The African Network for Soil Biology and Fertility (AfNet): Network Research Progress Report, 2002

Tropical Soil Biology and Fertility (TSBF) Institute of CIAT

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Abstract
In 2001, network experiments addressing several research themes were carried out along a bio-climatic gradient at several benchmark locations in East, West and Southern Africa using commonly developed research protocols. The long-term on-station trials from which originated the technologies tested on-farm continued to run with the objective of identifying sustainability indicators. Soil samples from the long-term trials were collected for measurement of these parameters using protocols provided by TSBF. Some of the indicators include microbial biomass, organic carbon and fractionation of soil organic matter. In addition, on-farm researchers and farmers' evaluations of soil fertility technologies were carried out at different sites. While pooling resources, this approach provides opportunities for wider use of the network research output, both to scientists and to farmer clients who are the end-users of the technologies. In order to determine the fertilizer equivalencies of organic amendments, manure collected in the different sites and crop residues were analysed for N, P, K, polyphenol and lignin. Whereas the fertilizer equivalency values of low quality manures were very poor in the sub-humid and humid zones, their values were very high in the semi-arid zones indicating that the critical value for immobilization and mineralization is site-specific. In contrast, data from long-term trials in Kenya have consistently shown high fertilizer equivalencies for green manures (Tithonia = 100). In addition to supplying N to annual crops, cattle manures were found to overcome P deficiency. These data suggest that several technologies evaluated over the year have the potential for agricultural intensification to improve crop and livestock productivity. Future research needs to put more emphasis on the scaling-up and scaling out of these technologies. Since most of the trials in East and Southern Africa were terminated in 2001, proposals are being developed for new research to start in 2002, which will cover the four TSBF research themes. These

proposals will be submitted to appropriate donors. A brief account of each proposal is included in this report. Future efforts will be geared towards integrating AfNet research with activities being conducted by other networks such as, a) CIAT bean network: Trials on beans and P nutrition in Ethiopian highlands under maize-bean cropping systems, b) Soil-fert network: Trials in Zimbabwe on resource quality its effect on soil organic matter and c) ICRAF agroforestry network: Trials in the highlands of Rwanda and Burundi on low quality resources and N equivalency of cereal-legume rotations. Research activities in West Africa will be through a memorandum of understanding between TSBF institute of CIAT and ICRISAT

Acknowledgement

We would like to thank the following institutions and organizations for support towards implementation of the Soil Biology and Soil fertility network experiments, in Eastern, Southern and Western Africa, 2001.

The Rockefeller Foundation for the continued support to AfNet

The System-wide Livestock Programme of the International Livestock Research Institute,

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) with which TSBF signed a memorandum of understanding (MOU) to facilitate the work in the Sahelian countries,

The International Institute for Tropical Agriculture (IITA) who facilitated the work in the Coastal countries of West Africa,

All NARS partners in the AfNet participating countries who implemented the field trials.

I. Introduction

The overall goal of Tropical Soil Biology and Fertility Institute of CIAT aims to contribute to human welfare and the conservation of environments in the tropics by developing adoptable and sustainable soil management practices that integrate the biological, chemical, physical, and socio-economic processes that regulate soil fertility and optimize the use of organic and inorganic resources available to the land users The African Network for Soil Biology and Fertility (AfNet) is the single most important implementing agency of the programme.

AfNet is a network of scientists working in Africa in a mechanism to facilitate and promote collaboration, research and development among scientists, to develop innovative and practical resource management practices for sustainable food production.

The Network is presented with a challenge to help empower farmers and land managers to combat soil nutrient depletion and land degradation, which are both serious threats to food production on the continent. The objective of these network activities is to develop and implement management options that both mitigate soil degradation, deforestation and biological resources losses and enhance local economies while protecting the natural resource base.

In 2001, trials were established at representative benchmark sites in some important agro-ecological zones of East and Western Africa. On-station and on-farm researcher managed and farmer-managed trials were carried out. This report is not intended to summarize all the data collected by network members in collaboration with TSBF research officers but to give some few highlights of the research output in 2001. Soil samples are still under analysis for the measurement of sustainability indicators from the long-term field trials. The determination of biological nitrogen fixation using isotopic dilution techniques can be assessed only after receiving the laboratory analysis for 15N from the International Atomic Energy Agency (IAEA) from Vienna, Austria.

Most of the experiments in East and Southern Africa were concluded by 2000/2001 seasons and proposal development for future experiments was initiated in May 2001. These proposals will form the basis for the next set of network trials to be conducted in the region across benchmark sites in Ethiopia, Kenya, Uganda, Rwanda, Burundi, DR Congo, Tanzania, Zambia, Madagascar and Zimbabwe.

II. Network trials

1. Highlights of past research

As per the four TSBF research themes (Managing ecosystem services, Managing nutrient cycles, Managing below-ground biodiversity and Empowering farmers), the following research has been carried out by 2000.

a) **Managing ecosystem services:** (i) The development of the Organic Resource Database (ORD), (ii) Combining organic/ inorganic N and P sources, (iii) Cattle manure management (iv) Fertilizer equivalencies of organic materials.
b) **Managing nutrient cycles:** (i) Efficacy of soil organic matter fractionation methods on soils of different texture under similar management,

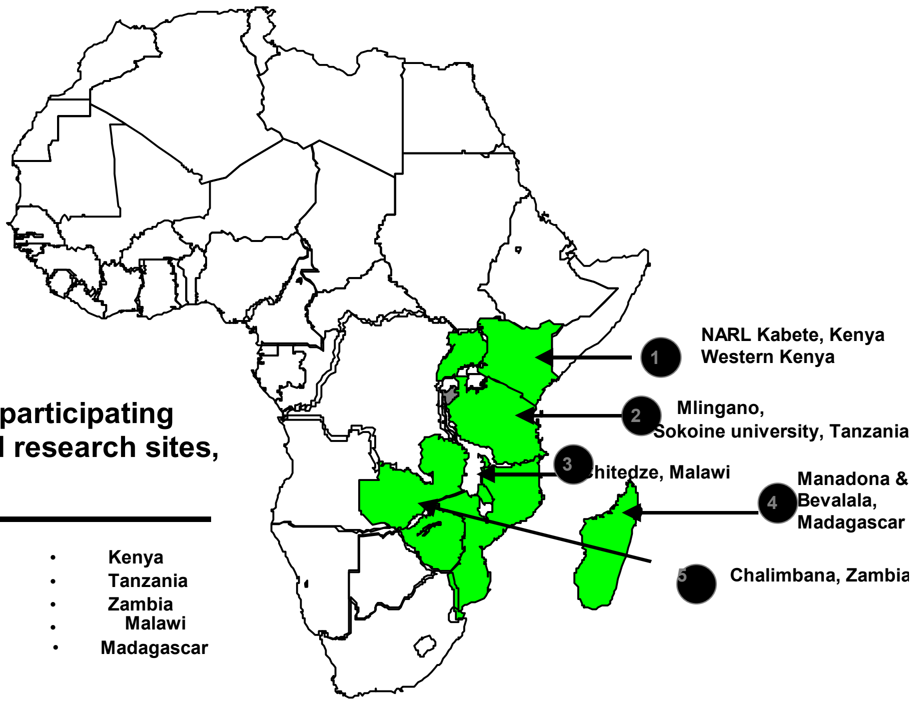
(ii) Maintenance of soil fertility under continuous cropping in a maize-bean rotation.

c) **Managing below-ground biodiversity:** (i) Diversity, abundance and functions of soil fauna in relation to quality of organic residues, (ii) Regional network for biological nitrogen fixation, (iii) Soil beneficial microorganisms and sustainable agricultural production.

d) **Empowering farmers:** (i) An economic analysis of soil conservation on smallholder farms (ii) Soil fertility management in small scale farmers' fields, (iii) Kraal manure and inorganic fertilizer interaction.

During this same period, network trials were established in Eastern and Southern Africa (**Map 1**). The main research highlights in 2000 can be summarized by the data in Figure 1.

Map 1: AfNet participating countries and research sites, 2000



Strong additive effect of combined inorganic N and organic material was noticed in Kabete site Kenya (**Fig 1**), whereby more than 180% increase of maize grain yield was obtained from a combination of urea and tithonia. As compared with a yield increase of 60% when the same amount of N is applied only in form of inorganic fertilizer (urea).

The fertilizer equivalency value for different organic materials was found to be dependent on the %N contained in the material (**Table 1**). The higher the N content in the material, the higher the fertilizer equivalent value as it was noted in Madagascar and Malawi with the use of tephrosia and Pigeon pea respectively.

2. Network research sites in 2001

Tropical Soil Biology and fertility African Network has now extended and taken root in West Africa, where several sites have been established in the year 2001. **Map 2** below shows the sites where field trials were carried out in 2001. The table below shows a list of Network collaborative trials in Western, Central and Eastern Africa, 2001 giving the type of trial, site and scientist involved.

