

CIEPCA NEWSLETTER

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Editorial

Several people have requested from us some information relating to the effects of cover crops on cotton. In this issue we have included abstracts dealing with this matter. In this regard we wish to thank Dr. N. Hulugalle and his colleagues for kindly sharing their experience in the use of cover crops in cotton-based farming systems in Australia.

This issue will be our last one. As our funding is uncertain, CIEPCA is likely to reduce or cease activity from January 2002.

We seize this opportunity to express our gratitude to the Rockefeller Foundation for their support, failing which CIEPCA certainly would have already disappeared two years ago. Our thanks also go to the MOIST programme of Cornell University, USA, for hosting and maintaining our website as well as the electronic discussion list on cover crops, EVECS-L and to IITA-Benin.

ANIMAL FEEDING AND AGRONOMIC REPORTS ON COVER CROPS

Adoption of mucuna as animal feed in northern Benin: the experience of the Livestock Development Project in Eastern Borgou (PDEBE)

R. Ahlonsou and B. Loko

The Livestock Development Project in Eastern Borgou (PDEBE) was created in order to promote animal husbandry and settle cattle breeders. One of the major constraints is the lack of grazing land resources, especially during the dry season. To rectify this situation PDEBE has undertaken extension activities with fodder crops and particularly *Mucuna*.

The area covered by the project is characterized by a unimodal rainfall pattern (1000–1200 mm per annum) and a fodder-poor vegetation, especially during the dry season. The pre-extension campaign carried out in 1994–1995 started with sensitization through the projection of a series of slides showing the importance of *Mucuna* as a high potential crop for fodder production. Seeds were distributed to farmers who wished to grow mucuna, provided that they would reimburse half the quantity of seeds received. The results of these activities carried out in several villages show that 80% of interested pastoralists and agro-pastoralists have accepted to plant mucuna in June for seed production, and in July for fodder production, both on the same plot. The June planting of 4–5 seeds per hill was done at the bottom of trees in yam fields. The plants were highly productive and some produced up to about 100 pods each. However, some mucuna stems were severely attacked by *Phytophthora* (Phythium). This was due to the presence of *Cissus populnea*, a natural host for Phythium, which grows in newly established yam fields. To control this fungus the mucuna seeds were treated using Macozeb. The mucunacrop planted between late July and early August was harvested before flowering at the beginning of the dry season and stored to be used as hay. Some pastoralists and agro-pastoralists preferred to grow mucuna as a sole crop instead of intercropping it with cereals (maize,

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sorghum) as indicated for this technology package.

An overall issue raised by all the farmers was the poor germination rate of the seeds purchased from the RAMR^a project. Following evaluation sessions organised by participating pastoralists and agro-pastoralists, some recommendations were made for better management in order to solve the problems encountered and to stimulate adoption.

Various research activities have accompanied the extension exercise. One of these studied field management practices for mucuna intercropping. The design used was a split split-plot with three treatments: planting date, mucunavariety, and planting density. The results obtained show that appropriate dates for the planting of mucuna are 22 July and 5 August; *Mucuna* var. *cochinchinensis* should be recommended for late planting; mixing seeds of the two varieties (*utilis* and *cochinchinensis*) can help solve problems relating to rain break; intercropping *Mucuna* with maize reduces the maize yield to the advantage of *Mucuna*.

In 2000, in spite of the difficult financial situation confronting PDEBE, a minimum extension activity was carried out to respond to numerous requests from target groups excited about the successful experience with *Mucuna*. Within this framework 100 pastoralists and agro-pastoralists received 471.5 kg of seeds of *Mucuna* var. *rajada* purchased at the Kpinnou Livestock Farm, southern Benin. The PDEBE project bought the seeds at CFA 300/kg but distributed them free of charge to the pastoralists and agro-pastoralists.

