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Full Length Research Paper

Participatory selection and characterization of quality protein maize (QPM) varieties in Savanna agro-ecological region of DR-Congo

K. Mbuya[1,2], K. K. Nkongolo[4]*, A. Kalonji-Mbuyi[1,3] and R. Kizungu[1,2]

[1]University of Kinshasa, B.P 117 Kinshasa 11, RD–Congo.
[2]Institut National pour l' Etude et la Recherche Agronomiques (INERA), B.P. 2037, Kinshasa 1, RD-, Congo.
[3]Nuclear Research Center, Kinshasa, RD-Congo.
[4]Department of Biological Sciences, Laurentian University, Sudbury, Ontario, Canada.

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Maize (*Zea mays* L.) is a major cereal crop for human nutrition in the Democratic Republic of Congo (DR- Congo). Prevailing normal maize is deficient in two essential amino acids, lysine and tryptophan. Participatory variety selection was applied to select diversified quality protein maize (QPM) varieties that possess farmers' preferred plant and grain traits. The varieties were planted with and without chemical fertilization. Selection was based primarily on agronomic traits such as time to maturity, plant and ear aspect, disease and insect resistance, yield and yield components as well as flour quality. There were significant differences among QPM varieties for several agronomic traits. The use of participatory approach in agricultural research allowed selection of one QPM, (QPMSRSYNTH), and one normal improved maize (AK9331-DMR-ESR-Y) for their yield advantage over currently released normal maize varieties in more than one criterion. The adoption of these newly introduced varieties is expected to be high since they were selected based on farmer's preference.

Key words: Quality protein maize, participatory varietal selection, DR-Congo.

INTRODUCTION

Several hundred million people in developing countries rely on maize as their main staple food. However conventional maize (corn) has two significant flaws; it lacks the full range of amino acids, namely lysine and tryptophan, needed to produce proteins, and has its niacin (vitamin B_3) bound in an indigestible complex. In addition diets high in corn produce a condition known as wet-malnutrition that leads to 'Kwashiorkor' caused by a chronic lack of protein in the diet (Hugo, 2000; Olakojo et al., 2007; Upadhyay et al., 2009).

Quality protein maize developed by the international maize and wheat improvement center (CIMMYT) in the late 1990's produces 70 to 100% more of lysine and tryptophan and yields 10% more grain than the most modern varieties of tropical maize (Bjarnason and Vasal, 1992; Vasal, 2000). These two amino acids allow the body to manufacture complete proteins, thereby eliminating wet-malnutrition. In addition tryptophan can be converted in the body to Niacin, which theoretically reduces the incidence of Pellagra. QPM offers 90% of the nutritional value of skim milk, the standard for adequate nutrition value (National Research Council, 1988; Hugo, 2000; Olakojo et al., 2007; Upadhyay et al., 2009).

QPM varieties have yielded positive results in China, Mexico, and Central America for yield and reduction of wet malnutrition. In Africa, 17 countries have introduced and promoted QPM. These include South Africa, Burkina Faso, Cameroon, Ivory Coast, Ethiopia, Ghana, Guinea, Kenya, Malawi, Mali, Mozambique, Nigeria, Ouganda, Senegal, Tanzania, Togo and Zimbabwe (Bressani, 1991; Olakojo et al., 2007; Upadhyay et al., 2009). The introduction of QPM in Democratic Republic - Congo is limited and localized in "National Institute for Agronomic Research and Studies (INERA) in Gandajika.

*Corresponding author. E-mail: knkongolo@laurentian.ca.