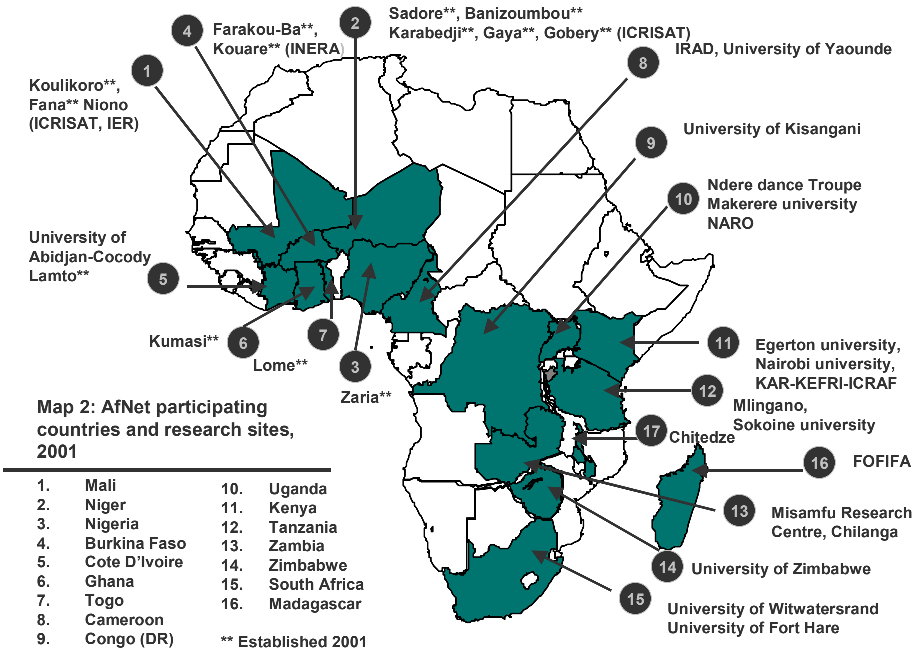
Network collaborative trials in West Africa, 2001

Country	Type of Trials	Sites	Scientist
Burkina Faso	Long-term cropping systems and integrated soil fertility management	Kouare	V. Bado
		Farakoba	"
	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients	Rice-based cropping systems at Kou Valley	"
		Maize cropping in Farakoba	"
Côte d'Ivoire	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients	Lamto	Y. Tano
	Nutrient use efficiency in legume and cereal rotation systems	Lamto	"
Ghana	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients	Kumasi	E. Yeboah
	Nutrient use efficiency in legume and cereal rotation systems	Kumasi	"
Mali	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients	Niono	M. Bagoyoko
	Monitoring nutrient budget	Koulikoro	R. Tabo/ M. Bagayoko
	Monitoring nutrient budget	Fana	"
	Biological nitrogen fixation	Koulikoro	R. Tabo/ M. Bagayoko
	Biological nitrogen fixation	Fana	"
	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrient	Koulikoro	"
	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrient	Fana	"

Country	Type of Trials	Site	Scientist
Niger	Long-term operational scale research	Sadore	Aboudoulaye/ Abdoulaye/ Mahamane
	Long-term cropping system	Sadore	“
	Long-term crop residue management	Sadore	“
	On-farm evaluation of soil fertility restoration technologies	Sadore	“
		Karabedji	“
		Gobery	“
		Gaya	“
	Methods of P and manure application	Sadore	“
		Karabedji	“
	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients	1. Banizoumbou 2. Karabedji 3. Gobery Gaya	“
	Monitoring nurtient budget	Banizoumbou	“
	Biological nitrogen fixation	Banizoumbou	“
	Corral experiment	Sadore	“
Nigeria	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrient	Zaria	Emmanuel Iwuafo
	Nutrient use efficiency in legume cereals rotation systems	Zaria	“
	Biological nitrogen fixation	Mirijibur IITA Research Station	Abdou/ Abdoulaye
	Monitoring nutrient budget	Mirijibur IITA Research Station	“
Togo	Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients	Davie	Tossah
	Nutrient use efficiency in legume and cereal rotation systems	Davie	“

Network collaborative trials in East and Southern Africa, 2001

Country	Type of Trials	Site	Scientist
Tanzania	Nitrogen fertilizer equivalencies based on organic input quality	NSS, Mlingano, Tanga	S. Ikerra/ A. Marandu
	Optimum combinations of organic and inorganic N sources	NSS, Mlingano, Tanga	“
Zimbabwe	Base nutrient dynamics and productivity of sandy soils under maize-pigeon pea rotational	University of Zimbabwe	P. Mapfumo/ F. Mtambanengwe
Zambia	Nitrogen fertilizer equivalencies based on organic input quality	Mt. Makulu, A.R.S, Chilanga	M. Mwale
	Optimum combinations of organic and inorganic N sources	Mt. Makulu, A.R.S, Chilanga	“
Kenya	Nitrogen fertilizer equivalencies based on organic input quality	Maseno, W. Kenya Kabete, Central Kenya	P. Mutuo/ J.Kimetu
	Maintenance of soil P with small applications of organic and inorganic sources	Maseno, W. Kenya Kabete, Central Kenya	J. Kinyangi/ P. Mutuo
	Residual effects following different rates of phosphorus application	Maseno, W. Kenya	P. Mutuo
	Hedgerow intercropping	KARI, Embu	D. Mugendi
	Assessment of the adoption potential of soil fertility improvement technologies	Chuka, Kenya	D. Mugendi/ R. Kangai
	Enhancement of soil productivity using low-cost inputs	Central Kenya	D. Mugendi/ M. Mucheru
	Nutrient management by use of agroforestry trees for improved soil productivity	Central, Kenya	D. Mugendi/ Kinyua



Map 2: AfNet participating countries and research sites, 2001

3. Experiments conducted in 2001

(i) Long-term soil fertility management trials

Long-term management of phosphorus, nitrogen, crop residue, soil tillage and crop rotation in the Sahel

Since 1986 a long-term soil fertility management was established by ICRISAT Sahelian Center to study the sustainability of pearl millet based cropping systems in relation to management of N, P, and crop residue, rotation of cereal with cowpea and soil tillage. The data in table 2 give the main treatments in this trial. In this split-split-plot design the split-split plot consisted of crop residue application or no crop residue application consisting of leaving half of the total crop residue produced in the plot and the sub-sub plot was with or without nitrogen application. The traditional farmers' practices yields 146 kg/ha of pearl millet grain whereas with application of 13 kg P/ha, 30 kg N/ha and crop residue in pearl millet following cowpea yielded 1866 kg/ha of pearl millet grain (**Table 3**). These results clearly indicate the high potential to increase the staple pearl millet yields in the very poor Sahelian soils.

Maintenance of soil fertility under continuous cropping in maize–bean rotation

The Kabete long-term trial was started by KARI at the National Agricultural Laboratories site, on a humic Nitisol in 1976. The objective of the trial was to find appropriate methods for maintaining and improving the productivity of soil through the use of inorganic N and P fertilizers, farmyard manures and crop residues under maize-bean rotation practices that are common to small-scale farmers. In 2001, samples were collected from key treatments to study P dynamics and to examine the effects of the different treatments on P pools and P availability. The results will be given in the next progress report.

Long-term management of manure, crop residues and fertilizers in different cropping systems

Since 1993 a factorial experiment was initiated at the research station of ICRISAT Sahelian Center at Sadore, Niger. The first factor was three levels of fertilizers (0, 4.4 kg P + 15 kg N/ha, 13kg P + 45 kg N/ha), the second factor was crop residue applied at (300, 900 and 2700 kg/ha) and the third factor was manure applied at (300, 900 and 2700 kg/ha). The cropping systems are continuous pearl millet, pearl millet in rotation with cowpea and pearl millet in association with cowpea. The analysis of variance data indicate that fertilizer; crop residue and manure application resulted in a highly significant effect of both pearl millet grain and total dry matter yields. Fertilizer alone account for 34% in the total variation of the dry matter whereas manure account for 18%. Although some interactions are significant they account for les than 3% in the total variation.

For pearl millet grain, the application fertilizer, manure, crop residue and cropping systems alone account for 66% of the total variation. The data in **Fig 2** illustrate the response of pearl millet grain to the crop rotation and to the different input of organic and inorganic fertilizers. The farmer's practices yield 236 kg/ha; the application of 13 kg P and 45 kg N/ha yielded 800 kg/ha but when these mineral fertilizers are combined with 2.7 t/ha of manure or crop residue in rotation with cowpea, yield of 1500 kg/ha can be achieved.

The N and P fertilizer value of manure and crop residue is 27 and 13 respectively and the N and P equivalency of manure is 113% and 153% for crop residue (**Table 4**). The high values of fertilizers equivalency of manure and crop residue over 100% suggest that the organic amendment have beneficial roles other than the addition of plant nutrient such as addition of micronutrients and better water holding capacity. In addition, the release of nutrient with mineralization over time can match more the plant demand and this will result in higher nutrient use efficiency from the organic amendments. It is also well established that the application of organic amendments can reduce the capacity of the soil to fix P and then increase P availability to plant.

(ii) Optimum combination of organic and inorganic sources of nutrients

Although the combined application of organic resources and mineral inputs forms the technical backbone of the Integrated Soil Fertility Management approach, procuring a sufficient amount of organic matter of a desired quality is very often a problem farmers are facing. While high quality organic resources (high %N, low %lignin and polyphenols) are known to behave as fertilizers through fast mineralization of their tissue N, lower quality organic resources are often more abundant on farmers' fields. Examples of such lower quality resources are crop residues or farmyard manure.

Sole application of low quality organic resources may lead to N immobilization and reduced crop growth. Consequently, mineral N is required to overcome the demand for N by the microbial decomposer community and to supply N to the crop. While preliminary evidence shows that high quality resources rarely cause immobilization of mineral N, low quality organic resources may lead to immobilization of fertilizer N. Depending on whether this immobilization phase lasts or not, decreased or enhanced crop yields may be the result (**Fig. 3**). In the case of long-term immobilization, residual effects may be more relevant rather than immediate N supply to the crop.

In 2001, network experiments were conducted at 7 benchmark locations across 7 countries to investigate the nitrogen and phosphorus contribution of different low quality organic materials that are available for direct use by farmers.

