Sustainable production of grains in Amazonian floodplain

José Ricardo Pupo Gonçalves [A], José Roberto Antoniol Fontes [A], Ronaldo Ribeiro de Morais [A], Maurisrael de Moura Rocha [B] and Lauro José Moreira Guimarães[C]

[A]Brazilian Agricultural Research Coorporation–Western Amazon, Manaus, AM, Brazil, Email ricardo.pupo@cpaa.embrapa.br
[B]Brazilian Agricultural Research Coorporation –Middle North, Teresina, PI, Brazil, Email mmrocha@cpamn.embrapa.br
[C]Brazilian Agricultural Research Coorporation – Maize and Sorghum, Sete Lagoas-MG, Brazil, Email lauro@cnpms.embrapa.br

Abstract
The Amazonian floodplains present high natural fertility and can be used for sustainable production of grains by the local populations of Amazonas. With the objective to evaluate the potential productivity of the floodplain ecosystem, two experiments with maize and cowpea were carried out at the district of Iranduba-AM, Brazil, in a soil classified as Gley Humic. The experimental design of cowpea experiment was a randomized block with twenty treatments consisted by twenty cowpea genotypes. The variables evaluated were flowering, 100 grain weight and yield. The experimental design of the maize experiment was a randomized block with twenty five treatments and two replications. The variables evaluated were plant height, stand, ear length and grain yield at 13% moisture. The data of both experiments were subjected to analysis of variance and treatment means were compared by the Scott Knott test at 5% probability. The genotypes MNC05-832B-234-5, California Black Eye, Vaina Blanca, MNC99-541F-5, MNC99-537-4, MNC99-542F-5 and MNC99-537F-1 can be a good option for the floodplain conditions in the State of Amazonas. In the case of corn, the yield did not show significative differences between the genotypes, but some treatments reached more than 5000 kg/ha.

Key Words
Maize, cowpea, Amazonas, food security.

Introduction

The central Amazonian floodplain is composed of an extensive mosaic of wetlands including lakes and seasonally flooded grasslands and forests. These habitats are highly productive and contain a diverse biota (Palha *et al.* 2003). The Amazonian River floodplain (várzeas) belongs to the few areas in central Amazonia with relatively high natural fertility and productivity, because of annual flooding with sediment-rich water add nutrients to the system. Many development planners consider the area to be of high agricultural production potential and of great importance for regional and national economy and development. Inland fishery provides an important part of the animal protein supply of the local population. However, agricultural production is low and does not satisfy the demand of large cities like Manaus, because of the specific ecological conditions of the *várzea*. (Junk 2001). Despite the difficulties of predicting the frequency of flooding, a large portion of food crops are produced in these areas (Smyth 1996). Maize is an essential crop for food security around the world. In Brazil, maize is the second most important grain crop, both in cultivated area and production just after soybean (Stork *et al.* 2009). The cowpea (*Vigna unguiculata* L.) is the main grain legume in the Amazon, where it is grown under subsistence crop rotation or intercropped with cereals. Studies in humid conditions with incorporation of cowpea residue have shown that that legume can be an important source of N for subsequent crops (Smyth *et al.* 1987). Representing nearly 100% of the dry grain yield of all crops grown in the state of Amazonas, the cowpea is cultivated in the floodplains and uplands. Yields vary considerably in both ecosystems, while in the floodplain area the average is around 1000 kg/ha, on upland, the yield rarely exceeds the 300 kg/ha. Due to the high fertility of floodplains and the optimal availability of water, light and heat, it is believed that the yield can be easily (Nogueira 1980). Although several authors have reported on the high fertility of the floodplain, few studies with data from cultures have been reported. This study aimed to evaluate the productivity of maize and cowpea for Amazonas River floodplain conditions in the district of Iranduba, Amazonas State, Brazil.

Methods

Local characteristics

Two experiments were carried out at the Caldeirão Experimental Station of Embrapa Western Amazon, in the district of Iranduba - AM, Brazil, located at coordinates 03°15' S 60°13' W. The altitude is 30 m and the soil is a Gley Humic, considered to have high fertility (Table 1). The climate according Köppen classification is Ami with average annual temperature of 27° C, average annual rainfall of 2015 mm and

relative humidity around 88%. The experiments aim to evaluate two species with potential use by local populations: cowpea and maize.