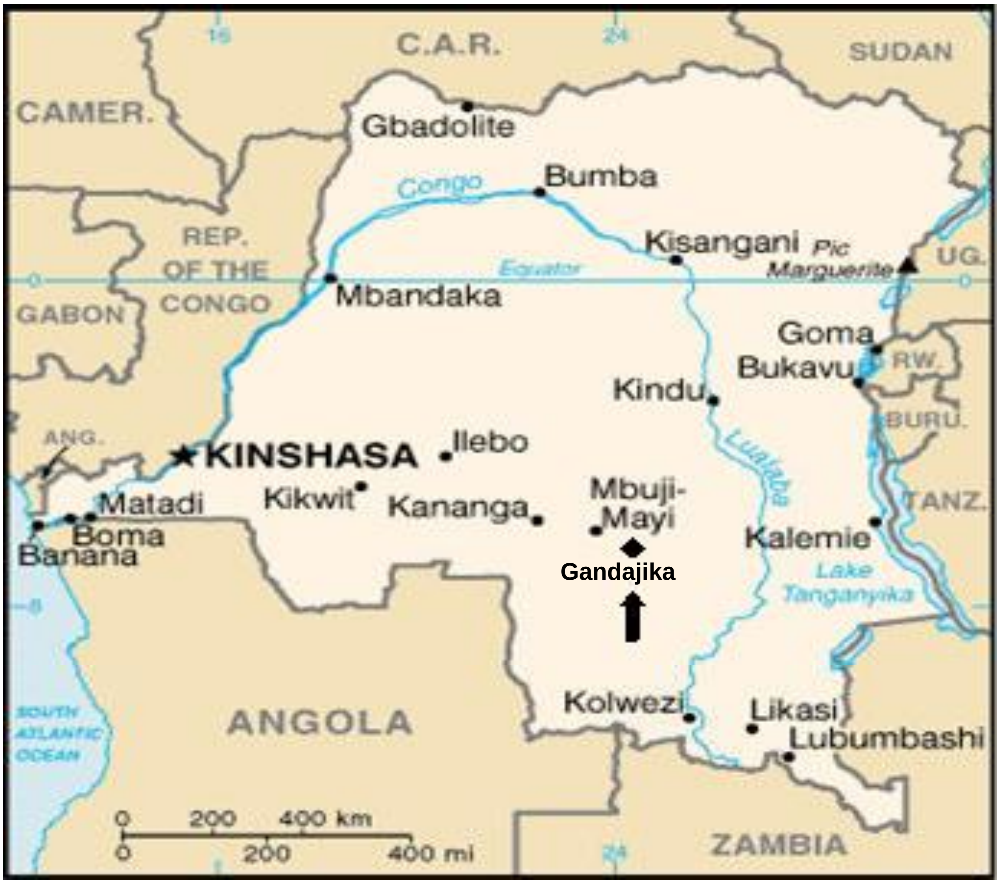

Figure 1. Map (in white) of DR- Congo. The arrow indicates the site location (Gandajika).

The low adoption rate of many of the crop varieties, especially in subsistence and small scale farming systems, has been attributed to the release of station-bred varieties that were evaluated and managed by researchers under conditions that are most favorable to crop growth without regard to local constraints and farmers (Gyawali et al., 2007; Weltzien et al., 2003). More recently, plant breeding strategies that make use of, and maintain crop diversity have been advocated by some researchers as one way of improving crop yields, productivity, stability, and adoption rate (Witcombe et al., 1996; Mekbib, 2006). Participatory plant breeding (PPB) or participatory variety selection (PVS) is one of such strategy that aims at strengthening cooperation between researches, especially breeders, and farmers in evaluating plant germplasm and establishing plant breeding goals that take into account farmers' knowledge and gender factors. Witcombe et al. (1996) were able to distinguish between works involving segregating or stable lines using participatory approach. They refer to work involving farmers in evaluating stable lines as "participatory variety selection" (PVS) while work with still-segregating material are referred to as PPB. The strategy is premised on the observation that the agronomic, socio-economic, and socio-cultural requirements of smallholder farmers and consumers are too diverse to be filled by a limited number of genotypes. Efforts to develop agriculture in a manner that will benefit the poor must fully address gender equality and the empowerment of women. Sex-disaggregated data, gender analysis, and women's participation in decision-making are necessities in agricultural planning and implementation, including development of new varieties.

The objective of this study was to use participatory variety selection (PVS) strategy to evaluate agronomic performance and flour quality of QPM among male and female farmers in a maize growing region of Gandajika, DR-Congo.