The data in **Table 5** give the rainfall and chemical characteristics at study sites in the Sahel. These soils are acidic and inherently low in nutrients with ECEC of less than 1 cmol/kg for all the sites except Gaya where the organic carbon is slightly higher and an ECEC of 1.3 cmol/kg. The data in **Figure 4** on phosphorus sorption isotherm clearly indicated that most of the soils have very low capacity to fix P due to their sandy nature.

As manure was used in most of the trials in combination with mineral fertilizer, a systematic chemical characterization of the manure used at the different sites was undertaken and the data are reported in **Table 6**. Those data will be used to determine the fertilizer equivalencies of different manure sources for nitrogen and phosphorus. The nitrogen and phosphorus levels in the manure were very low and varied from 0.47% to 0.71% and the P levels varied from 0.08% to 0.38%.

Site 1: Banizoumbou, Niger

Interaction of N, P and manure.

A factorial experiment of manure (0, 2 and 4 t/ha), nitrogen (0, 30 and 60 kg N/ha) and phosphorus (0, 6.5 and 13 kg P/ha) was established in Banizoumbou to assess the fertilizer equivalency of manure for N and P. The data in **Table 7** show a very significant effect of N, P and manure on pearl millet yield. Whereas P alone accounted for 60% of the total variation, nitrogen accounted for less than 5% in the total variation indicating that P is the most limiting factors at this site. Manure account for 8% in the total variation.

Biological nitrogen fixation.

15N dilution technique was used to quantify the biological nitrogen fixation of three cowpea varieties (local, TN5-78 and Dan illa) under different soil fertility conditions. A non-fixing (NF) cowpea variety was used as non-fixing crop. The samples have been sent to the International Atomic Energy Agency in Vienna, Austria for mass spectrophotometer analysis of 15N in order to assess the biological nitrogen fixation.

Combining organic and inorganic plant nutrients for cowpea production

The data in **Table 8** clearly indicate the comparative advantage to combine organic and inorganic plant nutrients for the low suffering soils in the Sahel. The use of only organic P sources yield 5000 t/ha of cowpea fodder whereas the application in the organic farm gave 5718 t/ha.

Site 2: Maseno, Western Kenya.

An integrated nutrient management experiment at maseno was established in the highlands of Western Kenya on a nitisol at an elevation of 1420 m ASL and receiving an annual rainfall of about 1800mm distributed over two growing seasons. Farmyard manure (quality parameters) was used as the low quality organic resource and was integrated with 0, 30, 60 and 90 kg N ha^{-1}. **Fig 5** shows the maize yield response to N in the presence or absence of manure. Since this was a poor season, the overall grain yield and subsequent response to N was poor. However at 0-30 N levels, treatments integrated with organics consistently yielded higher than urea-N. These differences declined beyond 30N. In contrast, these manures appeared to be effective in overcoming P deficiency that is widespread on farms in Western Kenya (**Fig 6**)

Site 3: Kogoni, Mali

The experiment was conducted in collaboration with the Institut d' Economic Rurale (IER), Mali at the research station in Niono. The site was located at Kogoni in the rice-growing region. Low quality manures derived from livestock fed predominantly rice residues were used in combination with urea-N at 0, 30, 60, 90 and 120kg ha-1. The data in **Fig 7** shows rice yield response to N in the presence or absence these manures. Application of 90-120 kg N gave the highest paddy yield (approx 7.5 t ha^{-1}) thereby doubling yield over the control. Integration with manure did not significantly increase the rice yields at any N levels; rather there was a slight additive effect of applying the low quality material.

Site 4: Farakou Ba, Kou Valley, Burkina Faso

In Burkina Faso, trials were conducted at the Kou valley research station in collaboration with the INERA. The low quality organic input was manure (<1.0%N). The test crop was irrigated rice. The manure applied at 1, 2, 3 and 4 tons dry matter per hectare was combined with urea-N at 0, 40, 80 and 120 Kg N ha^{-1}. The data in **Fig. 7** shows rice yield response to urea-N alone or in combination with organic matter at 4 levels. Applications of N alone doubled rice grain yield over the unfertilized control. There was an additive increase when organic matter was integrated with inorganic-N at all manure levels, however this increase was not significant.

Site 5: Zaria, Nigeria

The experiments at Zaria are conducted in collaboration with Ahmadou Bello University. The site is located adjacent to the Danayamaka village to the North of Zaria within the Guinean zone. Low quality manure that is typical of farmer organic resource input was used. The manure applied at 1, 2, 3 and 4 t dm ha-1 was combined with 0, 30, 60 and 90 kg N ha-1 in a split plot design arrangement where the main plots were treated with N at 4 levels and the sub-plots received manure inputs at 4 levels. The data in **Fig 9** shows the yield obtained with sole applications of urea-N (response curve) or urea-N in combination with organic manure inputs. At this site, additive effects of manure and fertilizer combinations were not significant indicating that these manures contributed little to the N demand for the maize crop. In addition, the data in **Fig 10** shows that these low quality manures can contribute significantly to overcome P deficiency to maize crop.

Site 6: Kumasi, Ghana

The Soils And Fertilizer Research Institute was the implementing partner for the network experiments in Ghana. The benchmark site was located within the humid forest zone north of Kumasi. The trial was arranged as a randomized block design on a uniform site that was recently cleared. Low quality maize stover and giant panicum grass were tested as possible organic resources that can be combined with mineral fertilizers for soil fertility improvements. However, the giant panicum treatments did not have sufficient replication to warrant being included in this report. In conclusion, the results for this site are not yet available.

Site 7: Davie, Togo

The site in Togo is located at Davie within the derived savannah zone. Partners from ITRA, Togo implemented the network experiments. For INM1, local organic resources used consisted of rice residues, which were obtained from an adjacent rice scheme. In order to achieve the required weight in dry matter equivalent for the materials added, not all residues could be incorporated and some of it remained as surface mulch for prolonged periods of time during the growing season. **Fig 11** summarizes the response of maize to the application of rice residues. There was little or no response to N at this site, probably due to moisture stress resulting from drought during the first season

Site 8: Kabete, Kenya

In addition to the long-term trial that was earlier reported an adjacent experiment was established to investigate the optimum combination of organic and inorganic N sources. Three different materials of differing quality were applied at 60 kg N/ha equivalent. At this N rate, the fertilizer equivalency value of tithonia was 100% while for senna and calliandra it was 43% and 38% respectively (**Fig 12**). This indicated that tithonia was as good as urea in supplying N to maize crop.

(iii) Equivalency of fertilizer value of legume-cereal cropping

Experiments were established at Maseno in Western Kenya, Zaria in Nigeria, Kumasi in Ghana and Davie in Togo

These experiments were to investigate Optimum N and P management in legume-cereal rotations. Although the combined application of organic resources and mineral inputs forms the technical backbone of the Integrated Soil Fertility Management approach, procuring a sufficient amount of organic matter of a desired quality is very often a problem farmers are facing. In-situ production of organic matter is an attractive alternative to technologies harvesting the organic resources from other sites within or outside the farm. Opting for legumes during the organic resource production phase has the potential to enrich the soil with N through biological N_2 fixation.

Herbaceous or green manure legumes usually leave substantial amounts of N in the soil although when left to grow to maturity, harvesting the seeds may substantially reduce the net N input into the soil. ‘Traditional’ grain legume germplasm has a large

N harvest index indicating that although a significant part of the N taken up by the legume was certainly fixed from the atmosphere, more N was taken away during grain harvest resulting in a negative net N input. However, dual-purpose germplasm is now available for, e.g., cowpea and soybean, which produces substantial amounts of haulms besides grains and has a relatively low N harvest index. As such, a net N input into the soil can be expected. Besides fixing N, certain legumes are also known to access less available P pools, alter the soil pest spectrum or improve soil biological properties. These benefits are often summarized as non-N benefits. The effect of a legume on a following cereal crop is often expressed as its N equivalent. One needs to take into account that the processes mentioned above might also lead to a better utilization of legume or fertilizer N although the improved yields are not necessarily an improvement of N supply.

The current experiments aim at quantifying the contribution of herbaceous and grain legumes to N supply and, where relevant, at quantifying the impact of targeting P to certain phases of the rotation on the overall yield. No data is available for this report yet as we will be able to monitor the rotation effect only during the next cropping season.

Picture 1: Soil fertility benefits of legume crops such as mucuna can be realised when grown in rotation with cereal maize

(iv) Phosphorus (P) placement and P replenishment with Phosphate rock

Single Superphosphate (SSP), Tahoua Phosphate Rock (TPR) and Kodjari Phosphate Rock (PRK) were broadcast (bc) and/or hill placed (HP). For pearl millet grain P use efficiency for broadcasting SSP at 13 kg P/ha was 18 kg/kg but hill placement of SSP at 4 kg P/ha gave a PUE of 83 kg/kg P. Whereas the PUE of TPR broadcast was 16 kg grain/kg P, the value increased to 34 kg/kg P when additional SSP was applied as hill placed at 4 kg P/ha. For cowpea fodder PUE for SSP broadcast was 96 kg/kg P but the hill placement of 4 kg P/ha gave a PUE of 461 kg/kg P. Those data clearly indicate that P placement can drastically increase P use efficiency and the placement of small quantities of water-soluble P fertilizers can also improve the effectiveness of phosphate rock (**Table 9**).

(v) Placement of phosphorus and manure

A complete factorial experiment was carried out with three levels of manure (0, 3, 6t/ha) three level of P (0, 6.5 and 13 kg/P ha) using two methods of application (broadcast and hill placement).

The data in **Fig 13** give the response of millet to P and manure for the two methods of application. For pearl millet grain the hill placement of manure performed better than broadcasting and with no application of P fertilizer, broadcasting 3 t/ha of manure resulted on pearl millet grain field of 700 kg/ha whereas the point placement of the same quantity of manure gave about 1000 kg/ha. The data in **Fig 14** and **15** for cowpea are showing also the same effect as for pearl millet.