The extension of *Mucuna* as a fodder crop deserves further research in order to better understand the determinants of its adoption by pastoralists as well as the plant's response to various agro-ecological and socioeconomic conditions.

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Can lucerne (*Medicago sativa* L.) strips improve soil quality in irrigated cotton (*Gossypium hirsutum* L.) fields?

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The effects of sowing lucerne (*Medicago sativa* L.) strips in irrigated cotton (*Gossypium hirsutum* L.) fields on soil quality was evaluated in a Vertisol at the Australian Cotton Research Institute (ACRI), and in a Vertisol and an Alfisol at two on-farm sites in New South Wales, Australia, from December 1995 to February 1997. Chemical (pH, EC, CEC, exchangeable sodium percentage, organic C), physical (air-filled porosity, plastic limit, dispersion index, soil strength), and biological (earthworm activity) indicators of soil quality were measured in each site. Overall soil quality in cotton and lucerne strips was evaluated using a 'soil health condition report card' format to award a score to each soil quality indicator and summing up the individual scores to give a single value for each crop at any one site. The decision to award a particular score to any one indicator was based on a value range derived from the literature. In comparison with cotton, lucerne strips had higher air-filled porosity and organic C in the sub-soil of both on-farm sites, but had no significant effect at ACRI. However, lucerne did result in higher organic C in the soil surface at ACRI. Soil strength was higher and EC lower within lucerne strips in all three sites. Sowing lucerne strips resulted in higher earthworm activity at ACRI and at one commercial site, with highest numbers of earthworm burrows being observed in the former. We suggest that this has affected liquid flow patterns at ACRI where preferential flow mediated via the earthworm burrows appears to dominate. Overall soil quality was improved by lucerne strips only at ACRI, whereas that in the on-farm sites was not affected.

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^a Recherche Appliquée en Milieu Réel

Effect of broad beds and dolichos residue management on the properties of an irrigated vertisol

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The effects of mulching or incorporating residues of dolichos (*Lablab purpureus* L.), sown in rotation with cotton (*Gossypium hirsutum* L.), in broad (1.5 m wide) beds on soil properties of a vertisol were studied in Northern New South Wales, Australia. Soil was sampled from the 0–to 0.10 m (bed surface) and 0.20–0.30 m (below bed) depths of edges and centres of broad beds during January 1993. Soil properties measured were particulate, mineral-associated and total organic matter, dispersion index, plastic limit, geometric mean diameter (GMD) of soil aggregates formed after puddling and drying at 40 °C (soil reactivity), soil density, exchangeable cations and nitrate-N.

Compared with mulching, incorporating dolichos residues resulted in a significantly lower dispersion index. Mulching also resulted in higher values of dispersion index below beds when compared with bed surfaces. Plastic limit at the centres of beds was significantly lower than that in the edges. Smallest GMD of soil aggregates occurred in the centre of mulched beds. Greatest soil compaction occurred at soil water contents $\leq 0.15 \text{ m}^3 \text{ Mg}^{-1}$ below beds when dolichos residues were mulched. Where dolichos residues were incorporated, at soil water contents $\leq 0.10 \text{ m}^3 \text{ Mg}^{-1}$ compaction in the soil surface was lower in bed centres when compared with those at the edges of beds.

Residue management had no significant effect on soil organic matter fractions, although coarse (2 mm–212 μm), fine (212–53 μm) and total soil organic matter contents on bed surfaces were greater than those below beds, and coarse particulate organic matter at the edges of beds was greater than that at the centres. Greatest exchangeable K, and lowest exchangeable Na and exchangeable sodium percentage (ESP) occurred where dolichos residues were incorporated.

In comparison with mulching, exchangeable Mg was higher and exchangeable Ca lower below beds with residue incorporation. Nitrate-N on bed surfaces was higher than that below beds with mulching. Mulching improved only friability of surface soil in bed centres, whereas indices of soil physical and chemical fertility such as aggregate stability, exchangeable cations, ESP and soil compaction in both bed surfaces and below beds were improved by incorporating dolichos residues.