MATERIALS AND METHODS

Thirteen open pollinated (OP) quality protein maize varieties and ten normal maize varieties were evaluated for agronomic characteristics and disease reaction at two sites in Gandajika which falls within the savanna agro-ecological region. Gandajika is in Eastern Kasai of DR- Congo with latitude 6° 45' S, longitude 23° 57' E and altitude 780 m (Figure 1). Three of the normal varieties were hybrids and seven were OP. Five varieties adapted to local conditions were used as checks. They include four genetically improved and released varieties (Salongo 2, Mus 1, Kasaï, and GPS 5) along with a local farmer variety. The environmental

Table 1. Temperature, Relative humidity, and rainfalls during the 2008 to 2009 growing conditions in Gandajika (DR-Congo).

Month	Temperature (°C)			Relative humidity (%)			Rainfalls
	Max.	Min.	Mean	Max.	Min.	Mean	(mm)
October	33.5	21.2	27.4	75.1	52.1	63.6	155.9
November	32.8	21.6	27.2	81.4	64.3	72.8	164.0
December	31.6	22.2	26.9	86.7	67.0	76.8	125.1
January	32.5	21.2	26.8	80.6	71.4	76.0	115.8

Source: INERA Gandajika.

Table 2. Origin, year of introduction, and types of the 24 varieties evaluated with farmers in Gandajika, DR-Congo.

Varieties	Origin/Provider	Year of introduction	Type	category
ECA-QVE 3	CIMMYT-Kenya	2008	QPM	OP*
ECA-QVE 4	CIMMYT-Kenya	2008	QPM	OP
ECA-QVE 6	CIMMYT-Kenya	2008	QPM	OP
ECA-POPE1	CIMMYT-Kenya	2008	QPM	OP
POOL15QC7-SRC1-F2	CIMMYT-Kenya	2008	QPM	OP
DMR-ESR-W	IITA-Ibadan	1994	NORMAL	OP
AK9331-DMR-ESR-Y	IITA-Ibadan	1994	NORMAL	OP
QPMSRSYNTH	CIMMYT-Kenya	2008	QPM	OP
SUSUMA	CIMMYT-Kenya	2008	QPM	OP
OBATANPA-SRC1-F3	CIMMYT-Kenya	2008	QPM	OP
POOL15QPM-S	CIMMYT-Kenya	2008	QPM	OP
S99TLWQHG-AB	CIMMYT-Kenya	2008	QPM	OP
SOOTLWQ-AB	CIMMYT-Kenya	2008	QPM	OP
SOOTLWQ-B	CIMMYT-Kenya	2008	QPM	OP
LONGE 5	NARI-Ouganda	2008	QPM	OP
OPAQUE-2	CIMMYT -Kenya	2007	O-2**	OP
SALONGO-2	INERA-Gandajika	1976	NORMAL	OP
KASAI-1	INERA-Gandajika	1976	NORMAL	OP
MUS-1	INERA-Gandajika	1996	NORMAL	OP
GPS-5	INEAC-Gandajika	-	NORMAL	OP
LOCALE	Farmers	-	NORMAL	OP
PAN 67	South Africa	2008	NORMAL	Hybrid
PAN 77	South Africa	2008	NORMAL	Hybrid
MH 18	South Africa	2008	NORMAL	Hybrid

*Open pollinated varieties, **opaque-2 gene, NARI : Namulonge agriculture research institute, CIMMYT: International maize and wheat improvement center, INERA : 'Institut National pour l'Etude et la Recherche Agronomiques' (in french), INEAC: 'Institut National d'Etude Agronomique au Congo Belge' (in french), IITA: international institute of tropical agriculture.

conditions (temperature, relative humidity, and total monthly rainfall) recorded during the growing season at the evaluation site are presented in Table 1.

The source and year of introduction of each variety to DRC are described in Table 2. Selection of farmer for this study was based on willingness to participate as well as their knowledge of maize crop and its production. Care was taken for gender considerations, therefore both men and women were involved. Staff members of ¨the National Institute for Agronomic Studies and Research or 'Institut National pour l'étude et la recherche agronomique (INERA)' and local NGOs participated in the site and farmer selection. Participating farmers (23 men and 16 women) were from Gandajika and five surrounding villages (Kalunga, Mpembanzeu, Muyembi, Mpiana and Bena Kayumba). They were briefed on their role as well as the objectives and expectations of project activities.