Cowpea
The experimental design of cowpea experiment was a randomized block with twenty treatments and four replications. The treatments consisted of twenty cowpea genotypes: MNC99-537F-1, MNC99-537F-4, MNC99-541F-5, MNC99-541F-8, MNC99-542F-5, MNC00-553D-8-1 -2-2 (BRS Novaera), MNC00-553D-8-1-2-3, MNC99-557F-2, MNC01-627F-14-2, MNC01-627F-14-5, MNC03-720C-20, MNC03 -720C-31, MNC03-731C-21, MNC03-732C-5, CTX-5058-09C, MNC05-784B-32-2, MNC05-832B-234-5, Vaina Blanca, California Black Eye and BRS Guariba. The soil was tillage mechanically with one plowing and two harrowing. The sowing was done manually on 26/08/2008, leaving two plants per hole after thinning. The variables evaluated were flowering, 100 grain weight and yield. The data were subjected to analysis of variance and treatment means were compared by Scott Knott test at 5% probability. Considering that the state average yield is low, it is estimated that at around 350 kg/ha, the genotypes MNC05-832B-234-5, California Black Eye, Vaina Blanca, MNC99-541F-5, MNC99-537-4, MNC99-542F-5 and MNC99-537F-1 can be a good option for the floodplain conditions in the State of Amazonas.

Maize
The experimental design of maize experiment was a randomized block with twenty five treatments and two replications. The treatments consisted of twenty five maize genotypes: Sintetic 256 L, VSL FB 33, VSL BS 42 C 60, BRS 2020, BRS Caimbé, Sintetic 1 X, BRS 4103, Sintetic RxS Spod, BRS Eldorado, Sol da Manhã, MC 20, BR 473, BR 106, Sint Pro VA, BR 106 Q, BRS 2022, AL BDE/40, AL 30/40, H25ALTA, AL Piratininga, UFV 8, BIO 4, AEO 2008, UFV 7 e Sint. Multipla TL. The sowing was done manually on 19/11/2008, at 0,8m of spacing and leaving five plants per meter after thinning. The variables evaluated were plant height, stand, ear length and grain yield at 13% moisture. The data were subjected to analysis of variance and treatment means were compared by Scott Knott test at 5% probability. Considering that the state average yield of cowpea is low, it is estimated that at around 350 kg/ha, the genotypes can be a good option for the floodplain conditions in the State of Amazonas.

Results

Soil
The chemical results of soil analysis are in the Table 1. The soil chemical analysis indicates high levels of phosphorus, calcium and magnesium, as well as high base saturation and low levels of exchangeable aluminium. According to these results, it can be inferred that the soil has the ability, at least chemically, support crops such as maize and cowpea.

Table 1. results of chemical analysis of soil taken at depth 0-20cm.

Depth	pH	O.M.	P_2O_5	K_2O	Ca^{2+}	Mg^{2+}	Al	H+Al	SB	t	T	V	m
(cm)		g /kg	(--- mg/dm^3 ---)		(---------- cmol$_c$/dm^3 ----------)							------- % -----	
0-20	5,39	13,47	67	75	9,27	2,25	0,44	2,05	11,83	12,27	13,88	85,26	3,58

O.M.=organic matter; SB=sum of basis; t= effective cation exchange capacity; T= cation exchange capacity at 7,0 pH; V=basis saturation; m=Aluminiun saturation.

Cowpea
In Table 2 are the data for the cowpea genotypes evaluated. All treatment results are significant by F test and Scott Knott at 5% probability. The yield of the test ranged from 538 to 1447 kg/ha and the genotypes with higher yields were MNC05-832B-234-5, California Black Eye, Vaina Blanca, MNC99-541F-5, MNC99-537-4, MNC99-542F-5 and MNC99-537F-1 with yield of 1447, 1.406, 1229, 1212, 1211, 1207 and 1205 kg/ha, respectively. The genotypes MNC 01-627F-14-2, MNC05-784B-38-2, MNC01-627-14-5, CTX-5058-09C and MNC03-732C-5 presented the lowest yields with 801, 774, 757 and 538 kg/ha, respectively. The genotype MNC05-832B-234-5 showed good productivity, relative precocity, average of 45.25 days to flowering and good 100 grains weight (19.92 g). These attributes are of great importance for the choice of variety to be sown early in the meadow ecosystem, the growing season is short and the earlier the variety, the greater the possibility of growing another culture and enjoy better availability of the area and the residual effect promoted by the cultivation of legumes. BRS Guariba e BRS Novaera produced 1103 and 954 kg/ha, respectively, with flowering period of 49 days and 100 grain weight of 17.20 and 16.57 g. Thus, considering that the state average yield is low, it is estimated that at around 350 kg/ha, the genotypes MNC05-832B-234-5,

California Black Eye, Vaina Blanca, MNC99-541F-5, MNC99-537-4, MNC99-542F-5 and MNC99-537F-1 can be a good option for the floodplain conditions in the State of Amazonas.

Table 2. Data of commercial subclass, yield, 100 grains weight and flowering of cowpea genotypes evaluated in the Amazon River floodplain at Iranduba, AM, Brazil (2008).