Better soil quality can, therefore, be maintained at this site by incorporating rather than mulching residues of dolichos sown in rotation with cotton.

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Cotton rotation systems in a grey clay: effects on soil quality, lint yield and profitability

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Rotation crops such as wheat and safflower sown immediately after cotton can improve soil structure and other physical properties, while leguminous rotation crops improve the soil's N status. These observations have been made in short-term trials with long-term experimental data being sparse. At the same time, the interactions between issues such as soil quality, weeds, soil microbiology and pathology, crop agronomy and yield, water use and economics have also not been considered in previous studies. In 1993, the Australian Cotton CRC decided to explore the long-term effects of rotation crops and established several irrigated and rainfed field experiments at various sites in New South Wales and Queensland. Their common objective was to evaluate the sustainability of selected cotton-rotation crop sequences sown in Vertisols. Crop sequences were selected on the basis of recommendations made by local cotton grower organisations, and the indices used to evaluate sustainability included soil quality, microbiology, yield and economics. This paper presents data on soil physical and chemical properties (soil organic C, plastic limit, compaction as air-filled porosity of clods, exchangeable Ca, Mg, K and Na, pH, electrical conductivity (EC) and EC/ESP monitored to a depth of 0.6 m), lint yield and profitability (as gross margins/ha and gross margins/ML of irrigation water) from an irrigated trial established in a highly sodic, moderately saline, Vertisol at Merah North, north-western

New South Wales. The six cropping systems sown after minimum tillage were: continuous cotton, long-fallow cotton, cotton-green manured faba bean, cotton-dolichos-green manured faba bean followed by cotton-wheat, cotton-dolichos, cotton-fertilized dolichos (with P & K removed by cotton replaced as fertilizer).

Soil compaction was least with wheat at the surface but highest with continuous cotton in the 0.15–0.30 m depth. Compaction was also lower with wheat in the deeper depths. Generally, however, soil compaction decreased with time in all treatments as did soil organic C. The decrease in compaction was probably caused by the change from intensive to minimum tillage. In general, differences in soil quality between rotation systems were far less than those which occurred with time. The changes in soil quality were characterized by falls in pH, organic C and compaction, and increases in EC and ESP. The increases in EC and ESP may have been caused by the (bore) irrigation water which although of moderate salinity (EC = 0.4 dS/m) was dominated by Na (67%).

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Sowing wheat or field pea as rotation crops after irrigated cotton in a grey vertisol

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The effects of green manured field pea (*Pisum sativum* L.), low-input (LI) wheat (*Triticum aestivum* L.) (seeding rate of 40 kg/ha and 85 kg/ha of diammonium phosphate), and high-input (HI) wheat (seeding rate of 100 kg/ha, 85 kg/ha of diammonium phosphate, and 180 kg/ha of urea) sown as rotation crops after cotton on soil