The community plot at each site was ploughed and ridged at a spacing of 0.75 × 0.5 m. Gross plot size (experimental unit) was 5 m long and 1.5 m wide. Two seeds were planted per stand and later thinned to one two weeks after seedling emergence to provide a uniform plant population of 53,333 plant / ha. Manual weeding

Table 3. Plant aspect, reaction to downy mildew and maize streak virus (MSV), days to flowering and plant height of 13 QPM, 7 normal open pollinated maize varieties and 3 normal maize hybrids evaluated under chemical fertilization in community plots in Gandajika, DR-Congo.

Varieties	Plant aspect	Reaction to downy mildew	Reaction to maize streak virus	Days to 50% male flowering	Days to 50% female flowering	Plant height
	1-5	1-5	1-5	Days	Days	cm
ECA-QVE 3	1.5	1.0	1.5	53.3	56.0	141.7
ECA-QVE 4	1.5	1.0	1.8	51.3	54.7	132.3
ECA-QVE 6	1.5	1.0	1.3	52.7	56.0	135.0
ECA-POPE1	1.5	1.2	1.3	51.3	55.7	138.0
POOL15QC7-SRC1-F2	1.5	1.0	1.3	52.0	55.3	145.3
DMR-ESR-W	1.7	1.0	1.0	52.7	56.0	132.7
AK9331-DMR-ESR-Y	1.3	1.0	1.3	56.0	58.7	149.7
QPMSRSYNTH	1.3	1.0	2.0	56.7	59.3	162.7
SUSUMA	1.7	1.0	1.8	57.0	59.7	158.7
OBATANPA-SRC1-F3	1.5	1.2	1.3	57.3	60.7	167.0
POOL15QPM-S	1.5	1.0	1.8	53.0	57.0	132.3
S99TLWQHG-AB	4.0	1.0	4.2	60.7	63.3	137.7
SOOTLWQ-AB	4.0	1.0	3.8	59.3	62.7	132.7
SOOTLWQ-B	4.0	1.0	3.5	59.0	61.3	156.7
LONGE 5	1.5	1.0	1.2	59.7	59.7	152.3
OPAQUE-2	1.3	1.0	1.0	63.7	63.7	144.7
SALONGO-2	1.3	1.0	1.8	65.3	65.3	171.0
KASAI-1	2.0	1.0	2.2	63.7	63.7	165.3
MUS-1	1.3	1.0	1.3	59.7	59.7	157.7
GPS-5	1.5	1.0	1.7	64.7	64.7	165.0
LOCALE	1.8	1.0	1.5	63.7	63.7	181.0
PAN 67	1.2	1.2	1.5	60.7	60.7	163.7
PAN 77	1.8	1.0	1.5	61.0	61.0	167.7
MH 18	3.0	1.0	3.0	60.3	60.3	152.7
LSD (0.05)	0.7	ns	0.8	1.5	1.5	16.9
CV (%)	23.3	10.2	25.7	1.6	1.6	6.8

was carried out as to keep the field clean. The trial was a completely randomized block design (RCBD) with three replicates. At each site, two trials were conducted, one with chemical fertilizer application and the second with no fertilizer application. The fertilizer treatment consisted of the application of 140 kg/ha of NPK (17-17-17) at 14 days after planting followed by 20 Kg/ha of nitrogen (urea fertilizer) application 25 to 30 days later.

Data collection was based on farmer and breeder criteria. The following data were collected from the two middle rows of each plot: plant aspect, days to 50% flowering, plant heights, husk tip cover, and cob aspect using ratings 1 to 5, where 1 = excellent, 2 = very good, 3 = good, 4 = fair and 5 = poor. All varieties were observed for the natural symptoms of two main local diseases, maize streak virus (MSV) and Downy mildew (caused by *Peronosclerospora (sclerospora) sorghi*). Severity of each of the two diseases was scored using a rating 1- 5 where, 1 = no symptom, 2 = slight infection, 3 = moderate infection, 4 = severe infection, and 5 = very severe. Other yield related characters included ear number, kernel rows, kernels per row, and grain filling. At harvest, ears from the middle two rows were harvested together, shelled and grain yield per plot was determined at 14% moisture content from which grain yield per ha was estimated. Grain yield was adjusted to 83% shelling recovery from the de- husked cob weight per plot. The key criteria for male and females farmers include grain yield, big cob size, small cob rachis, easiness for shelling, and corn flour quality for local dishes (fufu).

