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Use of the West African pearl millet landrace Iniadi in cultivar development

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Summary

Plant breeders generally use elite germplasm that has demonstrated its potential in terms of superior farmer-acceptable products and as good parents in breeding programmes. In pearl millet (*Pennisetum glaucum* (L.) R.Br.), Iniadi, an early maturing and productive landrace from West Africa, has been exceptionally useful in both its transferability and its parental worth in breeding programmes in widely different geographic locations. Available information on the distribution, agronomic features and germplasm collections available is described. The use of Iniadi in cultivar development in India, West and Central Africa, southern and eastern Africa and the USA also is described. Although the use of Iniadi germplasm has contributed extensively to the genetic improvement of pearl millet, it does not appear to have created situations of potential genetic vulnerability. The information provided here demonstrates the value and impact of germplasm collections in pearl millet improvement.

Introduction

The availability of crop genetic resources has improved in the last 20 years following the establishment of the International Plant Genetic Resources Institute (IPGRI, formerly the International Board for Plant Genetic Resources, IBPGR). Genetic resource conservation has been transformed from individual efforts into an internationally coordinated network. Plant breeders ultimately control the amount of genetic diversity to be found in widely grown cultivars (Plucknett *et al.* 1987). Few elite materials dominate the basic cereal and legume crops worldwide (Wilkes 1993). This is because plant breeders generally use proven elite germplasm that will lead to products that are likely to gain farmer acceptance rather than using unadapted exotic cultivars that have not proven their agronomic worth.

Iniadi, a prominent, early maturing and productive landrace from West Africa, has remarkably contributed desirable variability to recent genetic improvement of pearl millet (*Pennisetum glaucum* (L.) R.Br.) worldwide.

Pearl millet is grown principally as a food grain on an estimated 26 million ha in the tropical and subtropical areas of Africa and the Indian subcontinent (Anand Kumar 1989). The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with IPGRI and the national agricultural research systems (NARS) has assembled over 25 000 accessions of pearl millet from over 40 countries (ICRISAT 1995). Although this collection reveals a wealth of variability for numerous traits related to adaptation, productivity, quality and various morphological characteristics, the landrace Iniadi, simply known as the Togo type, is being increasingly used in cultivar development in India, Africa and the USA.

Distribution

The Togolese type of pearl millet that breeders now generally refer to has its distribution in Benin, Burkina Faso, Ghana and Togo. In Benin, this millet is grown in the north, around the eastern Tanguieta, Nattingou and Djogou regions. In addition, it is also grown by the Fon ethnic group in the Abomey region where it is known as Likoun. This region is isolated from other millet-growing areas in Benin. Farmers plant and harvest two crops in a year since this region has two rainy seasons. In Burkina Faso, Iniadi is grown in the southeast around Diapaga (close to Benin border) and in the Pô region close to the frontier with Ghana (Clement 1985). In Ghana, Iniadi, under the name of Nara, is grown around Bolgatanga, Bawku and Nakpanduri (Appa Rao *et al.* 1985). Iniadi is grown in most of northern Togo almost to the Sokode region (Appa Rao *et al.* 1990). The approximate distribution of Iniadi is shown in Fig. 1.

In the areas of its cultivation farmers generally plant Iniadi with the first rains for an early harvest as a hunger crop. It is also used for late planting situations in high-rainfall areas (600 to 700 mm annual rainfall) where delay in the onset of rains may force farmers to plant their fields from late June to mid-July. Under such conditions, grain yields of normal millets (100 to 120 days maturity) are drastically reduced. Iniadi is intercropped with late pearl millet, late-maturing sorghum (*Sorghum bicolor* L. Moench), and among legumes with cowpea (*Vigna unguiculata*) and groundnut (*Arachis hypogaea* L.).