quality; cotton growth, yield and nutrient uptake; and gross margins (\$AU/ha and \$AU/ML of irrigation water) were evaluated from 1993 to 1998 in an irrigated Vertosol in the central-west of New South Wales. Soil quality indicators monitored were aggregate stability (dispersion index), compaction (air-filled porosity), soil resilience to structural destruction (as geometric mean diameter of soil aggregates formed after puddling and drying of soil), exchangeable cations, calcium carbonate, nitrate-N, pH, organic C, development of arbuscular mycorrhiza (AM), and incidence of cotton root diseases (black root rot). In comparison with wheat, field pea increased soil nitrate-N levels during the early stages of the experiment and formed smaller aggregates after puddling and drying, but it was ineffective in ameliorating soil compaction. In contrast wheat was very effective in ameliorating soil compaction. Nitrate-N values under wheat–cotton rotations increased with time such that after 4 years they were similar to that under the field pea–cotton rotation. Soil chemical fertility indicators such as organic C, pH, EC, and exchangeable cations were not affected consistently by either wheat or field pea, whereas minimum tillage, retention of crop residues, and cropping phase (i.e. rotation crop or cotton) affected them more. A net decrease in organic C and an increase in EC was observed with time in all treatments. By sowing either field pea or wheat, the mycorrhizal colonisation of cotton roots was improved. Black root rot incidence was increased 3-fold by sowing field pea, but was not significantly affected by wheat. Cotton lint yield was unaffected by rotation crop, although profitability shown as gross margins/ha and gross margins/ML irrigation water were greater with wheat compared with field pea. Gross margins/ha were in the order HI wheat > LI wheat > field pea, and gross margins/ML irrigation water were in the order LI wheat > HI wheat > field pea. In terms of ameliorating soil compaction, minimising black root incidence, and maximising returns to the cotton grower, wheat is a better rotation crop than field pea. The decision to apply fertiliser and sow wheat at a higher seeding rate will depend on whether land or water is the major limiting factor.

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Maize response to *Canavalia* green manure

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Canavalia ensiformis used as green manure before flowering has a potential of improving maize yield in semi-deciduous rain forest zone of Ghana. When *C. ensiformis* was applied to the soil by incorporation or non-incorporation (i.e., surface application), height of maize after *C. ensiformis* treatments was significantly higher than with inorganic fertilizer application. Similar trends were observed for the leaf area index and dry matter yields, with the values for residue incorporation being greater than those for surface application. Maize stover yields from incorporated and non-incorporated green manures were, respectively, 43% and 19% higher than the absolute control, and 30% and 10% higher than inorganic fertilizer treatments. With the addition of one-half rate of inorganic fertilizer to the *C. ensiformis* green manure, the increases over control and inorganic fertilizer alone were more than doubled. Grain yields were highly significantly increased over control. The increases range between 267% and 400% over control, and between 60% and nearly 200% over inorganic fertilizer treated plants.

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Efficiency of the use of organic and inorganic nutrients in maize-based cropping systems in Benin

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2000. PhD Thesis. University of Gent, Belgium.

The level of soil depletion of nutrients suggests that large amounts of fertilizers are needed to maintain soil fertility, although small-scale farmers do not have enough resources to spare for their needed mineral fertilizers. In the Mono Department, located in the derived savanna (DS), southwest Benin, fallow periods have practically disappeared while farmers still use inappropriate cultural practices such as continuous cereal cropping without addition of organic or inorganic inputs. The alternative to the use of N fertilizers has been the growing of legumes in rotation or mixed cropping with the cereals, as a source of N in order to

take advantage of their capability to biologically fix nitrogen from the atmosphere for the plant and soil system. However, several studies on organic inputs show that although organic materials are available, the quantity generally obtained might not be enough and therefore combination of organic and inorganic inputs might be a way forward to resolve the problem of low soil productivity. The limited success of transfer of knowledge on soil fertility generated by the research community to farmers' conditions is often related to the lack of prior assessment of indigenous knowledge related to this theme.

A farm survey was carried out with 232 farmers, carefully selected in three villages located in the ecoregional benchmark area of the DS in Benin, to determine the current availability and use of organic and inorganic inputs by farmers. On average, 46% of the farmers used inorganic fertilizers, but the quantities applied were limited. Mean N applications was only 24 kg N ha⁻¹ being 50% less than 60 kg N ha⁻¹ required for cereals in West Africa. The use of organic inputs is still in its infancy and the herbaceous legume mucuna is the most widely known cover crop in the DS in Benin. However soil factors compromise its growth and establishment and reduce its symbiotic nitrogen fixation potential on some degraded fields. Few or no nodules were found on the root systems due to poor rhizobial population or the presence of inefficient and incompatible rhizobia. Mucuna biomass decreased by 69% for N and by 33% for P when these nutrients were absent in the growing media indicating urgent needs for N and P application (Houngnandan et al. 2001). The use of inoculation was effective in increasing nodulation, biomass production, and N accumulation by mucuna but the cropping sequence and low level of P in some soils affect this. AMF colonization rate of mucuna was stimulated by rhizobial inoculation, alleviating P deficiency. The amount of N₂ fixed averaged 60 kg N ha⁻¹ or 55% of the plant total N (Houngnandan et al. 2000). The subsequent maize grain yield and N accumulation were higher when mucuna was previously inoculated than when uninoculated or N fertilized. These increases averaged an equivalent of 75 kg N ha⁻¹ as urea. Maize grain DM yields were highly correlated with N accumulated in previously inoculated mucuna biomass.