A complete factorial experiment of three level of P (0, 13 and 26 kg P/ha), three levels of N (0, 30 and 60 kg N/ha), and three levels of manure (0, 2, 4 t/ha) was carried out. For pearl millet grain, the optimum combination of organic and inorganic soil amendment gave yield of about 2 t/ha whereas the control yield was 450 kg/ha. The data in **Table 10** gave P and N fertilizer equivalency of manure ranging from 291 to 397%.

(vi) Farmer's evaluation of soil fertility restoration technologies

(a) Karabedji

Past research results indicated a very attractive technology consisting of hill placement of small quantities of P fertilizers. With DAP containing 46% P2O5 and a compound NPK fertilizer (15-15-15) containing only 15% P2O5, fields trials were carried out by farmers on 56 plot per treatment to compare the economic advantage of the two sources of P for millet production. As hill placement can result in soil P mining another treatment was added consisting of application of phosphate rock at 13 kg P/ha plus hill placement of 4 kg P/ha as NPK compound fertilizers.

The data in **Table 11** clearly shows that there was no difference between hill placement of DAP and 15-15-15 indicating that with the low cost per unit of P associated with DAP, this source of fertilizer should be recommended to farmers. The basal application of Tahoua Phosphate rock gave about additional 300 kg/ha of pearl millet grain. The combination of hill placement of water-soluble P fertilizer with phosphate rock seems a very attractive option for the resource poor farmers in this region. The data in **Figure 16** is showing the variation of yield of each plot in farmers fields as compared to the farmer's practices and clearly shows that the application of Tahoua PR with hill placement of water soluble P outperformed the other treatments in most instances.

Picture 2: Hill placement rather than broadcasting
increases the P use efficiency

Picture 3: Hill placement of small amounts of P fertilizer (4 kg P/ha) increases
millet growth in the Sahel

(b) Sadore

Low, medium and high inputs of mineral fertilizers evaluation

Farmers' practices were compared to a low input system consistency on increasing crop planting density at recommended level, a medium input where Tahoua Phosphate rock was applied at 13 kg P/ha and SSP hill placed at 4 kg P/ha and high input as recommended by the extension services where SSP is broadcast at 13 kg P/ha with nitrogen applied at 30 kg N/ha as urea.

The data in **Table 12** indicates that grain yield can be increased three fold with the medium input and higher economic returns can be anticipated with this treatment. The data in **Figure 17** shows how the yield of the technologies evaluated fluctuated as compared to the farmers' practices with the high input systems dominating the other systems in most instances.

As for Karabedji, DAP, NPK and SSP were compared and there was any significant effect between the three sources and yield can be increased for more than two fold with this low input technology. The variation of the grain yield of the different treatment as compared to farmer's practices is reported in **Figure 18**.

III. Network proposals

Most of the trials that had been established in East and Southern Africa were almost coming to termination stage by the year 2001. Subsequently, during the AfNet meeting held at Arusha, Tanzania, members agreed to develop research proposals as an initial stage in establishing new network experiments in the region. In 2002, a systematic organization of the benchmark sites in East and Southern Africa will be undertaken. A brief note of each of these proposals that will be submitted to appropriate donors is given below.

On farm testing of P availability from phosphate rocks as affected by addition of local organic materials

S. Ikerra, R. Okalebo, E. Gikonyo, N. Nhamo, B. Tossah, E. Munyanziza

Abstract:

Soil nutrient depletion is currently one of the factors limiting crop production in sub-humid tropical Africa and has been of big concern among farmers, researchers and policy makers. Phosphorus is widely limiting in most of agricultural soils in Sub - Saharan Africa. The use of fertilizers is a possible option to reverse the trend but their high costs constitute a handicap mainly to resource poor farmers. There is therefore a need for alternative, affordable P sources. Rock phosphates, which are found in most parts of Africa, are of igneous origin and have low reactivity. They, however offer a cheaper source of P for resource poor farmers. Solubility of these phosphate rocks can be improved by using combination of the rock and organic/green manures. Besides their solubilization effects the organic materials influence soil P availability by altering some processes governing soil P pools such as microbial activities and P sorption.

Different organic inputs are likely to impart different effects on rock phosphate dissolution and soil P availability depending on their composition, rate of application, and type of soil and agro- ecological zone.

The objective of this network trials therefore is to do on farm testing of Phosphate rocks P dissolution as influenced by different types and rates of organic materials and the subsequent maize yield. .

Objectives:

1. To identify, characterize and evaluate locally available organic materials for their potential to enhance phosphate rock solubilization under farmer's conditions.
2. To establish the effect of local organic materials on PR dissolution and its relative agronomic effectiveness
3. To assess the effects of organic and inorganic P sources on soil P dynamics and fractions
4. To develop and disseminate socio-economically acceptable soil management options for poor resource farmers
5. To improve capacity building

AfNet Participating Countries: Tanzania, Kenya, Zimbabwe, and Togo

Integrated approach to manure management for improved productivity in Eastern and Southern Africa

F. Kihanda, J. Lekasi, S. Kimani and F. Matiri

Abstract:

Sub-Saharan Africa is the only region in the world where the per capita food production lags behind population growth. This decline in food production results to a large extent, from several factors including unpredictable weather, natural catastrophes, civil wars, and land degradation. A major factor in land degradation is

the low and declining soil fertility, resulting partly from soil erosion, and continuous cropping without adequate nutrient replenishment. Soil fertility maintenance and improvement by using chemical fertilizers and organic materials therefore holds the key to enhanced food production. However, there are several mitigating constraints in the use of chemical fertilizers. In Kenya for instance, the collapse of the cooperative movement and credit institutions, coupled with market liberalization in the region has led to a decline in the use of inorganic fertilizers.

In recent years, there has been considerable interest in the use of organic materials to ameliorate soil fertility decline. Of these organic materials, livestock manure is the single most important soil amendment available on-farm. However, manure use is beset by several problems, including low nutrient concentration and inadequate quantities. Recent studies show that improving manure management via collection, storage, handling and composting enhances nutrient concentration and fertilizer equivalency. Other studies have shown that appropriate combinations of manures with modest amounts of inorganic fertilizers, improves nutrient use efficiency and crop yields. In addition studies have also indicated the possibility of correlating discernible manure characteristics with measured laboratory indices.

This project seeks to address the problems of low nutrient concentration in livestock manures through improved management strategies in smallholder farms. The project will relate farmers' perceptions of livestock manure quality with key quality indices identified laboratory measurements. In addition, the project will explore how socio-economic and cultural factors such as labour availability, household resources, household composition and gender influence manure management practices.

Enhanced soil fertility and food production will go a long way in addressing the problem of food security and general livelihood of smallholder farmers. The three-year project will be executed in six countries in Eastern and Southern Africa.

Objectives:

1. Review past manure work in the individual countries and identifying technologies that could be disseminated without doing basic research. To test and validate, various composting/storage techniques on crop yield, soil fertility maintenance and economics with farmers' participation.
2. To test and validate appropriate inorganic/organic combinations for the different areas factors influencing the response and residual effects their fertilizers equivalencies.
3. To promote the use of the best-bet technologies through training and partnership with National Agricultural Research Systems, extension systems, non-governmental organizations and community based organizations.
4. To extrapolate benchmark location results through simulation models, decision support systems and geographic information systems.
5. To identify the socio-economic and cultural factors that affect manure management practices and farmers' perception on quality.

AfNet Participating Countries: Kenya, Uganda, Tanzania, Zambia, Malawi, and Zimbabwe

Enhancing biotic activities for soil fertility improvement in the dry lands of East Africa: Case studies of Kenya and Uganda

F. Ayuke, M. Silver, I. Tabu, M. Mwangi, M. Opondo-Mbai, M. Odendo, M. Bekunda, G. Lamtoo, J. Tumuhairwe, C. Nkwiine, R. Miiro, M. Kuule, J. Tumuhairwe, D. Kyeyune, S. Natigo, M. Okwakol, M.J. Swift, J. Ramisch, A. Bationo

Abstract:

In large parts of sub-Saharan Africa and East Africa in particular, over 80% of the people derive their livelihood from small-scale subsistence agriculture. Often such farmers employ exploitative methods e.g. poor tillage methods, limited nutrient replenishment, continuous cropping and limited use of soil conservation structures resulting in soil impoverishment. These problems are serious in dry land areas characterized by low (<1000 mm/year) and unreliable rainfall, high temperatures and poor soils. How to increase and maintain soil fertility for increased crop yields to meet the needs of the growing population, is a major national problem for these countries. Soil biological technologies such as use of biological nitrogen fixation, mycorrhizal fungi and soil biota manipulation offers some solutions because they are cheap, easy to apply and are environmental friendly. This project will therefore review and assess the constraints affecting soil nutrient depletion and will try to develop, with farmers' participation, appropriate technologies to restore soil fertility through management of below ground biodiversity. By appreciating the role of soil biota in soil productivity, the project will seek to develop practical means of manipulating them (soil biota) to derive potential benefits in agricultural production. The project will propose a set of management options for improving tropical soil

fertility through biological processes. The project will also seek to develop methods for integrating biological methods for soil fertility and pest management.

The project will utilize on farm field experiment approach to assess the impact of best-bet technologies for biological management of soil fertility. Farmers' participatory approach will be used to better assess the effects of farmers' land management practices on soil biota composition and soil properties. Farmers' understanding and attitude of soil fauna will also be assessed through participatory approach. Decision support systems and analyses will be used to extrapolate project

The experiments will be implemented based at various benchmark sites in farmers' fields. The project results will be disseminated through workshops, publications and extension materials

Objectives:

Broad objective: To improve soil productivity through use of soil biota.