Other names for Iniadi

Generally the Togolese material reference is to the early Iniadi type. Iniadi is called by different names depending on the ethnic group (Table 1). The most prevalent varia-

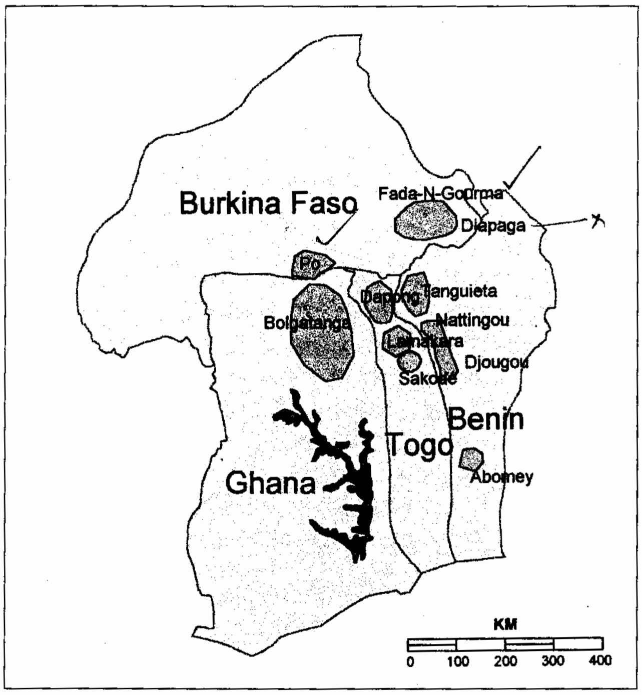

Fig. 1. Distribution of the pearl millet landrace Iniadi in Benin, Burkina Faso, Ghana and Togo.

tions of Iniadi are Ignati, Ignie, Likoun, Misse and Nara. It should be noted that late-maturing versions with Iniadi features also exist in all these countries and are known by other names (Clement 1985).

Table 1. Local names for pearl millet accessions that are early, with short and conical earheads in four West African countries

Country	Local name
Burkina Faso	Nara, Ignati, Ignate
Togo	Nata, Ignie, Misse
Benin	Nara, Ignati, Likoun
Ghana	Nara

Agronomic features of Iniadi

Iniadi has very distinctive features that have contributed significantly to pearl millet improvement. The morphological attributes that appeal to farmers, consumers and plant breeders alike are the lustrous, bold grain and the compact, conical head with excellent exsertion. It is early maturing and relatively photoperiod-insensitive; it is traditionally used in both the early (first) and late (second) rainy seasons since the rainfall pattern is bimodal in some areas of its production. This may have led to adaptation to perform in different photoperiod regimes and thereby to its wide transferability (Andrews and Bramel-Cox 1993).

Its early maturity (70 to 85 days) is considered a good drought-escape mechanism in traditional production areas, which are characterized by frequent terminal droughts. Its susceptibility to high soil surface temperatures (in the Sahel, soil temperatures at the time of emergence of seedlings could go as high as 50–60°C) sometimes results in below-optimum plant stands. Plant height is normally between 1.5 to 2.0 m and unlike many other West African cultivars which are low-tillering (1-2), each plant produces two to four tillers. The rate of grain filling is rapid, with a shorter grain-filling period (23-25 days) relative to other millets (25-32 days).

Iniadi tolerates the diseases downy mildew (caused by *Sclerospora graminicola* (Sacc.) Schroet.), ergot (*Claviceps fusiformis* Loveless) and smut (*Tolyposporium penicillariae* (Sacc.) Schroet.). Symptoms of downy mildew—foliar infection, light green, chlorotic or yellow leaves—tend to appear late in the season on nodal tillers. The appearance of the principal symptom of downy mildew, 'greenear', is rare. Earliness helps in escaping severe attacks of both smut and ergot. Because of its earliness, it generally escapes damage by the millet head miner (*Heliocheilus albipunctella* de Joannis), and damage by the millet stem borer (*Coniesta ignefusalis* Hampson) is also minimal. However, as with other cultivars, empty earheads result when insect pests such as blister beetles (*Psalydolytta* spp.) and scarabid beetles (*Rhinyptia infuscata* Burm.) attack at flowering and devour floral parts.

The most characteristic features of Iniadi are its conical head shape and very large globular grains (15-20 g/1000 grains) of a strong, bright, bluish-gray colour (Fig. 2). The endosperm is starchy. Some accessions with white grain have also been found. The dominant traits of earliness, conical head shape, and large blue-gray grain occur strongly in progeny of its crosses. It shows excellent combining ability when used in crosses, but unlike the majority of African cultivars, it contains a high level of maintainer alleles to Tift A_1 cytoplasmic male sterility.

Grain yield of Iniadi depends on management and rainfall pattern in a particular season. Generally in on-station and on-farm trials, 0.8-2.5 t/ha grain yield has been recorded. Tests outside its growing areas indicate that food quality (*tô*, a typical West African food product, thick porridge) may not be readily acceptable, or is satisfactory to acceptable.