Collected data were subjected to analysis of variance (ANOVA) using Genstat discovery version 3 and the least significant differences among means were calculated to identify differences among specific treatments.

RESULTS

Data related to plant development are summarized in Tables 3 and 4 for both trials with and without fertilization. In the first trial (with chemical fertilization), days to 50% flowering varied from 51.3 to 62.3 for male flowering and 54.7 to 65.3 for female flowering. Plant aspect rating varied between 1 and 4. ECA-QVE3, ECA-QVE6, POOL15QC7-SRC1-F2, DMR-ESR-W, AK9331- DMR-ESR-Y, QPMSRSYNTH and MUS-1 were overall

Table 4. Average agronomic performance of 13 QPM varieties, 7 normal open pollinated varieties and 3 normal hybrids evaluated under chemical fertilization (NPK and urea) in community plots in Gandajika, DR-Congo.

Varieties	Cob aspect*	Kernel rows per cob	Cob size/ diameter (cm)	Cob rachis size (cm)	Cob length (cm)	Adjusted grain yield* (t/ha)	Flour quality*
	1-5	Number					1-5
ECA-QVE 3	1.8	14.7	4.3	2.6	15.1	3.1	1.5
ECA-QVE 4	1.7	14.7	4.3	2.4	13.7	3.8	1.5
ECA-QVE 6	1.7	14.0	4.3	2.5	13.5	3.2	1.5
ECA-POPE1	1.7	14.6	4.3	2.4	13.8	3.7	2.0
POOL15QC7-SRC1-F2	1.7	14.7	4.3	2.5	15.3	3.8	2.0
DMR-ESR-W	1.7	13.3	3.8	2.1	13.7	2.9	1.5
AK9331-DMR-ESR-Y	1.5	14.0	4.3	2.4	15.0	4.8	1.5
QPMSRSYNTH	1.7	14	4.3	2.5	16.6	4.2	1.5
SUSUMA	1.5	14.7	4.6	2.4	15.3	3.7	1.0
OBATANPA-SRC1-F3	1.7	14.0	4.5	2.4	15.4	3.3	1.0
POOL15QPM-S	2.2	14.0	4.5	2.5	14.1	2.6	1.5
S99TLWQHG-AB	2.0	16.0	4.4	2.4	15.3	-	-
SOOTLWQ-AB	2.5	14.7	4.4	2.5	15.3	-	-
SOOTLWQ-B	1.7	15.3	4.4	2.5	15.7	-	-
LONGE 5	1.7	14.0	4.3	2.7	14.8	3.1	1.0
OPAQUE-2	3.0	13.3	4.4	2.4	17.5	2.5	2.5
SALONGO-2	1.8	14.7	4.4	2.5	15.0	3.5	1.5
KASAI-1	1.8	16	4.6	2.5	15.2	3.4	1.5
MUS-1	1.8	14.7	4.3	2.7	15.1	3.8	1.0
GPS-5	2.2	12	3.8	2.2	15.1	2.2	1.5
LOCALE	1.8	10.7	3.7	1.4	14.0	3.5	1.5
PAN 67	1.8	12	4.5	2.2	16.2	3.9	2.0
PAN 77	2.0	13.3	4.5	2.7	16.7	4.1	2.0
MH 18	2.2	14.0	4.3	2.3	15.4	3.5	1.5
LSD (0.05)	0.6	1.4	0.3	0.3	1.1	0.4	-
CV (%)	20.1	6.1	4.5	6.9	4.3	7.5	-

1= best and 5 = worst.

preferred by farmers for their plant aspect (Table 3), whereas among the QPM varieties, S99TLWQHG-AB, SOOTLWQ-AB, and SOOTLWQ-B received the lowest score of 4 and were not selected by farmers. Other QPM entries were not significantly different from released normal varieties and the local farmer variety. Among the hybrids, MH18 showed a moderate score of 3 (Table 3). All the varieties showed good husk cover. Plant heights vary from 116.7 to 167.3 cm with the local farmer variety, Salongo-2, GPS-5, Kasai- 1, Obatanpa-SRC1-F3, and the hybrid PAN 77 producing the tallest plants (Table 3). In general, early maturing varieties were shorter than late maturing.