Specific objectives:

1. To evaluate farmers' knowledge and perception of soil biota.
2. To characterize soil biota (diversity, population and activities) in different dry land ecosystem niches.
3. To compare beneficial and detrimental biotic activities.
4. To identifying potential of soil biota in the utilization of low input resources.
5. To determine cost effective and sustainable soil fertility management practices and options.

6. To disseminate the best-bet technology on biological management of soil fertility.

7. To promote capacity building and training by our institutions of higher learning on soil biology.

AfNet Participating Countries: Kenya, Uganda

Soil Organic Matter Dynamics for Sustainable Cropping and Environmental Management in Tropical Systems: Effect of Organic Resource Quality and Diversity

P. Mapfumo, F. Mtambanengwe, S. Nandwa, E. Yeboah, B. Vanlauwe, K.E. Giller, D. Mugendi, P. Chivenge, J.O. Fening, S.K.A. Danso, E.O. Apontuah

Abstract:

The proposed three-year collaborative work focuses examining the functional role SOM in sustaining crop productivity and environmental service functions in tropical agro-ecosystems as affected by management of quality and quantities of the diverse organic resources available to smallholder farmers in Africa. The ultimate aim is to promote sustainable food production and environmental quality on smallholder farming systems in sub-Saharan Africa. The specific objectives of the project are to: i) characterize the quantity and quality of organic materials available to smallholder farmers in benchmark areas, and determine how these have influenced SOM status and dynamics under different management practices and biophysical environments; ii) determine the quantitative effects of continuous application of low and high quality organic inputs on SOM build up, soil nutrient supply patterns and soil physico-chemical properties; iii) quantify the differential contribution of distinct SOM functional pools (fractions) to soil properties essential for maintenance of crop

productivity and environmental quality under different management systems, soils types and climatic environments in selected benchmark areas; iv) define the biophysical and socio-economic boundaries within which SOM management can be enhanced for increased soil productivity and environmental services in tropical farming systems in Africa. The work will be conducted in different agro-ecosystems in East, Southern and West Africa. The project will provide postgraduate training in the field of soil organic matter management and sustainable agriculture and natural resource. It is anticipated that the research will further scientific understanding of the SOM dynamics in the tropics and provide a basis for valuation of the environmental service functions of SOM. Through reports, workshops, policy briefs and brochures, the project will recommend to researchers, extensionists, policy makers and farmers the appropriate methods for management of organic resources to improve soil fertility and environmental quality. Collaboration and networking among regional and international scientists working on biological management of soil fertility in the tropics will be promoted.

Objectives:

The overall objective of the project is to enhance the functional role SOM in sustaining crop productivity and environmental service functions in tropical agro-ecosystems through appropriate management of quality and quantities of the diverse organic resources available to farmers in Africa.

Specific Objectives:

1. To characterize the quantity and quality of organic materials available to smallholder farmers in benchmark areas, and determine how these have influenced

SOM status and dynamics under different management practices and biophysical environments.

2. To determine the quantitative effects of continuous application of low and high quality organic inputs on SOM build up, soil nutrient supply patterns and soil physico-chemical properties.

3. To quantify the differential contribution of distinct SOM functional pools (fractions) to soil properties essential for maintenance of crop productivity and environmental quality under different management systems, soils types and climatic environments in selected benchmark areas.

4. To define the biophysical and socio-economic boundaries within which SOM management can be enhanced for increased soil productivity and environmental services in tropical farming systems in Africa.

AfNet Participating Countries: Ghana, Kenya, and Zimbabwe

The Role of termites in tropical agro-ecosystems: Case studies in Tanzania, Kenya, Uganda, Zimbabwe, Cote d'Ivoire and Cameroon

J. Wickama, F. Ayuke, J. Tumuiahirwe, F. Mtambanengwe, Y. Tano, Debog and M. Swift

Abstract:

This proposal is on the role of termites in tropical agro-ecosystems. In this project priority is given to inventorying indigenous knowledge and perception of the local communities on the harmful and beneficial aspects of termites. These will be investigated with respect to soil fertility and agricultural productivity. The proposal itself covers six African countries south of the Sahara. These are Kenya, Uganda,

Tanzania, Zimbabwe, Cameroon, and Cote de Ivore. The ultimate objective of the proposal is to enrich our scientific knowledge and document farmers' perception on termites as well as building the farmers' problem solving capabilities by using the resources at their disposal. At activity level the study will employ participatory techniques to study farmers perception of the termites benefits, problems and their efforts towards coping with them.

In each country the project will be conducted in different agro-ecosystems so as to capture farmers knowledge in each system. The project will be conducted in two discreet phases. The first phase (1 year) will concentrate on collection and documentation of the baseline information, biophysical data and socio-economic information of the affected communities. In the second phase (2-3years) the project will concentrate on the farmers' experimentation of the researchable areas jointly developed with farmers during the first phase. Further, the project will also assess whether farmers' practices in the affected areas are to a significant extent influenced by presence of termites in their productive activities. This proposal is the first ever such effort which brings together six African countries to deal with termites. The proposal also covers a topic that has received very little attention and its major priority is to redress this gap. If accomplished, this project will increase our understanding of both scientific and indigenous knowledge on the importance of termites in African farming systems. By focussing on the termites' linkage to soil fertility and agricultural productivity in the affected areas the information generated in this project contribute towards increased agricultural productivity in the affected areas and beyond them in a sustainable manner.

Objectives:

The general objective of this project is to build our understanding on the importance of termites in African farming systems. Specifically the project will seek to achieve the following objectives:

1. Inventorize farmers' perceptions and indigenous knowledge on the importance of termites
2. Investigate about farmers' control and utilization practices
3. Identify the type and distribution patterns of termites in different agro-ecosystems and investigate factors affecting them
4. Evaluate the socio-economic determinants of farmers' perception on termites
5. Identify the knowledge gaps, which may need further research
6. Document and disseminate the generated information.

AfNet participating Countires: Tanzania, Kenya, Uganda, Zimbabwe, Cote d'Ivoire and Cameroon

Nutrient cycling by arbuscular mycorrhiza and legume cover crops: potential for crop production in sub-Sahara acid soils

D. Nwaga, A.B. Mvula, C. Gachengo, J. Kung'u, M. Silver, Nhamo, E. Munyanziza, R. Ambassa-Kiki, M.J. Swift

Abstract:

In order to assess the potential of arbuscular mycorrhiza and legume cover crops such as Mucuna for nutrient cycling a network proposal will be carried out between 6

African Network (AfNet) of TSBF member countries: Cameroon, Kenya, Tanzania, Uganda, Zambia and Zimbabwe during five years. The main objective is to increase our understanding on the role of theses beneficial soil organisms and evaluate their potential to improve on sustainable agricultural production (maize, common bean, cowpea groundnut or soybean) for farmer profit. In order to achieve this goal, it will be necessary to develop mycorrhiza resource bank, field assessment of the potential of mycorrhiza inoculation on soil fertility and succeeding crops and African farmers awareness on the use of these technologies.

Objectives:

General objective:

The overall objective of this project is to improve our understanding of the role of AM fungi for nutrient acquisition and interactions with other soil organisms for crop production and profitability under field trials.

Specific objectives:

1. AM fungi resource bank and selection of strains for legume cover crops.
2. Assess the effect of microsymbiont inoculation on legume cover crop for biomass production, N and P cycling and soil fertility.
3. Quantify the impact of legume cover crop on succeeding crops yield improvement.
4. Evaluate the potential of AM fungi on soil microbial activity and disease tolerance.
5. Develop awareness, training for use and socio-economic aspects for farmers' profits.

AfNet Participating Countries: Cameroon, Kenya, Tanzania, Uganda, Zambia and Zimbabwe

The influence of land tenure on adoption of integrated land and natural resource management in Eastern and Southern Africa

M. Odendo, A. Kaliba, J. Ramisch

Abstract:

Farmers consider a variety of factors in deciding whether or not to adopt particular land management practices. Non-economic factors, such as awareness of the local environment play a role. Economic factors, including both short-term profitability and long-term asset value, are also important. Under insecure land tenure, farmers are concerned with short-term profitability of the land they farm and return from the available natural resources, but less so about its long-term value. By contrast, under secure land tenure, farmers care for both short-term profitability and the long-term value of the land and the natural resources. We would thus expect to see-tenure related differences in adoption of different land management practices and decision on utilization of available natural resources, depending on how those practices affect short-term socio-economic gains, long-term value of land or the resource, or both.

Land tenure has a critical impact on market values and thus on economic decision making as to the uses to which land should be put and how to utilize the natural resource. Nature of land rights affects use; duration of right affects nature of long-term investment. The World Bank estimates suggest that the capital value of land and natural resources constitutes half to three quarters of a nation's wealth: the less domestic capital and the less developed the economy, the higher this proportion.

What is true for the nation is also typically true for the family and individual. Land and natural resources are therefore likely to be by far the largest class of asset in most economies. Its efficient use and management must be one of the keys to successful economic development. Secure land rights will move the key economic resource of land towards the highest and economically most efficient use.

Lack of secure land tenure is associated with overexploitation of resources. In turn, overexploitation of land and natural resources critically affects the economic welfare and food security. With insecure land tenure, farmers have no incentive to commit land term investments for sustainable farming and livelihood.

Objectives:

1. To review and compile existing land and natural resource use and investment policies that has direct implication to smallholder farmers' decision-making process.
2. Identify categories of tenure that play major role in adopting available technologies for integrated land management and natural resource use.
3. Estimate socio-economic gains associated with secure land tenure through bio-economic modelling/simulation.
4. Suggests policy instruments that would encourage secure land tenure and maximize national goals of improving smallholder farmers' welfare.
5. To publish the findings into book forms and other materials for promoting secure land and natural resources' rights in Eastern and Southern Africa.