Germplasm collections

A summary of collections from four countries where Iniadi types of millet are known to be cultivated by farmers is given in Table 2. The first known systematic collecting of Iniadi material occurred in 1977 when 128 accessions were assembled by (the then) IBPGR-ORSTOM from Togo (Clement 1985). In 1978 efforts of an IBPGR-ORSTOM collecting mission to Benin resulted in the assembly of 126 additional cultivated millet accessions (Clement 1985). Two IBPGR-ORSTOM missions in collaboration with ICRISAT and Institut national d'études et de recherches agricoles (INERA) into Burkina Faso in 1981 and 1982 collected 287 cultivated millets, of which 34 were classified as early types (Clement 1985). Collecting in Ghana in 1981 by ICRISAT, the German Agency for Technical Cooperation (GTZ) and the Crops Research Institute (CRI), Kumasi resulted in 135 samples (Appa Rao *et al.* 1985). A collecting mission was launched by ICRISAT's Genetic Resources Division, Sahelian Center and the Department de Recherche Agronomique (DRA) of Togo in 1989,

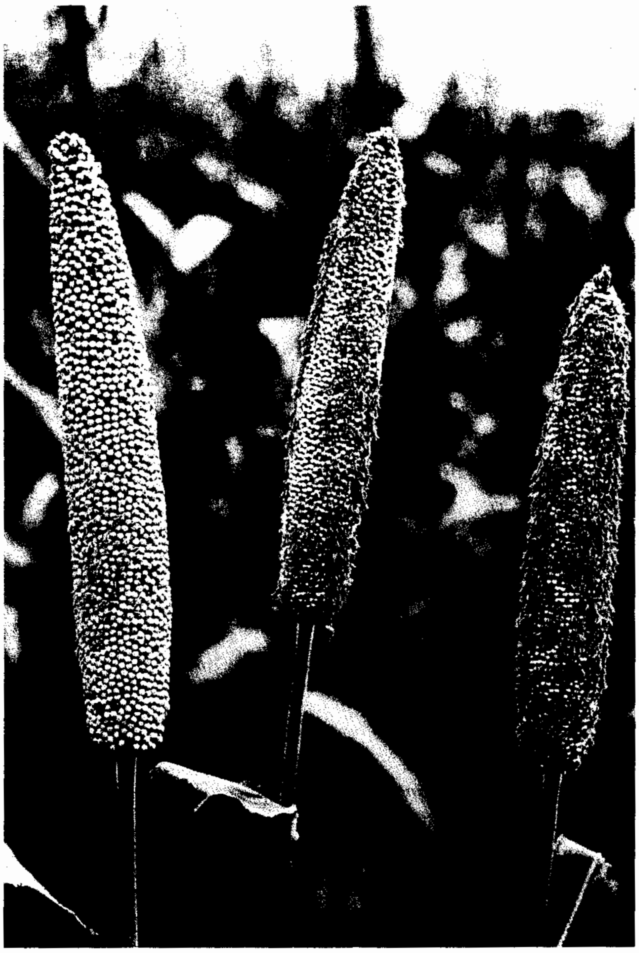

Fig. 2. Earheads of the West African pearl millet landrace cultivar Iniadi.

which contributed 480 accessions (Appa Rao *et al.* 1990).

Thus, a total of 1156 accessions are available from these four countries. However, the number of accessions that actually correspond to Iniadi type is not explicitly known. The collections launched into Ghana and Togo by ICRISAT in collaboration with CRI and DRA, respectively, do not always provide the local names.

Table 2. Germplasm collections from Benin, Burkina Faso, Ghana and Togo[1]

Country	Year	Organizations involved in collection	Number collected	Early types
Benin[2]	1978	IBPGR, ORSTOM	126	20
Burkina Faso[2]	1981/82	IBPGR, ORSTOM, ICRISAT, INERA	287	34
Ghana[3]	1981	ICRISAT, GTZ, CRI	135	1
Togo[2,4]	1977	IBPGR, ORSTOM	128	40
	1989	ICRISAT, DRA	480	1

[1] Details on number of early types collected are not provided.
[2] Clement (1985).
[3] Appa Rao *et al.* (1985).
[4] Apppa Rao *et al.* (1990).

