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ABSTRACTS

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cision equipment to apply commercial fertilizer has been available for some time but is now also available for liquid manures, which should help strengthen nutrient management planning. Remote sensing of crop stresses from inadequate nutrients, diseases, or drought also continue to advance. Yield monitors are allowing producers and researchers alike to establish cause and effect relationships of growth factors on a field scale, answering more questions from a whole-farm perspective. These efforts serve to increase the speed of grower adoption of new practices. With each cropping season, more is learned about improving the efficiencies of production. Finally, with the improved use of applied nutrients, it is expected that environmental benefits will follow.

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Agricultural Production, Soil Nutrient Balance, and Impact on the Environment in Extensive Agriculture.

H. BREMAN, *International Fertilizer Development Center*

All forms of agriculture influence the environment. A judgement on the impact is never objective, and will be very different for farmers and other members of the society. The quality of the judgement by both groups improves by distinguishing several types of extensive agriculture in their relation with the environment. The distinction proposed uses the actual agricultural production in comparison with the potential production as determined by the carrying capacity of the environment. Three main situations can be distinguished: a) under-exploitation of natural resources; b) actual production equals the potential production; c) over-exploitation of natural resources. In addition, three questions should be answered for a balanced judgement: i) can the agricultural resource use be regarded as optimal; ii) are external inputs used to reinforce the carrying capacity of the natural resources; iii) what are the main factors determining farmers behaviour. In case the society regards farmers' extensive production systems to be negative in view of environmental impact, governments have to wonder if their policy could change farmers' behaviour. The paper treats the choices of farmers and policy options, in particular the public investments required in extreme situations. Most examples presented are from tropical West Africa.

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Environmental Issues Facing Industrial Agriculture in the 21st Century.

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Intensive high input/output modes of agricultural production can have numerous adverse environmental impacts, such as gaseous emissions that contribute to global climate changes and pollution of land and water. This paper begins with a brief description of the evolution and typology of global, industrial agricultural systems, followed by an overview of the principal environmental impact domains at various scales. It then focuses on the main biophysical and socioeconomic determinants of environmental outcomes that are associated with industrial agriculture with a focus on nutrient management in crop and animal production. The paper proceeds with a discussion of technology and policy options for improving environmental performance. It concludes with a call for more integrated development approaches that improve the capacity of policy makers, extension programs, farmers, future land mangers and agribusiness to make integrated nutrient management decisions that consider all components of an agricultural system and associated environmental impacts.

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Influence of Nutrient Management Practices in Intensive Animal Production Systems on Surface Water Resources.

J.M. BURKHOLDER, *NCSU*

Exponential growth of concentrated animal operation industries (CAOs) during the late 1980s-1990s proceeded with little comprehension of environmental impacts on adjacent receiving waters. Moderate precipitation periods havae led to ruptures and overflows of waste holding lagoons which have resulted in fish kills, anoxia from surface to bottom through expanses of river segments (days to weeks), extremely high riverine nutrient levels, algal blooms, and high densities of fecal coliform bacteria indicating the presence of other pathogenic microorganisms that harm human health. In routine waste management practices, nutrient-sensitive waters near CAOs frequently are found to contain elevated nutrients and fecal indicators, including high proportions of antibiotic-resistant bacteria. Violations of required waste management practices are numerous, commonly involving spray-application of wastes onto already-saturated fields with little ability for further absorption. Little is known about the impacts from other leached animal waste constituents (e.g. heavy metals, xenoestrogens) on aquatic communities. The amassing available data support the premise that current waste disposal practices of CAOs are causing chronic, serious impacts on receiving waters from nutrient over-enrichment and accompanying pollutants, as a widespread issue in water resource management.

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Trends of Agricultural Nitrogen in the Mississippi Basin.

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Agriculture is the major contributor to hypoxia in the Gulf of Mexico through nitrate loads in the Mississippi River. The distribution of excess agricultural nitrogen was calculated for census years 1949-97 using dominant sources and losses of nitrogen. Sources include, fertilizer, manure, nitrogen fixed by legumes, and redeposition of ammonia. Losses include harvest, volatilization, plant senescence, and denitrification. Mineralization and immobilization were balanced with crop-residue nitrogen to estimate soil-nitrogen changes. The Upper Mississippi and Ohio hydrologic regions had the largest increases in sources since 1949 and the largest reductions in the excess nitrogen. Only the Tennessee River showed little change in sources and excess nitrogen. All hydrologic improved agricultural nitrogen efficiency when excess nitrogen is measured against total sources. The Ohio and Upper Mississippi Regions began as the most efficient and had the greatest improvement in efficiency. These regions use a greater fraction of the nitrogen sources for crops than do other regions. Excess nitrogen in the Tennessee, Arkansas/Red, and Lower Mississippi are greatest when analyzed as a percent of the total sources. The Lower Mississippi, in particular, has doubled the excess nitrogen during the period. Although losses have increased in this region as well, there is only a modest improvement in the efficiency of the region in utilizing that nitrogen.

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The Nutrient Balance under Slash and Burn-Alternatives in the Amazon.

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Over 30 million ha/yr of forest in Latin America are converted to agriculture. Save some fragments, the primary forests of the Eastern Amazon have been replaced by slash-and-burn agriculture involving annual crops (2-yr cycle) and semi-permanent crops (5-10 yr cycles)where secondary forests regenerate the soil over a 4-10 yr period. Around 70% of the study region (Pará) is covered by secondary forests. Slash and burn of a 7-yr-old fallow leads to above-ground C losses of up to 30 t/ha, but does not immediately affect the soil C stock of 150-200 t/ha. Field preparation without fire retards losses. Carbon residence time in the form of mulch ranges from 6-12 months. Enrichment planting can double the rate of C sequestration in the first two yr of fallow. Nutrient stocks in a 7-yr-old fallow can amount to 200 kg N, 10 kg P, and 100 kg K per ha. Burn losses of these nutrients can total 96, 47, and 48%, respectively. Mulch-based systems avoid such losses and improve the flexibility and productivity of the cropping regime. Fallow elimination would lead to soil degradation and losses in biodiversity and ecosystem function.

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Proper Nutrient Management to Achieve Sustainable Crop Production.

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Landscapes of natural vegetation are biologically sustainable over long periods. But when humankind started to produce food crops, the natural unamended soils were found to contain too little readily available plant nutrients to support crop production for long. The increasing availability of mineral fertilizers from the early 19th century made it possible to supplement soil nutrient supplies and recycled nutrients in organic amendments. Thus it is now possible to produce optimum yields of currently available cultivars in economically viable ways. But economically viable farming has to be environmentally benign if the very existence of humankind is not to be threatened.The long term field experiments on agricultural crops started at Rothamsted and its associated stations from 1843 and continued since provide excellent examples of biologically and economically sustainable cropping systems and also some failures. Success or failure for economic husbandry has depended on matching nutrient inputs and other management