AfNet Participating Countries: Kenya, Ethiopia, Lesotho, Tanzania, Uganda, and Malawi

Green manure and legume cover crops for soil fertility improvement

W. Sakala, R. Delve, Z. Mkangwa, T. Amede, S. Ikerra

Abstract:

In many parts of Africa, soils have been cultivated continuously resulting in the depletion of their nutrient capital. Depending on the type of nutrient, there are different methods for replenishing the pool, but for yields to be maintained, appropriate use of inorganic fertilisers, integration of crops and livestock, optimal crop rotations, fallowing, and intercropping with grain legumes and green manures are essential farming activities. Apart from the occasional application of small amounts of inorganic fertilisers, all the other activities form the principal means of managing soil fertility in African agriculture. But the continued low yields are an indication of insufficient inputs and/or inappropriate use of the technologies.

Historically, fallows played an important role in maintaining the productivity of the soils through uncontrolled regeneration of natural secondary vegetation, which was then cut and burned at the initiation of another cropping cycle. Research has begun to focus on the improvement of fallows, to fit differences in human population, land availability, climate, soil, management and farmer objectives. At one end are fallows enriched with long-lived useful tree species (agroforestry) while on the other extreme are short duration improved fallows consisting of planted and managed fast-growing species that allow for the rapid replenishment of soil fertility. The latter appears a feasible option for maintaining and improving soil fertility in smallholder farming where population pressure and land scarcity have resulted in the reduction in the length of the fallow periods. The fast-growing herbaceous nitrogen-fixing legumes

used in improved fallows are, hereafter, termed green manure cover crops (GMCCs).

Integration of GMCCs into the farming systems is one practice that has the advantage that food crops are still produced while organic biomass is produced for soil management. Past research has focused on the ability of the GMCCs' potential to improve soil productivity through increased soil organic matter content, improved soil microbial and physical properties, suppression of weeds and pests, erosion control and contribution of nitrogen through nitrogen fixation. These factors have a bearing on the GMCCs being recommended for use by farmers. But this may be at the expense of competing with the food crops if inter- or relay cropped, or for land if rotated. Coupled with these is the fact that benefits may vary between sites and seasons, depending on the availability of soil moisture and nutrients. Preliminary findings with farmers in Western Kenya serve to indicate that there still are some shortcomings in the previous research in understanding the mechanisms that are necessary for the successful introduction of the GMCCs in the agricultural systems of resource poor farmers

Objectives:

1. Introduce GMCCs to farming systems where they could play a significant alternative/complementary role in soil fertility maintenance
2. Determine the influence of above and below ground biomass from LCC on following food crop production
3. Investigate the relationship between source and quantity of cover crop N and % N recovery in the subsequent crop

4. Determine the optimal amount of legume cover crop and N that is needed to produce maximum yield and yet minimize N losses

AfNet Participating Countries: Malawi, Ethiopia, and Tanzania

For more information about the African Network for Soil Biology and Fertility (AfNet), please contact the coordination office
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Tables

Table 1: Percentage fertilizer equivalencies of different organic inputs in East and Southern Africa, 1999

Site	Organic material	%N in material	%Fertilizer equivalency
Madagascar	Tephrosia	4.0	93
Kenya	Tithonia	3.5	87
Zambia	Sesbania	5.0	39
Tanzania	Sesbania	3.5	36
Malawi	Pigeon pea	2.8	33

Table 2: Main treatments used in the operational scale research trials at Sadore.

1= Traditional practices
2= Animal traction (AT) +no rotation +Intercropping + P
3= Animal traction (AT) + rotation +Intercropping + P
4= Hand Cultivation (HC) +no rotation +Intercropping + P
5= Hand Cultivation (HC) + rotation +Intercropping + P
6= Animal traction (AT) +no rotation +Pure millet + P
7= Animal traction (AT) + rotation + Pure millet + P
8= Hand Cultivation (HC) +no rotation + Pure millet + P
9= Hand Cultivation (HC) + rotation + Pure millet + P

Table 3: Effect of fertilizers, soil tillage, crop residue, cropping system on pearl millet grain yield; Sadore 2001 cropping season.

Treatments	Pure millet grain yield (kg/ha)							
	- Rotation				+ Rotation			
	- Crop residue		+ Crop residue		- Crop residue		+ Crop residue	
	-N	+N	-N	+N	-N	+N	-N	+N
Traditional	146	181	331	473				
Phosphorus + HC	873	1145	1247	1649	703	1067	1649	1866
Phosphorus + AT	708	816	935	1114	904	1225	1381	1529

HC: hand cultivation, planting on flat
AT: Animal traction, planting on ridges

Table 4: Fertilizers equivalency of manure and crop residue at Sadore, Niger, 2001 cropping season

Parameters	Grain (kg/ha)	Total dry matter (kg/ha)
Absolute control	236	1523
% N in manure	0.71	0.71
% P in manure	0.18	0.18
% N in crop residue	0.71	0.71
% P in crop residue	0.03	0.03
Yield at 2.7t/ha of manure in continuous cropping	800	3461
Yield at 2.7 t/ha of crop residue in continuous cropping	634	2527
Equivalent N and P of the manure	27	58
Equivalent N and P of the crop residue	13	58
Fertilizer N and P equivalency of manure (%)	113	243
Fertilizer N and P equivalency of crop residue (%)	153	290

Table 5: Annual precipitation (2001) and soil characteristics for selected villages.

Sites	Rainfall Mm	pH KCl	C.org (%)	P-Bray1 (mg/kg)	Ca^{2+} Cmol/kg	ECEC Cmol/kg	N_{min} (mg/kg)
Sadore	460	4.3	.12	2.0	0.3	1	3
Banizoumbou	344	4.4	.12	1.5	0.4	0.8	5
Karabedji	378	4.2	.16	1.9	0.2	0.8	4
Goberi*	450	4.1	.16	1.7	0.2	0.8	2
Gaya	985	4.2	.33	2.5	0.4	1.3	9

Table 6: Characterization for N, P, K and polyphenols of the organics materials used for the trial in each site.

Sites	Manure origin	Total N (%)	Total P (%)	Total K (%)	Polyphenols (%)
Banizoumbou	Composite	0.71	0.18	0.75	0.64
Karabedji	Composite	0.56	0.12	0.45	1.02
Goberi	Composite	0.47	0.08	0.23	0.64
Gaya	Composite	0.58	0.38	0.80	0.75

Table 7: Fertilizers equivalency of manure at Banizoumbou, Niger, 2001 cropping season

Parameters	Grain (kg/ha)	Total dry matter (kg/ha)
Absolute control	290	1275
Control for N	1210	4550
Control for P	635	2280
% N in manure	0.71	0.71
% P in manure	0.18	0.18
Yield at 2t/ha of manure without N	1530	5450
Yield at 4t/ha of manure without N	1695	4855
Yield at 2t/ha of manure without P	810	2910
Yield at 4t/ha of manure without P	1070	3625
Equivalent N for 2t/ha of manure	41.53	38.90
Equivalent N for 4t/ha of manure	*	21.1
Equivalent P for 2t/ha of manure	3	2.71
Equivalent P for 4t/ha of manure	7.5	5.57
N fertilizer equivalency at 2t/ha of manure	292	273
N fertilizer equivalency at 4t/ha of manure	*	74
P fertilizer equivalency at 2t/ha of manure	83	75
P fertilizer equivalency at 4t/ha of manure	104.1	77

Table 8: Optimum combination of plant nutrients for cowpea fodder (kg/ha)

Treatments	Karabedji
1 Absolute Control	1875
2 30 kg N ha^{-1}	2531
3 12 kg P ha^{-1}	3781
4 8 tons manure + 30 kg N ha^{-1}	5718
5 6T manure + 3kg P + 30 kg N	4843
6 4T manure + 6 kg P + 30 kg N	4656
7 2T manure + 8 kg P + 30 kg N	4281
8 12 kg P + 30 kg N	5000
SE	204
CV	14%

Table 9: Effect of P sources and placement on pearl millet and cowpea yield and P use efficiency (PUE)

Treatments	Millet		Cowpea	
P sources and methods of placement	Grain yield (kg/kg P)	PUE (kg/kg P)	Fodder (kg/ha)	PUE (kg/kg P)
1 Control	468		1406	
2 SSP (bc)	704	18	2656	96
3 SSP (bc) + SSP (HP)	979	30	4468	180
4 SSP (HP)	798	83	3250	461
5 15-15-15 (bc)	958	38	4250	219
6 15-15-15 (bc) + 15-15-15 (HP)	1559	64	6500	300
7 15-15-15 (HP)	881	103	4062	664
8 TPR (bc)	680	16	2531	86
9 TPR (bc) + SSP (HP)	1048	34	3781	140
10 TPR (bc) + 15-15-15 (HP)	1065	35	4281	169
11 PRK (BC)	743	21	2468	82
12 PRK (BC) + SSP (HP)	947	28	4750	197
13 PRK (BC) + 15-15-15 (HP)	1024	33	5125	219
SE	46		120	
CV	18%		11%	

SSP: Single Superphosphate ,15-15-15: N_2 P_2O_5 K_2O compound fertilizer
TPR: Tilemsi Phosphate Rock, PRK: Kodjari phosphate rock
BC: Broadcast at 13 kg P/ha, HP: hill placed at 4 kg P/ha
PUE: P use efficiency kg yield/kg P applied

Table 10. Fertilizer equivalency of manure at Karabedji, Niger, 2001 cropping season