Utilization of Iniadi in the development of improved cultivars

In pearl millet, as in other crop plants, direct selection within adapted local landraces as a strategy to develop improved cultivars has shown limited success, mainly because of the narrow genetic variability within the landrace that results in small genetic gains. However, when the target environment for the breeding products has been well outside the area of domestication, Iniadi or derived material has proven to be a successful introduction (Rai and Anand Kumar 1994).

Photoperiodic control of flowering, an important attribute in tropical landrace cultivars for specific adaptation to their original environments, is frequently a barrier to their effective utilization in breeding for grain yield potential in locations with different daylengths, such as the temperate Midwest, USA. In most tropical landrace cultivars, simply replacing the dominant photoperiod alleles either through single crosses to day-neutral stocks, or by backcrossing earliness into the landrace, gives disappointing results. It is evident that in such germplasm many grain yield performance traits, particularly tiller organization and harvest index ratio, are closely correlated with crop production duration as controlled by photoperiod sensitivity. Apparently Iniadi germplasm is an exception. Its utility as germplasm *per se* and in crossing programmes at very different latitudes indicates that the heritable yield attributes of Iniadi are relatively independent of the vegetative growth period.

The use of Iniadi in pearl millet breeding programmes in the development of improved cultivars started in the early 1960s. Iniadi shows good combining ability as well as high parental worth in crosses with a wide range of genetically diverse material. Unusually, it confers earliness together with high yield. Its potential to contribute in the development of early, high-yielding cultivars has been realized and its use in breeding programmes has expanded over the past 15 years. Currently, over 50% of the new early and bold-seeded composites and breeding lines developed at ICRISAT contain Iniadi germplasm in their parentage (Andrews and Bramel-Cox 1993).

In the pearl millet grain-breeding programme at Kansas State University (KSU) at Hays, Kansas (39°N), Iniadi has become a principal exotic germplasm source because of its earliness even at that latitude. Among the 38 diverse PI introductions evaluated *per se* and in crosses in 1971, PI 185642, an Iniadi type collected from Kumasi market in Ghana, was the most promising because of its earliness, together with good combining ability and progeny with large clean grains that threshed easily. Much of the seed parent breeding in the KSU programme has been essentially backcrossing the d2 dwarfing gene (from the USDA forage millet breeding programme at Tifton, Georgia, USA), into Iniadi. The first seed parent, KS 79-2068A1, shortly to be released from the KSU programme (W.D. Stegmeier, pers. comm.) was derived from the first backcross of (PI 185642 x Tift 23DB1) x IP 185642, an accession conserved at ICRISAT. Several later-generation progenitors of KS 79-

2068B were supplied to ICRISAT, India where further reselections were made for downy mildew resistance. Two of the resulting male-steriles incorporating A_1 cytoplasm, 843 A (ICMA 2) and 842 A (ICMA 3) were recommended by the All India Coordinated Millet Improvement Programme (AICMIP) for general use as seed parents. They are now used commercially to produce early maturing hybrids in Northwestern India (Andrews and Bramel-Cox 1993).

A Ghana accession was used in crosses during 1950 in the pearl millet breeding programme at Ikiriguru, Tanzania. When the programme moved to Serere, Uganda, the derived progeny were used to establish B and R populations (with respect to Tift 23A1 cytoplasm) which strongly resembled the Iniadi phenotype. Serere populations were widely tested in the Eastern African Agricultural and Forestry Research Organization (EAAFRO) and released in Tanzania (Serere 3A, Serere 17), Kenya (Serere 17) and Botswana (Serere 6A) (Andrews and Bramel-Cox 1993). The open-pollinated cultivar Ugandi, released for cultivation in western Sudan in 1981, was derived from Serere Composite 2C (Jain and El Ahmadi 1982). Serere composites were contributed to ICRISAT in 1972 and used to develop new populations for recurrent selection.

The male-sterile line Serere 10LA was re-selected at ICRISAT and released in 1984 as ICMA 834 and ICMB 834. Using a similar selection of Serere 10L A, a private seed company in India produced a very successful hybrid, MBH 110, which was widely grown in Maharashtra. This hybrid strongly resembled the Iniadi phenotype and was therefore morphologically distinct from any other hybrid in India. Recently, when it became susceptible to downy mildew, it was withdrawn from commercial use.

In India, an early large-seeded Ghana accession (IP 81) apparently of the Iniadi type was introduced in the mid-1950s; it was initially called Improved Ghana and was eventually released during 1961 as Pusa Moti in the north (Joshi *et al.* 1961). However, this release was made prior to the widespread farmer realization of potential new cultivars of a different phenotype in pearl millet and the release was not successful.

