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Plant productivity in cassava-based mixed cropping systems in Colombian hillside farms

G.C. Daellenbach[a,b,*], P.C. Kerridge[a], M.S. Wolfe[c], E. Frossard[b], M.R. Finckh[d]

[a]*Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia*
[b]*Swiss Federal Institute of Technology (ETH), Zurich, Switzerland*
[c]*Wakelyns Agroforestry, Fressingfield, Suffolk, UK*
[d]*Faculty of Agriculture, University of Kassel, Witzenhausen, Germany*

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Abstract

In the Colombian hillsides cassava (*Manihot esculenta* Crantz) is cultivated because of its ability to produce high yields on acidic soils poor in nutrients. Farmers often plant mixtures of cassava cultivars, while bush-beans or maize are traditionally grown as cassava-intercrops. The objectives of this study were: (a) to determine if cassava or overall production can be improved by planting cassava cultivar mixtures or intercropping, (b) to assess the influence of soil properties on the dry matter production of cassava production systems, (c) to verify if soil cover can be increased by growing cultivar or species mixtures. On-farm trials were conducted at four locations in typical hillside environments with slopes up to 55% in the Southwest of Colombia from 1996 to 1998. Two cassava varieties contrasting in plant architecture (early branching variety, rich in apices versus erect, late branching variety, poor in apices) were grown as pure stands, as a variety mixture and each intercropped independently with upland rice or *Canavalia brasiliensis*. Rainfall during the trial period was only 76% of the long term average due to the 'El niño' phenomenon. The cassava cultivars produced tuber yields of 9.0 and 7.5 t ha^{-1} DM when planted in cultivar pure stands. Cassava growth and biomass production increased with increasing size of water stable aggregates and soil N content and decreased with increasing soil bulk density. In the cassava cultivar mixture, competition changed the pattern of biomass allocation, leading to a significantly lower harvest index compared to the mean of the pure stands (−6%). Intercropped *C. brasiliensis* significantly reduced cassava harvest index (−13%; mean of cassava/*C. brasiliensis* mixtures compared to mean of pure stands) as well as cassava (−53%) and total biomass production (−24%), while differences were not statistically significant in the cassava–rice systems probably because of the poor performance of rice. The strong reduction in cassava tuber yield in the

Abbreviations: ANOVA, analysis of variance; CIAT, Centro Internacional de Agricultura Tropical; coeff, coefficient; DAP, days after planting; DM (kg), dry matter; DMRT, Duncan's multiple range test; *p*, error probability level; $P < 0.1(^*)$, error probability level of 10%; $^*P < 0.05$, error probability level of 5%; $^{**}P < 0.01$, error probability level of 1%; $^{***}P < 0.001$, error probability level of 0.1%; ns, not significant; *r*, coefficient of correlation (Pearson-*r*); R^2, coefficient of determination; SBRA, stepwise backward multiple regression analysis; stdv, standard deviation; stdcoeff, standard coefficient; WSA, water stable aggregates

* Corresponding author. Present address: Bio Inspecta AG, Ackerstrasse, CH-5070 Frick, Switzerland. Tel.: +41 62 865 63 20; fax: +41 62 865 63 01.

E-mail address: georg.daellenbach@ipw.agrl.ethz.ch (G.C. Daellenbach).

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cassava/*C. brasiliensis* systems was due to competition for water between cassava and the intercrop, aggravated by the lack of rain. The percentage of soil cover was slightly higher in all mixed cropping systems compared to the pure stands. In contrast to the mixture concept which seeks to increase productivity and soil cover compared to monocropping, the mixed cropping systems used in the studies in Rio Cabuyal reduced cassava tuber yield and total biomass production of the cropping systems compared to the cassava cultivar monocrops. When total soil cover was improved compared to the cassava cultivar pure stands it was paralleled by reductions in terms of cassava tuber yield.
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Keywords: Cassava; *C. brasiliensis*; Upland rice; Cultivar mixture; Intercropping; Soil structure stability; Bulk density; Diameter of aggregates in air-dried soil; Soil cover

1. Introduction

Cassava (*Manihot esculenta* Crantz) is grown in the Colombian hillsides on acidic soils because tuber yield remains relatively high even under conditions of degraded land with low inputs (Braun et al., 1993; Olasantan et al., 1994). Erosion and nutrient depletion, especially of K (Howeler and Cadavid, 1990), are at the same time the reason for and the consequence of continuous cassava cultivation on steep slopes.

In Colombia, farmers often plant mixtures of cassava cultivars due to shortage of planting material or relative geographic isolation (Lozano et al., 1980). Gold and co-workers found that cultivar mixtures increased cassava yield by reducing herbivore load (Gold et al., 1989a, 1989b, 1990). Cassava with bush bean and maize intercrops may be grown where fertilizer is available for the intercrops (Zaffaroni et al., 1991; Mutsaers et al., 1993; Olasantan et al., 1996). Based on the principles outlined by Altieri (1994) and Risch et al. (1983) mixed cropping systems reduce susceptibility of crop(s) to pest (Ezulike and Igwatu, 1993; Gold, 1993) and disease attacks and the risk of total crop failure (Ahohuendo and Sarkar, 1995; Fondong et al., 2002). Such cropping systems can also improve soil cover and reduce erosion compared to monocrops directly (Francis, 1990; Evangelio et al., 1994; Leihner et al., 1996; Ruppenthal et al., 1997; Howeler, 1998) or indirectly by increasing water infiltration and earth worm activity (Hulugalle and Ezumah, 1991; Hulugalle et al., 1994). Plants with different aerial and subterranean architectures growing on the same fields might increase the resource use efficiency for light, water, and nutrients (Mason et al., 1986a, 1986b, 1986c; Ikeorgu and Odurukwe, 1990; Sitompul et al., 1992). By suppressing weeds, intercrops utilize resources otherwise economically lost (Akobundu, 1981; Unamma and Ene, 1984; Zuofa et al., 1992; Olasantan et al., 1994). Both is relevant for cassava since it grows slowly in its initial development phase making limited use of the available resources (Mohankumar and Hrishi, 1978; Mutsaers et al., 1993). Systems with intercropped legumes additionally improve the fertility status of the soil by N-fixation or by pumping nutrients from deeper soil layers (Obiagwu, 1995; Leihner et al., 1996; Lusembo et al., 1998). Mixed cropping systems can also improve labor efficiency (Odurukwe and Ikeorgu, 1994), enhance the diversity of the farmers' diet and provide them with an additional income (Gold, 1993), though these advantages are disputed (Benites et al., 1993). Cassava cultivars and intercrop partners have to be carefully selected concerning early development, plant architecture, competitive ability and time to maturity. Only fast maturing species may be planted simultaneously with cassava (Kawano and Thung, 1982; Tsay et al., 1988; Cenpukdee and Fukai, 1991; Ezumah and Lawson, 1990; Muhr et al., 1995; Okeke, 1996; Okoli et al., 1996; Polthanee and Anan, 1999; Hernandez et al., 1999).

Little is known about the beneficial or detrimental effects of cultivar or species mixtures for cassava under on-farm conditions. The purpose of this study was to evaluate different cassava cultivation systems with respect to their effect on plant productivity. On-farm trials were conducted using two contrasting types of cassava cultivars intercropped with each other or rice or *Canavalia brasiliensis* as intercrop partners. The objectives were: (a) to determine if production can be improved through cropping system diversification (i.e. by planting a mixture of cassava varieties, or intercropping cassava with another crop), (b) to assess the influence of soil properties on cassava production,

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