Parameters	Grain (kg/ha)
Absolute Control	171
Control for N	812
Control for P	356
% N in manure	0.56
% P in manure	0.12
Yield at 2t/ha of manure without N	1114
Yield at 4t/ha of manure without N	1432
Yield at 2t/ha of manure without P	708
Yield at 4t/ha of manure without P	1114
Equivalent N for 2t/ha of manure	44.5
Equivalent N for 4t/ha of manure	*
Equivalent P for 2t/ha of manure	7
Equivalent P for 4t/ha of manure	17.5
N fertilizer equivalency at 2t/ha of manure	397
N fertilizer equivalency at 4t/ha of manure	*
P fertilizer equivalency at 2t/ha of manure	291
P fertilizer equivalency at 4t/ha of manure	364

Table 11: Farmers managed trials at Karabedji, 2001 rainy season=

Treatments	Millet grain yield (kg/ha)
1=farmers' practices	487
2=NPK HP	1030
3=DAP HP	924
4=PRT+NPK HP	1325
SE	24
CV	19%

NPK: 15-15-15 compound fertilizers
DAP: Diammonium phosphate
HP: hill placement at 4 kg P/ha
PRT: Tahona Phosphate rock broadcast at 13 kg P/ha

Table 12: Farmers managed trials at Sadore, 2001 rainy season

Treatment	Millet grain yield (kg/ha)	Millet TDM (kg/ha)
1=control	248	1426
2=DAP HP	680	3158
3=NPK HP	659	3151
4=SSP HP	660	3404
SE	33	111
CV	23%	16%

NPK: 15-15-15 compound fertilizers
DAP: Diammonium phosphate
HP: hill placement at 4 kg P/ha
PRT: Tahona Phosphate rock broadcast at 13 kg P/ha

Figures

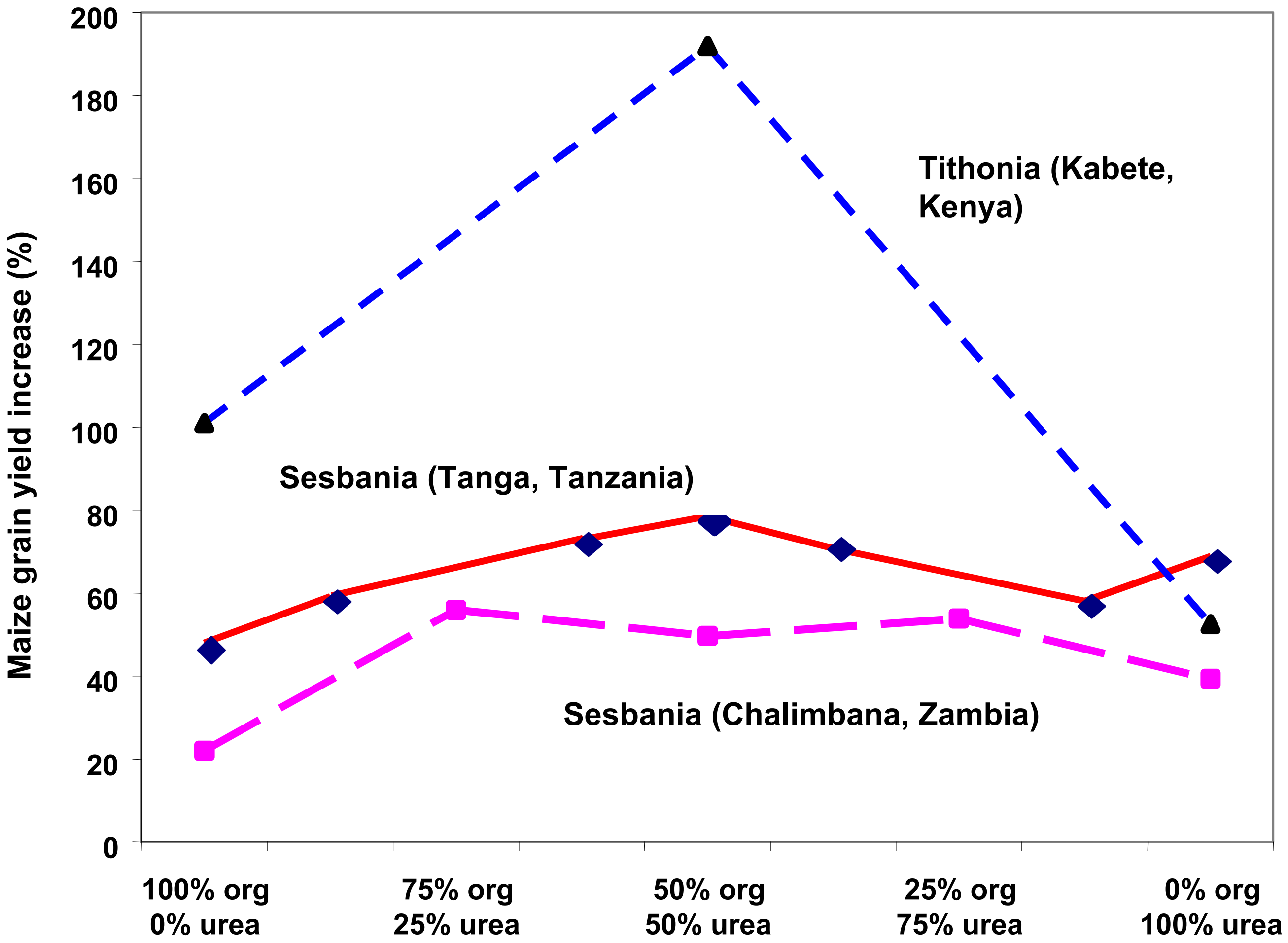


Fig 1: Determination of optimum combination of Inorganic and organic N sources at three sites in East Africa, 1999

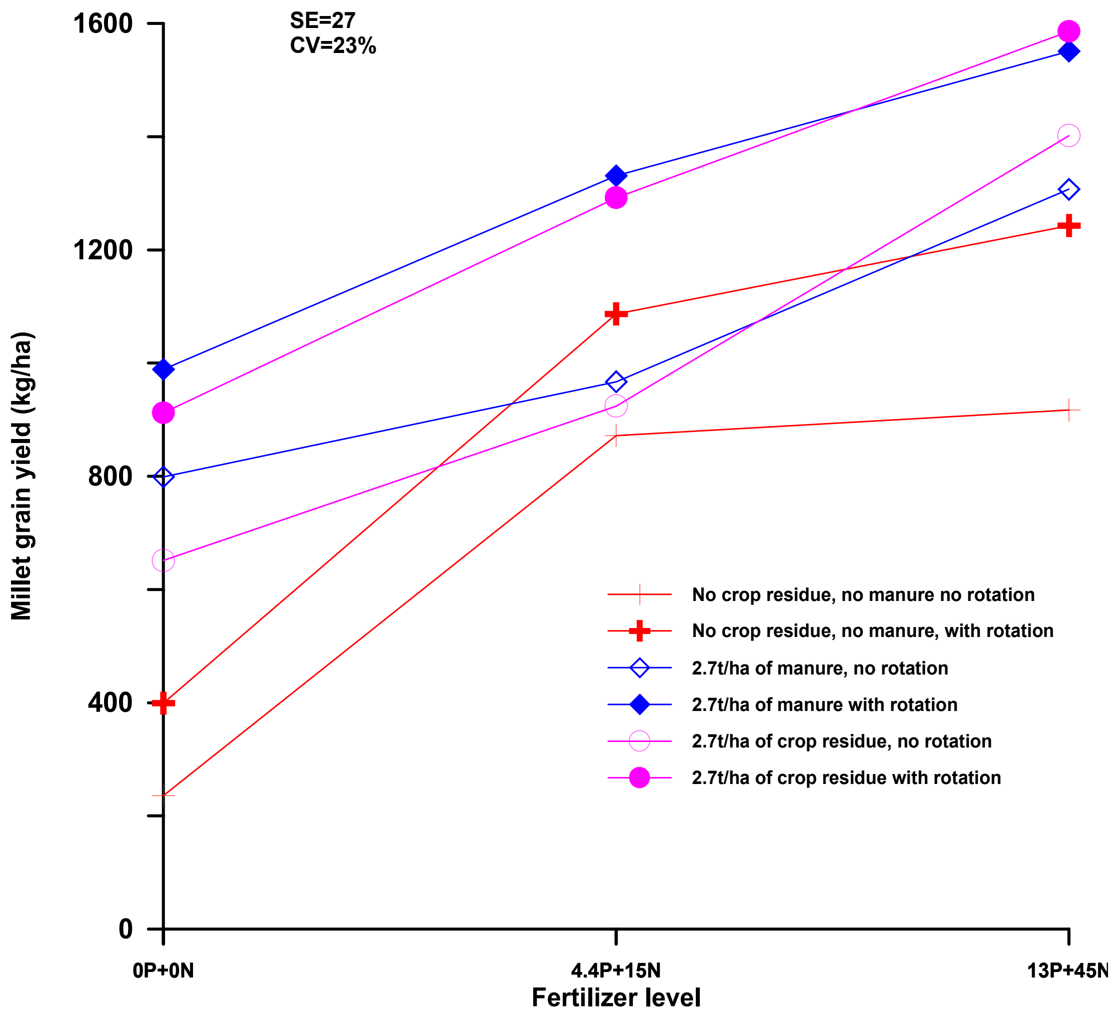


Figure 2: Millet grain response to fertilizers (N&P), crop residue, manure and rotation; Sadoré, Niger 2001 rainy season.

