmers have already demonstrated their dynamism and ability to adopt appropriate and affordable technology through their quick uptake of Okashana 1. In 2 years, 38% of the farmers in Owambo had adopted the new variety; and by the 3rd year it is estimated that 50% of the farmers were growing Okashana 1. This is certainly one of the success stories of technology adoption in the SADC semi-arid regions. The main advantage of genetic technology is that it is cheap. Management technologies are generally comparatively more expensive, especially the use of inorganic fertilizers.

The fact that some Namibian farmers are already using manure (large numbers) and inorganic fertilizers (few farmers) on pearl millet is an encouraging sign. The prospects of Namibian farmers adopting new management technologies will, therefore, largely depend on the appropriateness, affordability, relevance, and economics of the technology. The availability of a grain market for farmers to dispose of surplus production would be a good stimulus for the use of purchased inputs such as fertilizers. Increased yields may also promote adoption of cash crops since household annual food requirements are satisfied from a reduced pearl millet crop area. So it is important in the medium term for NARS to identify potential cash crops that fit into the agroecological zones where pearl millet is currently the major and/or sole crop.

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