There were no significant differences among the varieties under the trial conditions for incidence and severity of downy mildew. All the varieties showed resistance to this disease with ratings varying from 1 to 1.2 (Table 3). However there were significant differences among the varieties for maize streak virus ratings. S99TLWQHG-AB, SOOTLWQ-AB, and SOOTLWQ-B, and MH18 hybrids were considered susceptible under experimental conditions with disease rating ranging from 3.0 to 4.2. Kasaï 1 (score 2.2) was moderately resistant while the remaining 18 varieties were resistant (scores ranged between 1 and 2.0).

Result of yield related characters revealed that cob aspect rating ranged from 1.5 to 3. Most varieties produced good to very good ears (score 1.5 to 2.2) (Table 4). Cob length varied from 13.5 to 17.5 cm with OPAQUE 2 recording the longest cob, while the shortest cobs were observed in ECAQVE-6. However, QPMRSYNTH had the longest cob among the QPM varieties.

There were significant differences among varieties for number of kernel rows per cob. Kasaï 1 (an improved check) and S99TLWQHG-AB had the highest number of kernel rows (16 under chemical fertilization and 15.3 for Kasai 1 in trials without chemical fertilization) while the local farmer variety had the lowest (10.7 in plots with chemical fertilization and 11.3 in plots without fertilization).

Table 5. Characteristics (plant aspect, reaction to Downy Mildew and Maize Streak Virus) days to flowering and plant height of 13 QPM varieties, 7 normal open pollinated maize varieties and 3 normal maize hybrids evaluated under no-chemical fertilization in community plots in Gandajika, DR-Congo.

Varieties	Plant aspect	Reaction to downy mildew	Reaction to maize streak virus	Days to 50% male flowering	Days to 50% female flowering	Plant height
	1-5	1-5	1-5	Days	Days	cm
ECA-QVE 3	1.8	1.3	1.0	53.7	56.3	136.0
ECA-QVE 4	2.2	1.0	1.3	53.0	57.3	128.0
ECA-QVE 6	2.2	1.3	1.7	53.3	58.3	123.3
ECA-POPE1	2.0	1.3	1.3	53.3	57.7	119.7
POOL15QC7-SRC1-F2	2.2	1.0	1.8	53.0	57.3	121.0
DMR-ESR-W	1.8	1.0	1.0	53.3	58.3	124.3
AK9331-DMR-ESR-Y	1.5	1.0	1.5	58.7	62.0	125.7
QPMSRSYNTH	1.8	1.0	2.2	60.0	64.3	133.7
SUSUMA	1.7	1.2	1.5	59.3	63.0	140.3
OBATANPA-SRC1-F3	2.0	2.0	1.7	59.7	63.7	159.0
POOL15QPM-S	2.0	1.2	2.0	53.7	58.3	134.3
S99TLWQHG-AB	4.0	1.0	4.0	61.7	66.0	134.0
SOOTLWQ-AB	4.0	1.0	3.7	63.0	66.0	119.0
SOOTLWQ-B	4.0	1.0	3.7	62.0	65.0	135.3
LONGE 5	1.7	1.0	1.2	59.3	62.3	131.3
OPAQUE-2	2.2	1.0	1.0	63.7	69.7	116.7
SALONGO-2	1.5	1.0	2.2	62.7	68.7	138.7
KASAI-1	2.7	1.0	2.8	64.3	71.3	128.3
MUS-1	1.7	1.0	1.2	62.7	65.3	132.0
GPS-5	2.0	1.0	1.7	62.0	69.7	167.3
LOCALE	1.7	1.0	2.2	62.7	67.3	153.3
PAN 67	1.5	1.2	1.2	57.3	61.7	155.0
PAN 77	1.5	1.0	1.5	61.7	66.0	156.0
MH 18	2.0	1.3	2.3	59.7	63.7	131.3
LSD (0.05)	0.6	0.3	0.6	1.9	2.6	16.5
CV (%)	18.0	16.3	20.6	2.0	2.5	7.4

All the QPM varieties had relatively high number of kernel rows per cob varying from 14 to 15.3 on average. These values were significantly higher than for the local variety but similar to data recorded for most normal varieties. Cob diameter varied from 3.7 to 4.6 cm. The local farmer variety, GPS-5, and DMR-ESR-W had significantly smaller cobs than most of QPM and improved normal varieties. Cob rachis size (diameter) varied from 1.4 to 2.9 cm (Table 4). The smallest size of cob rachis was observed in the local farmer's variety.