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Sustainable management of weeds in plantain-based cropping systems through the use of herbaceous legume *Canavalia ensiformis*

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Available methods of weed control in plantain-based cropping systems in the Asunago District in the Brong-Ahafo Region have been ineffective and expensive for farmers operating under low input management. The study therefore aimed at integrating herbaceous legume, *Canavalia ensiformis*, into the traditional weed management systems to assist plantain farmers to reduce the cost of labour and improve soil physical properties and fertility. In a simple and participatory on-farm trial managed by 79 test farmers and 23 imitating farmers, *Canavalia ensiformis* showed a high potential under farmers low input management compared to two other conventional methods (manual and chemical). Different ways of introducing *Canavalia ensiformis* as a cover crop in the plantain-based cropping systems have been clearly spelt out in the study. Despite additional labour demand during the establishment of the legume, plantain farmers' interest in the technology grew during the study. Poorer farmers may be motivated to adopt the technology due to economic constraints. Other constraints that could slow adoption might be scarcity and high cost of seeds for initial establishment. Farmers may be highly motivated to save seeds for future expansion.

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Nitrogen balance under rice-based cropping systems and implications for productivity and sustainability of the systems

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For farming systems to remain productive and sustainable in the long term, it is required that nutrients removed or lost from the soil be replenished. In most rainfed rice systems in West Africa, N removed is not replenished. The situation has led to a reduction in productivity, profit margins, and sustainability of rainfed rice systems. The impacts of pre-rice mucuna, cowpea,

maize and weedy fallow rotations on productivity soil nitrogen and soil organic carbon contents were measured over a two-year period in a study aimed at increasing the productivity of rice-based cropping systems in the northern savanna belt of Ghana. Total soil N and soil organic carbon contents were recorded after annual cultivation of rice preceded by cowpea, mucuna, maize or weedy fallow in the same year. After two years of cropping, the productivity and partial N balance under each system was calculated. Two months old pre-rice mucuna fallow increased significantly the total N and organic carbon contents of the soil compared to a weedy fallow whereas cowpea reduced significantly their levels even though it was the most productive crop. Changes in these properties are discussed in view of long-term productivity and sustainability of the systems. The importance of improving the N-fixation of cowpea and other grain legumes so that they can contribute to soil fertility maintenance in cropping systems is emphasized.

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Effect of organic residue and rock phosphate application on sorghum yield in northern Ghana

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Northern Ghana leads in the production of sorghum in Ghana where the crop is a major staple as well as the grain for the local drink *pito*. The production of the crop has dwindled in recent times as a result of pests and declining soil fertility. As this crop is not fertilized traditionally with mineral fertilizer, low soil fertility has become a major limiting factor for its production. Even if farmers were willing to apply mineral fertilizers to this crop, their

ability to use them is severely limited by high costs.