In the intervarietal hybrid programme of the Institut de recherches agronomiques tropicales et des cultures vivrières (IRAT, France) at Bambey, Senegal, the hybrid using Iniadi in the cross showed the highest level of heterosis (+59%) of all hybrids made with 35 landraces on a common tester, Souna 2 (Lambert 1982). Unfortunately the project was closed in 1972 and no further selections were made from this outstanding cross.

The current impetus for the widespread use of Iniadi has come from successful development of open-pollinated cultivars by ICRISAT. ICRISAT's first source of Iniadi material is IBPGR-ORSTOM's 1971 collection. In the erstwhile ICRISAT-Burkina Faso Cooperative Programme, a set of this collection (27 early and 96 late-maturing types) was grown at Farako-Bâ during the 1979 rainy season. Among this set, several early maturing Iniadi accessions were observed that were downy mildew free and possessed well-filled compact heads. Several individual plants were selfed in 32 accessions (ICRISAT 1980, 1981). A bulk of the selfed seed of the selected lines was sown at the Agricultural Research Station at Kamboinse, near Ouagadougou, in June 1980 and was observed to be early and free of ergot, smut and downy mildew. In the same year, the harvest from this bulk was introduced as Togo Population into ICRISAT India.

Utilization of Iniadi in India

In India, the Togo Population that was introduced from the ICRISAT-Burkina Faso Cooperative Programme in 1980 was noted to be of high parental worth in ICRISAT's source material project. This population was used—either directly or as a parent in intervarietal crosses—in the development of several breeding products. Useful variability generated was also provided to ICRISAT-NARS collaborative programmes in Africa. Accessions from the last collection in Togo (Table 2) are also being used to develop breeding products.

The open-pollinated cultivar ICTP 8203 was developed from five S2 progenies selected from the Togo population. In 1988, this was released by the Government of India for cultivation in Maharashtra and Andhra Pradesh (Rai 1992). Later, it was released by the State Governments of Punjab (as PCB 138) and Karnataka. It has also been reported to be cultivated in parts of eastern Rajasthan. During the period of 1989 to 1994, ICTP 8203 has been annually grown on an estimated 700 000 to over 1 million ha in India (Rai *et al.* 1990).

Three open-pollinated cultivars (ICMV 88908, ICMV 221 and RCB-IC 911) were developed from a Bold-Seeded Early Composite (BSEC), which is largely based on ICTP 8203, its two sister cultivars ICTP 8202 and ICTP-A82, and six progenies, all derived from the same population that produced ICTP 8203. ICMV 88908 is under advanced tests as a possible replacement for Okashana-1 (see later section). Cultivar ICMV 221, outyielding ICTP 8203 by about 15%, was released in 1993 by the Government of India as a possible replacement for ICTP 8203 in peninsular India and is also in advanced tests in Kenya. RCB-IC 911 was released in 1994 for cultivation in the eastern and central Rajasthan (Rai and Anand Kumar 1994).

A restorer population, ICMR 312, developed from BSEC, has produced a high-yielding topcross hybrid on 81A. The hybrid (ICMH 88088) is under multiplication by several private seed companies in India. The grain yield of this pollinator is comparable to that of ICTP 8203 and WC-C75 (ICRISAT 1993a).

Two male-sterile lines with large grain size and high levels of downy mildew resistance, 863 A and ICMA 88004, were developed from B-lines selected from the same population that produced ICTP 8203. Male-sterile 863A is shy tillering but produces large earheads. On account of a short period of stigma receptivity that is often transmitted to hybrids, 863A has not been useful in public-sector hybrid breeding. However, at least one private seed company in India is producing and marketing a hybrid based on 863A (K.N. Rai, pers. comm.).

Male-sterile ICMA 88004 tillers well but has small earheads and has proven useful in breeding hybrids. ICMH 356 is the first hybrid developed on this male-sterile by ICRISAT and is currently under production. This hybrid, having similar grain yield as ICMH 451 (a commercially grown hybrid in India) but maturing a week earlier, was released in 1993 by the Government of India for cultivation throughout the country. Several hybrids bred by Indian institutes using this seed parent are now being evaluated in AICMIP trials.