There were significant differences among the mean grain yield of entries. It varied from 2.2 to 4.8 kg ha^{-1}. Only one QPM variety (QPMSRSYNTH) and one improved normal variety from IITA, AK9331-DMR -ESR -Y yielded more than the currently released varieties (Mus 1, Kasaï 1, GPS 5, Salongo 2) (Table 4). The same trend was observed in trial without fertilizer application. The flour quality score of OPAQUE 2 for making local dish (fufu) ranges from 1 to 1.5 and was considered excellent and very good (Table 4). The taste and palatability of local dish (fufu) made with the selected varieties was considered good by all the participants.

The data of trials without chemical fertilizer conducted in the same sites as the first one were summarized in Tables 5 and 6. Generally, the farmer's rankings of the varieties were similar to those described for trials with fertilizer application. However grain yield was 21% higher when NPK and urea were applied when compared to trials without fertilizer. In both trials, the normal improved variety AK9331-DMR-ESR-Y had the highest grain yield (4.8 T/ha and 3.9 T/ha, for fertilized and non fertilized trials, respectively) followed by the QPMSRSYNTH with 4.2 T/ha and 3.4 T/ha, for fertilized and non fertilized trials, respectively. The grain yield advantages of AK9331-DMR-ESR- Y over the improved normal varieties Salongo 2, Mus 1, and Kasaï were 25, 39 and 62% respectively, in trials without fertilization. Moreover, under the same condition the grain yield for this variety (AK9331-DMR-ESR- Y) was 77% higher than the local farmer variety. Average grain yield for AK9331-

Table 6. Average agronomic performance of 13 QPM varieties, 7 normal open pollinated varieties and 3 normal hybrids evaluated without chemical fertilization (NPK and urea) in community plots in Gandajika, DR-Congo.

Varieties	Cob aspect	Kernel rows / Cob	Cob size/diameter (cm)	Cob rachis size (cm)	Cob length (cm)	Adjusted grain yield (t/ha)
	1-5	Number				
ECA-QVE 3	1.7	14.7	4.3	2.6	13.3	2.3
ECA-QVE 4	2.0	13.3	4.0	2.5	12.5	2.7
ECA-QVE 6	2.0	14.7	4.1	2.5	12.4	2.9
ECA-POPE1	2.0	14.0	4.1	2.6	12.0	2.4
POOL15QC7-SRC1-F2	2.0	14.7	4.0	2.6	12.4	2.9
DMR-ESR-W	1.5	13.3	3.7	2.3	12.7	2.5
AK9331-DMR-ESR-Y	1.7	14.0	4.2	2.5	13.7	3.9
QPMSRSYNTH	1.8	13.3	4.0	2.5	13.7	3.4
SUSUMA	1.7	14.0	4.3	2.4	14.3	3.2
OBATANPA-SRC1-F3	1.7	14.7	4.0	2.5	12.8	3.0
POOL15QPM-S	1.8	14.0	4.1	2.5	12.5	2.3
S99TLWQHG-AB	1.8	14.7	4.1	2.5	14.0	2.9
SOOTLWQ-AB	1.8	14.7	4.2	2.5	14.0	-
SOOTLWQ-B	1.8	14.0	4.1	2.5	13.8	-
LONGE 5	1.8	14.0	4.3	2.5	13.4	-
OPAQUE-2	3.0	13.3	4.1	2.4	13.9	1.7
SALONGO-2	1.5	14.7	4.3	2.5	14.3	3.1
KASAI-1	1.7	15.3	4.2	2.4	13.7	2.4
MUS-1	1.7	14.0	4.1	2.5	13.8	2.8
GPS-5	1.7	12.0	3.7	2.5	13.6	2.1
LOCALE	2.7	11.3	3.7	1.4	12.4	2.2
PAN 67	1.7	12.0	4.2	2.2	13.2	3.1
PAN 77	1.5	14.0	4.7	2.6	14.9	3.4
MH 18	1.8	12.7	4.2	2.3	14.0	2.9
LSD (0.05)	0.5	1.6	0.4	0.3	1.1	0.4
CV (%)	15.1	7.2	5.4	6.6	5.0	5.1