The soils of this area are very low in organic matter, N and P and the real means of restoring them should include organic matter input and management. The use of leguminous cover crops can be an important alternative to mineral fertilizers for the resource-poor farmers in this regard. For a cover crop to be effective in improving cereal production, it must produce sufficient biomass that will ensure large nutrient input for the utilization of the succeeding crop. Leguminous cover crops fix atmospheric N₂ but can only recycle other nutrients like P and K. This means that for their sustainable use, these other nutrients must be supplied at regular intervals. *Calopogonium mucunoides* (calopo), *Crotalaria retusa* (devil bean) and *Mucuna pruriens* (mucuna) were supplied with P at the rate of 20 kg ha⁻¹ as rock phosphate and evaluated for biomass and nutrient accumulation as well as their effect on sorghum yield. The dry matter yield was 8.0, 16.9, and 4.5 t ha⁻¹, respectively, and the corresponding N accumulation was 130, 270 and 72 kg ha⁻¹, respectively. The dry matter of a weed fallow control was 3.5 t ha⁻¹. Calopo and devil bean application increased sorghum yield by 50%, and 100%, respectively, while mucuna had no effect on sorghum yield compared with the weed fallow. The high biomass production and rapid decomposition of calopo and devil bean may be responsible for the positive effect on sorghum yield.

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OTHER REPORTS ON COVER CROPS

The use of mucuna beans in high protein biscuits

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As part of continuing studies on the protein fortification of local diets and promotional strategies for mucuna adoption, the potential use of two varieties of mucuna bean flour in high protein biscuits is reported.

Incorporation of mucuna seed flour at 15% level in wheat flour increased the protein content from 7.36 to 10.0 (11.29 g/100 g DM). While there were no significant differences between the sensory qualities of both mucuna biscuits, they differed significantly from wheat control biscuit. The overall acceptability of the mucuna biscuit was appreciable (60.7–62.0), but inferior to the control (71.7) due to some off-flavour and colour deviation. L-DOPA level in the biscuits was low (60–63.0 mg/100 g) but further investigation into a more appropriate processing treatment will be necessary to reduce the risk of toxicity.

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Composition and functional properties of raw and heat processed velvet bean (*Mucuna pruriens* (L.) DC. var. *utilis*) flours

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The proximate composition and functional properties of raw and heat-processed velvet bean (*Mucuna pruriens* (L.) DC. var. *utilis*) flours were studied. The flours were prepared by soaking raw beans for 14h, boiling for 30 min (heat-processed), manual dehulling, oven-drying (65 °C) and milling. The heat-processed flour contained 6.8% moisture, 24.3% protein, 4.9% fat, 1.3% crude fibre, 3.5% ash and 61.2% carbohydrate. The flour was rich in potassium (125 mg/100 g), zinc (9.8 mg/100 g), and phosphorus (361 mg/100 g). Differences in proximate and mineral composition of raw and heat-processed flours were not significant. The flours showed minimum protein solubility at pH 4.5 and formed reasonably stable emulsions and foams. Compared to raw flour, heat-processed flour had better water and fat absorption capacities, but lower protein solubility, emulsion and foam capacities. The flours have potential for food product development.

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Economic feasibility of the use of improved fallow system in rice production systems in the Guinea savanna zone of Ghana

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Long fallow periods which hitherto ensured soil fertility restoration in traditional farming systems are no longer practicable as a result of socio-economic changes. In many parts of the Guinea savanna zone of Ghana, fallow periods are reduced to about two years only. As a consequence, land productivity can only be increased with the use of external inputs such as inorganic and/or organic fertilisers. While inorganic fertilisers are not affordable by the average Ghanaian farmer, socio-economic constraints hinder the effective use of animal droppings, the main source of organic manure. Thus the quest for a feasible method of improving soil fertility continues unabated. Results from a three-year on-farm study in the Guinea savanna zone of Ghana on the use of different fallow systems for rice production indicated that incorporating a leguminous cover crop such as *Calopogonium mucunoides* in the fallow systems proved superior in agronomic and financial terms to either continuous cropping or bush fallow. On the other hand, unavailability of suitable leguminous cover crop, difficulty of incorporating the cover crop residue and damage to cover crop fallow may constrain the feasibility of the technology at the farm level.

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