Male-sterile plants identified in a few Iniadi accessions from Ghana were shown to be cytoplasmic-nuclear type. Five male-sterile plants identified in an Extra-Early B-Composite constituted from Iniadi accessions from Togo and Ghana (see below) are being evaluated for the nature of their male sterility.

Several high-yielding, large-seeded and downy mildew resistant lines of short to medium stature and good yield potential have been developed from inbreeding in Iniadi accessions and in populations derived from crosses that had Iniadi as one of its parents. Promising inbred lines have also been developed from composites that contain Iniadi germplasm in them. These lines are currently being evaluated as potential maintainers for their conversion into male-sterile lines (K.N. Rai, pers. comm.).

The Extra-Early B-Composite (EEBC) was developed by random mating 286 S2 progenies derived from 45 Iniadi accessions from Togo and Ghana that were selected for high levels of downy mildew resistance and less sensitivity to extended daylength. This composite matures in 65 days, has large seed size (12-14 g/1000 seeds), is highly resistant to downy mildew and is a maintainer of male sterility in A_m (*monodii*) sterile cytoplasm (Hanna 1989). Currently, it is being evaluated for its yield potential. Results of preliminary yield trials indicate that its grain yield may be comparable to that of the earliest Indian commercial hybrid HHB 67 (Rai and Anand Kumar 1994). Iniadi germplasm has been extensively used in developing a Large-Grain Population and a Large-Seeded Gene Pool (i.e. germplasm pool). It has also been introgressed in several composites. Open-pollinated cultivars developed from some of these are now in the advanced AICMIP trials (Rai and Anand Kumar 1994; K.N. Rai, pers. comm.).

Utilization of Iniadi in west and central Africa

In the erstwhile ICRISAT-Burkina Faso Cooperative Programme, two cultivars, IKMV 8108 and IKMV 8109, were obtained by recombining selections from Iniadi material. Further evaluations indicated that in West Africa, Iniadi as a direct introduction has no potential outside its niche of adaptation. In the Sudanian Zone of northern Burkina Faso, it is exposed to insect pest attacks and feeding by birds. Consumers there also do not seem to like the quality of *tô*.

Two selections from Iniadi material, GT79 and GT85, were used in crosses with photoperiod-sensitive, full-season cultivars (140 days to maturity in the 500-1000 mm rainfall zone of West Africa). The objective has been to form intervarietal composites and select lines with bold grains, relatively shorter plant stature and maturity similar to the late full-season parent. Landraces included in these crosses were Kapelga (late-maturing landrace from Mossi plateau, Burkina Faso), Farako-Bâ local (from Burkina Faso) and Djiguifa (landrace from Mali). Although late-maturing progenies with relatively short height were recovered, grain yields were low. Progenies that combined slightly bolder grain and yield potential were tall and late maturing. Two late-maturing cultivars (ICMV IS 91106 and ICMV IS 91108) derived from these crosses are being tested on-station and on-farm in Benin and Burkina Faso (S.N. Lohani, pers. comm.).

Open-pollinated cultivar GB 8735 was developed from progenies of a cross involving Iniadi and Souna, an early maturing landrace from Mali, which has features very similar to Iniadi. In addition it has the ability to set seed under high ambient temperatures (45°C), and to recover and produce near-average yield when normal conditions follow a severe drought spell.

Following 3 years of on-farm tests by Centre national de recherche agronomique et de développement agricole (CNRADA), Mauritania, cultivar GB 8735 was recommended for general cultivation in 1994. In on-farm trials conducted in 1992 and 1993, cultivar GB 8735 had mean yields of 1.04 t/ha, a 37% increase over the control cultivar Souna III. Farmers are very enthusiastic about this early maturing cultivar because they can harvest the crop much earlier than the local cultivar and this helps them during the 'hungry period'. Some farmers call GB 8735 *rijal el ghaïss* meaning 'harbinger of good fortune and happiness' in the Hassania language, Mauritanian Arabic.

In Chad the FAO/UNDP project on Assistance à la Production de Semences en Zone Sahelienne has extensively tested GB 8735 in regional on-farm trials between 1991 to 1993 and has recommended it for general cultivation. Seed multiplication and extension were initiated in 1994. This is a farmer-preferred cultivar in Abeche (Ouaddai), Bilyine, Ati (Batha), northern regions of Guera and northern regions of Chari/Baguirmi. This is also being tried by farmers in the higher-rainfall areas (southern Bongor and northern Tandjile) and the project is now conducting date-of-planting experiments to check if delayed planting in the first week of August would affect yield. Currently this cultivar is estimated to occupy at least 30 000 ha and is expected to occupy nearly 100 000-125 000 ha in the Sahelien Zone within the next 2 years. The project estimates that between 10 000 and 12 000 farmers have grown this cultivar in the past 2 years (Saleh *et al.* 1994a, b).