DMR-ESR-Y variety was 37, 26 and 41% higher than Salongo 2, Mus 1, and Kasai 1, respectively under chemical fertilization regimen. The yield for AK9331-DMR-ESR-Y variety was 37% higher than for the local farmer variety in trials with chemical fertilization. The yield advantages of QPMSRSYNTH over currently released and local varieties vary from 10 to 62% in trials without fertilization. These values ranged from 10 to 24% under chemical fertilization. The agronomic performance of AK9331- DMR-ESR-Y and QPMSRSYNTH over the released normal improved maize varieties was confirmed in subsequent field observations during the 2009 to 2010 growing season.

DISCUSSION

The exotic QPM varieties tested under local conditions in Gandajika (DR-Congo) showed significant variation for grain yield, days to flowering, plant height, and plant and cob aspects. Two varieties, AK9331-DMR-ESR-Y and QPMSRSYNTH stood out of the collection for their agronomic performance in the two sites. The agronomic performance of other QPM and normal varieties were equal or slightly better than the genetically improved normal varieties currently released or the local farmer variety. The QPM variety Obatanpa developed in Ghana in 1992 and widely grown in many African countries (Sallah et al., 2003) had similar scores with currently released normal varieties for most yield components. The low incidence of downy mildew and maize streak virus symptoms in QPM plots was surprising because all the QPM varieties showed some level of susceptibility to MSV and downy mildew during pre-screenings at the Gandajika research station. This low incidence is likely a result of late planting of the trials during the 2008 to 2009 growing season that resulted in poorer conditions for pathogen inoculum growth. It has been reported that quality protein maize varieties are more vulnerable to diseases than normal maize varieties (National Research Council, 1988; Akande and Lamidi, 2006).

The two elite varieties (AK9331-DMR-ESR-Y and

QPMSRSYNTH) produced 23% more grain yield in fertilized plots than in unfertilized ones under the evaluation conditions. Considering that it costs 50% more per ha to use chemical fertilizers, it is recommended that the selected varieties could be grown without chemical fertilizer. The scores between male and female farmers in this study were very close, however, slight difference observed was an indication that male and female farmers have particular preferences for certain traits. The females, ranked flour qualities for making local dishes second to grain yield among the important criteria while males considered disease resistance second to grain yield during the selection. Farmers' knowledge about the crops in their areas has a high potential of strengthening PVS/PPB programs. It would serve well to empower scientists' knowledge for designing site-, crop- and farmer–specific activity.

One of the advantages of using PPB or PVS is that selected varieties can be released in a particular community without a formal release. Decentralization is often intertwined with participation in PPB or PVS programs in ways that makes it difficult to separate out the effects of these two distinct phenomena (Weltzien et al., 2003). The decision to decentralize can be based on the extent of G X E (Genetics X Environment) interactions and the target region. In the present study there was no significant G X E when most criteria were considered. Likewise no significant differences in ranking of accessions from location to location were observed. The two varieties, AK9331-DMR-ESR-Y and QPMSRSYNTH did score first and second place, respectively, at both locations. If decentralization is deemed to be beneficial, organizational issues come into play in determining how to best structure a decentralized program. Particular models of farmer participation may be especially appropriate for highly decentralized programs. But the degree and nature of participation can and should be considered separately from decentralization. The present project was decentralized since it targeted only two locations within an agricultural region and no multi-location evaluation of the corn varieties was conducted.

The two elite varieties are being considered for release locally in Gandajika since they have good culinary qualities and farmer preferences varied little among the two sites within the region. It is expected that they will be released across the corn growing regions in DR-Congo when multi-location evaluation is completed. There is abundance evidence supporting the fact that when the knowledge that farmers have is integrated in breeding scheme, it will increase the adoption rate of new varieties. This study clearly confirms previous reports that collaborative breeding and selection with farmers is extremely useful for decentralizing breeding programs (Gyawali et al., 2007).

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