Cowpea Genotype	Comercial Subclass	Yield*		100 grain weight*		Flowering*	
		(kg/ha)		(g)		(days)	
MNC05-832B-234-5	White	1.447	a	19,92	a	45,25	c
California Black Eye	Black Eye	1.406	a	15,68	b	45,25	c
VAINA BLANCA	Black Eye	1.229	a	16,24	b	45,25	c
MNC99-541F-5	White	1.212	a	15,10	c	49,00	b
MNC99-537F-4	White	1.211	a	17,58	b	49,00	b
MNC99-542F-5	White	1.207	a	17,87	b	49,00	b
MNC99-537F-1	White	1.205	a	17,64	b	49,00	b
BRS NOVAERA	White	1.103	b	17,20	b	49,00	b
MNC 03-720C-20	White	1.091	b	16,86	b	49,00	b
MNC99-541F-8	White	1.073	b	14,93	c	51,75	a
MNC03-731C-21	White	999	b	18,80	b	51,25	a
BRS GUARIBA	White	954	b	16,57	b	49,00	b
MNC00-553D-8-1-2-3	White	930	b	19,22	a	49,50	b
MNC99-557F-2	White	882	b	17,31	b	46,50	c
MNC03-720C-31	White	871	b	18,39	a	47,75	c
MNC01-627F-14-2	White	840	b	15,61	b	47,75	c
MNC05-784B-38-2	White	801	c	18,88	a	50,00	b
MNC01-627-14-5	White	774	c	15,04	c	49,00	b
TVx-5058-09C	White	757	c	12,66	c	52,25	a
MNC03-732C-5	White	538	c	17,54	b	51,25	a
** V.C. (%)		21,61		17,08		4,15	

* Values followed of the same letter did not differ by the Scott Knott test at 5% of probability.
** V.C. = variation coefficient.

Table 3. Data of yield, stand, height and ear length of maize genotypes evaluated in the Amazon River floodplain at Iranduba, AM, Brazil -2008.

Genotype	Yield*	Stand**		Height**		Ear Length*
	(kg/ ha)	(plants/ ha)		(cm)		(cm)
BRS 2020	5612	59375	a	2,03	a	11,51
H25ALTA	5105	61718	a	1,95	a	13,97
Sintetic RxS Spod	4957	33593	c	1,81	b	16,86
BRS Eldorado	4805	54687	a	2,27	a	14,75
VSL FB 33	4803	59375	a	2,04	a	13,98
Sintetic MULTIPLA TL	4780	55468	a	2,04	a	13,87
VSL BS 42 C 60	4647	55468	a	1,80	b	14,91
Sol da Manhã	4640	47656	b	2,24	a	13,87
BRS 2022	4536	56250	a	1,76	b	13,20
UFV 7	4501	60937	a	2,02	a	15,59
Sintetic 1 X	4495	57812	a	2,04	a	14,94
BRS 4103	4451	53906	a	1,85	b	15,62
AL Piratininga	4256	58593	a	2,15	a	14,83
BRS Caimbé	4199	53906	a	2,15	a	15,64
AL BDE/40	4155	59375	a	1,98	a	14,39
BIO 4	3978	52343	a	2,04	a	16,56
Sintetic 256 L	3899	60937	a	1,99	a	15,09
BR 106 Q	3809	47656	b	2,18	a	15,93
AL 30/40	3699	56250	a	1,98	a	12,68
BR 106	3667	53125	a	2,18	a	13,31
Sint Pro VA	3421	55468	a	1,65	b	13,64
BR 473	3394	53906	a	2,25	a	14,76
UFV 8	3213	54687	a	1,57	b	10,59
MC 20	3140	59375	a	2,02	a	15,34
AEO 2008	2851	39062	c	2,13	a	14,46
Variation Coefficient (%)	24,73	6,89		7,84		14,58

* No significance in the F test (P>0,01).
** Values followed by the same letter did not differ by the Scott Knott test at 5% of probability.

Maize

There was significance effects for the F test for height and stand, however, for the variables yield and ear corn length, there was no significance for this test (Table 3). The number of plants/ha ranged from 61,718 to 33,593, indicating that some genotypes and some plants died before completing the cycle, and are not adapted well to the climate. The genotypes AEO 2008, Sint RXS Sprode had the lowest numbers of plants per ha, with 39,062 and 33,593 plants/ha, respectively. Plant height ranged from 1.57 m to 2.27 m with an average of 2.01 cm indicating good development based on the overall mean. The shorter plants were UFV 8, Sint Pro VA, BRS 4103, BRS 2022, VSL BS 42 C 60 and Synthetic RXS Sprode. Yield ranged from 2851 to 5612 kg/ha, values higher than the regional average. Although there was no difference in the F test, these figures indicate that there are genotypes with good yield that can be recommended for cultivation in the floodplains areas.

Conclusion

Cowpea and maize represent a good alternative for food production and can be cultivated in a sustainable way in the Amazonian Floodplains. The cowpea can be cultivated in the Amazonian Floodplains without use of liming or fertilizer to achieve high yields and maize needs low amounts of nitrogen to achieve good yields in this ecosystem.

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