Variety GB 8735 was tested on-farm by Station de recherches sur les cultures vivrières (SRCV), N'Dali in northern Benin. Farmers have given it the name Banadabu meaning a variety which 'protects the back' because they are able to harvest a crop in the middle of the crop season when food stocks are generally very low (S. Dosso-Yovo, pers. comm.). Further on-farm tests with this variety are being continued.

In Ghana, the Savanna Agricultural Research Institute (SARI), Nyankpala, Tamale has developed the variety Manga Nara from local collections made in the upper eastern region. This variety is under extensive on-farm tests and will soon be recommended for cultivation in this region (I. Atakpole, pers. comm.).

Utilization of Iniadi in southern and eastern Africa

In southern and eastern Africa ICTP 8203 was released in Namibia in 1990 as Okashana-1, and multiplication and farmer use was started in 1987 to 1988. Even before Okashana-1 in Namibia, Iniadi-type materials were already known in the region beginning with cultivars such as Serere 17 in Tanzania and Serere 6A in Botswana. The release and rapid adoption of Okashana-1 in Namibia demonstrated the potential of this germplasm (Fig. 3). However, farmers have expressed concern about Okashana-1's susceptibility to storage insect pests (*Sitophilius* sp.) because of its fairly soft grain. Preliminary screening has indicated that Okashana-1 has only intermediate levels of resistance and selection for hard grain is being attempted (ICRISAT 1993b). However, studies conducted in India show that ICTP 8203 is less susceptible (measured as number of adults emerged) to three stored-product pests, *Tribolium castaneum*, *Sitophilus oryzae* and *Rhyzopertha dominica*, despite its soft endosperm. Its reaction to these pests was very similar to the least pest-susceptible cultivar WC-C75 in the study (Kishore 1993).

In Malawi, the ICRISAT-developed pearl millet cultivar SDMV 89004 produced double the yields obtained from the farmers' local cultivars, but they preferred Okashana-1 to SDMV 89004 because of its earliness and bold seeds, even though Okashana-1 produced only 55% more grain yield than local cultivars (ICRISAT 1994).

In the SADC/ICRISAT Sorghum and Millet Improvement Programme (SMIP) Okashana-1, ICMV 87901 and ICTP 8203 have been used in backcrossing and products are being identified for advanced national trials in Zimbabwe and Namibia. A Bold-Seeded Composite Population composed mainly of Iniadi materials has been developed. Cultivar SDMV 93032, involving a landrace from Zimbabwe and Okashana-1, is being evaluated on-farm in Namibia.

Fig. 3. Seed increase of pearl millet cultivar Okashana-1, derived from West African Iniadi germplasm, by a woman farmer in Oramboland, Namibia, April 1994.

Owing to the success of Okashana-1 in Namibia, the Namibian national programme is emphasizing the development of the Okashana type of cultivars. SADC/ICRISAT's SMIP and the Namibian national programme are re-evaluating available Togo germplasm. The objective is to incorporate Togo-type traits into adapted Namibian landraces. Traits of particular interest include large bold seed, early maturity with the stay-green trait and ability to perform under drought, a long strong stem to avoid lodging and harder grain for tolerance to storage pests (E.S. Monyo, pers. comm.).

Utilization of Iniadi in the USA

Iniadi-derived germplasm has been important in breeding seed parents at KSU and at the University of Nebraska (UNL), Lincoln, Nebraska. At KSU, Iniadi germplasm was used in breeding complementary male (A1 restorer) parents utilizing the cross of Tift 239 DB1 with Uganda population Serere 3A x IC 481-R80. Although Iniadi germplasm was probably a contributor to Serere 3A, sufficient other diversity together with A1 restoration alleles was involved to give progeny high levels of combining ability with KSU dwarf Iniadi-type seed parents. KSU restorer 89-0083R resulted from this procedure (W.D. Stegmeier, pers. comm.).

Seed parent development, using Iniadi germplasm, started at UNL in 1984. This programme sought to diversify the Iniadi background by using crosses made at ICRISAT, India between the dwarf KSU seed parents and many other different seed parents under development. Selection in the resulting populations, when moved to Lincoln (41°N), quickly identified earlier maturing segregates from which several new A_1 seed parents are now in the final stages of releases. Most of these seed parents are also maintainers in the A_4 cytoplasmic male sterility system (Hanna 1989) and thus A_4 versions of these are also being produced. Initially restorers for the A_4 system were very few, but interestingly several which have been found (Andrews and Rajewski 1994) had Serere 10L in their parentage. Line Serere 10L was also an Iniadi derivative, which became a successful A_1 seed parent in India.

Risk of genetic vulnerability

Such widespread use of just one source of material raises concerns of genetic vulnerability. Source material for Iniadi originates from a confined geographic area and all accessions are genetically related. In most countries where pearl millet is a staple crop, no general strategy exists for keeping a diverse range of back-up material because plant breeders do not have accurate information on the occurrence of imminent disease or pest epidemics on a cultivar(s) with wide farmer acceptance.

In both national and ICRISAT's pearl millet breeding programmes, Iniadi has been introgressed into a range of diverse backgrounds. Therefore, the widespread use of one specific landrace has not created potential genetic vulnerability. Ideally, cultivars under development should originate from broader parentage than the cultivars they displace. For plant breeders, however, few incentives are available for additional parental material development other than the very small numbers of elite materials that have proven their genetic and agronomic worth.

The likelihood that further cultivated germplasm will be discovered that confers unique trait associations of such general value as Iniadi is not good. However, future gains in production and product quality can still be expected through improvement to individual traits, some of which may be controlled by major genes which facilitate easier manipulation. Major genes such as the *bmr* gene improve forage quality (Cherney *et al.* 1988) and the *monodii* cytoplasmic male sterility system (Hanna 1989) are being discovered and utilized that will contribute to stable production and productivity increases.

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Résumé

Utilisation de la race locale Iniadi, mil chandelle d'Afrique occidentale, pour la mise au point d'un cultivar

Les obtenteurs utilisent généralement des matériels génétiques d'élite ayant démontré leur potentiel en termes de produits supérieurs acceptables par les agriculteurs et en tant que bons parents pour les programmes d'amélioration. Le mil chandelle (*Pennisetum glaucum* (L.) R.Br.), Iniadi, une race locale productive, à maturation précoce, provenant dÁfrique occidentale, a été particulièrement utile tant pour sa capacité de transfert que pour sa valeur en tant que parent dans des programmes d'amélioration exécutés sur des sites géographiques très différents. Figure dans cet article l'information disponible sur la distribution, les caractères agronomiques et les collections de matériel génétique. L'utilisation de la race locale Iniadi pour la mise au point de cultivars en Inde, en Afrique occidentale et centrale, en Afrique australe et orientale et aux Etats-Unis est également décrite. Bien que l'utilisation du matériel génétique d'Iniadi ait contribué dans une grande mesure à l'amélioration génétique du mil chandelle, elle ne semble pas avoir créé de situations présentant des risques de vulnérabilité génétique. L'information donnée ici fait ressortir la valeur et l'impact des collections de matériel génétique dans l'amélioration du mil chandelle.

Resumen

Utilización de las especies locales de mijo perla Iniadi de Africa occidental en el desarrollo de cultivares

Los fitomejoradores generalmente usan germoplasma selecto que haya demostrado su potencial en cuanto a dar productos de una aceptación superior por parte del agricultor y en cuanto a ser buenos progenitores en los programas de mejoramiento genético. El mijo perla (*Pennisetum glaucum* (L.) R.Br.), Iniadi, una especie local productiva y de maduración temprana del Africa occidental, ha sido excepcionalmente útil en los programas de mejoramiento genético, tanto por su valor parental que de transferencia, en varias zonas geográficas ampliamente diferentes. Se describe la información disponible sobre la distribución, las características agronómicas y las colecciones disponibles de germoplasma. Asimismo se describe el uso de la Iniadi en el desarrollo de cultivares en India, Africa occidental, central, austral y oriental y los Estados Unidos. Aunque la utilización del germoplasma de la Iniadi ha contribuido ampliamente al mejoramiento genético del mijo perla, no parece haber creado situaciones potenciales de vulnerabilidad genética. La información que se proporciona en este artículo demuestra el valor e impacto de las colecciones de germoplasma en el mejoramiento del mijo perla.