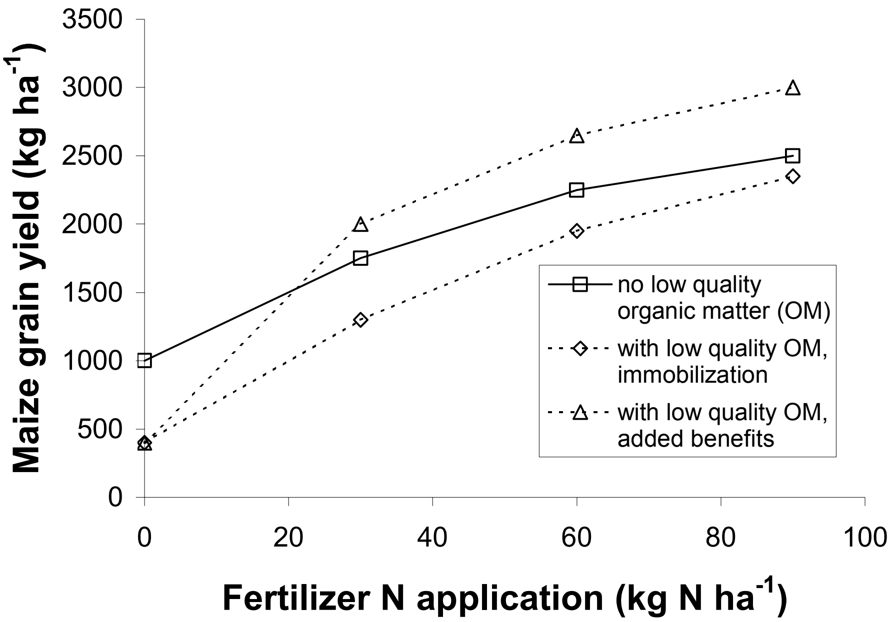


Fig 3: Hypothetical influence of low quality organic resource application on maize grain yield considering along immobilization leading to reduced crop growth and temporary immobilization of fertilizer N by decomposing low quality organic matter leading to added benefits

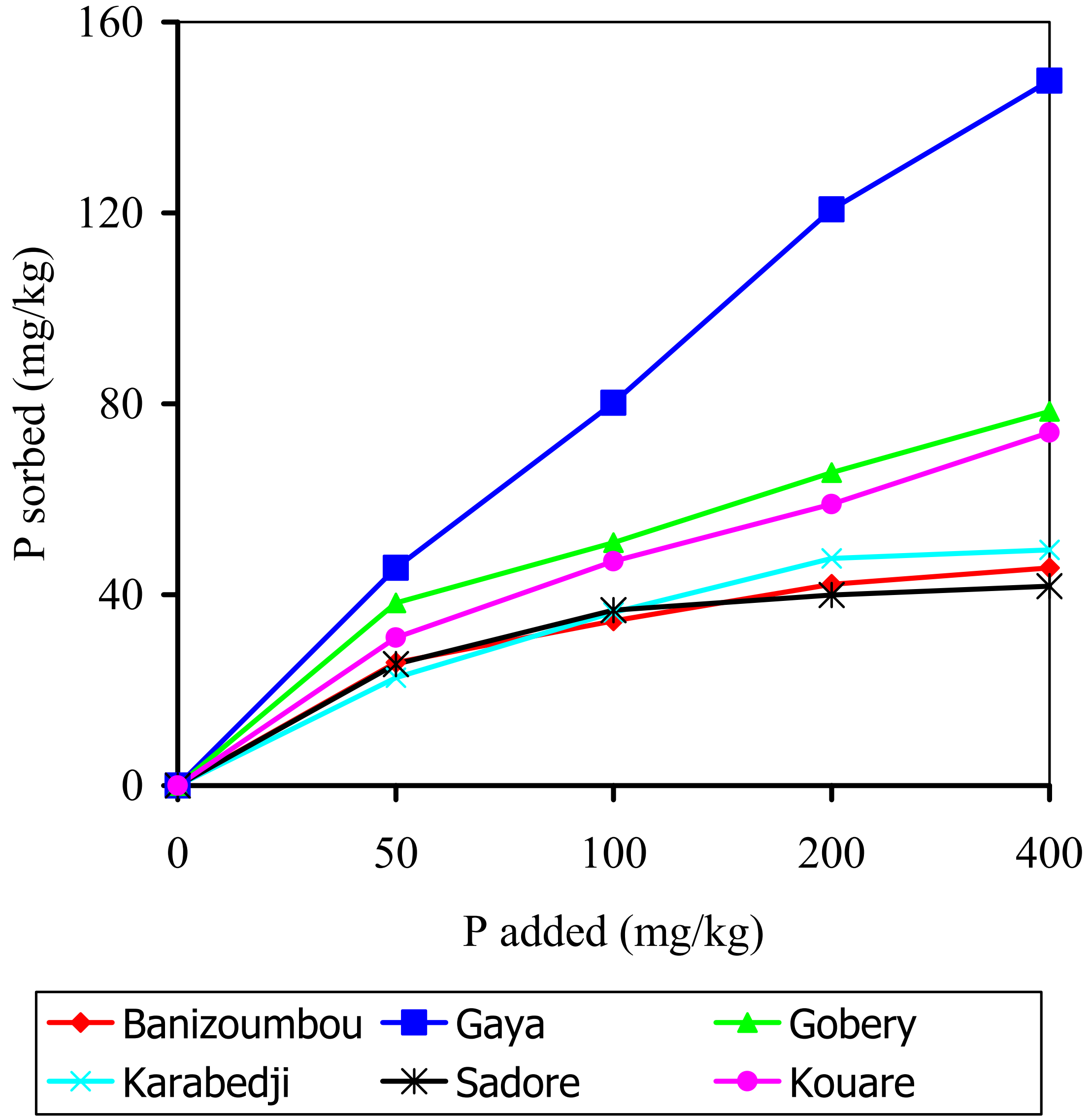


Fig. 4. Phosphorus sorption isotherms of soil samples from benchmark sites in Niger and Burkina Faso.

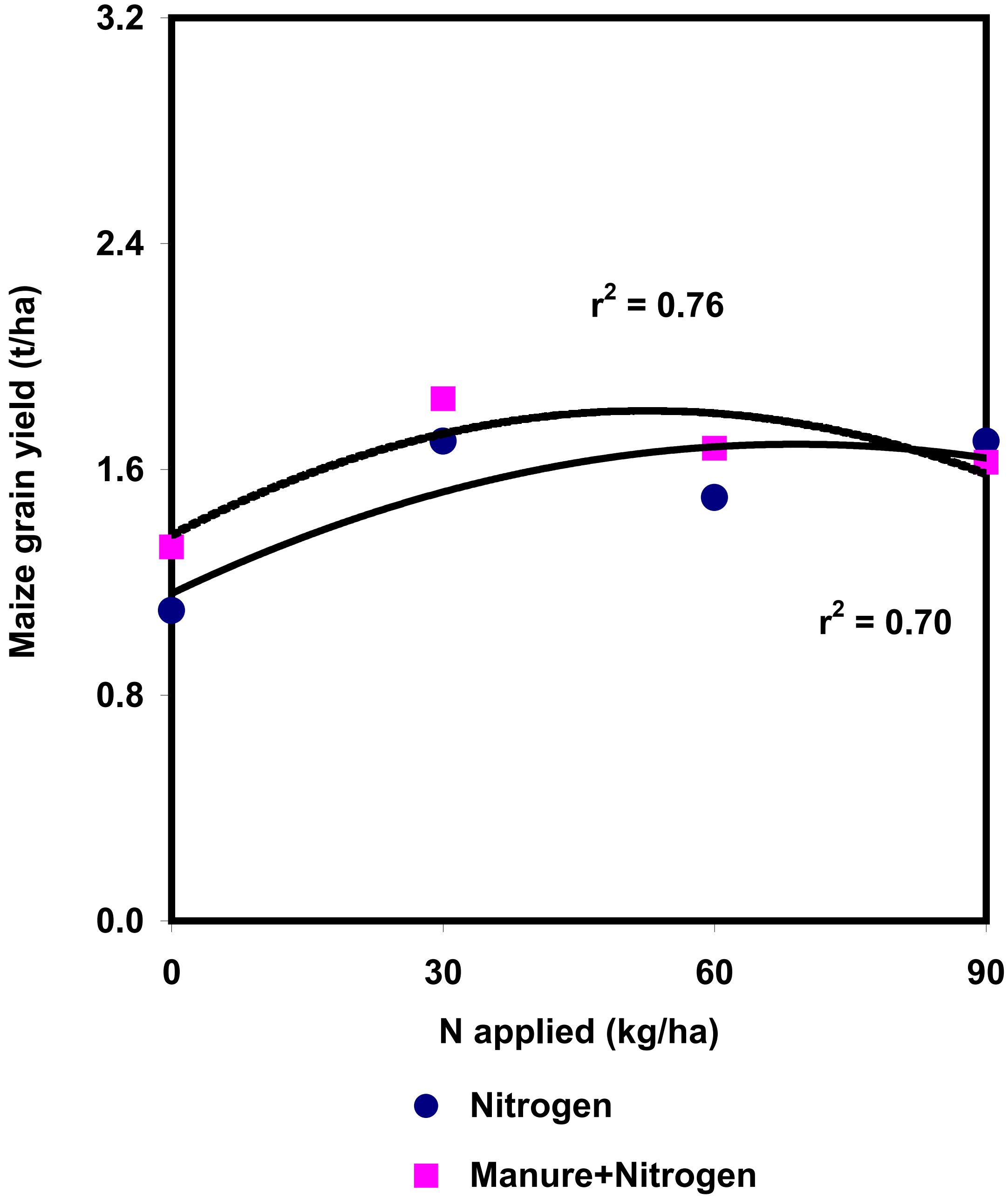


Fig 5. Maize grain yield response to manure and N levels, Maseno, Kenya, 2001

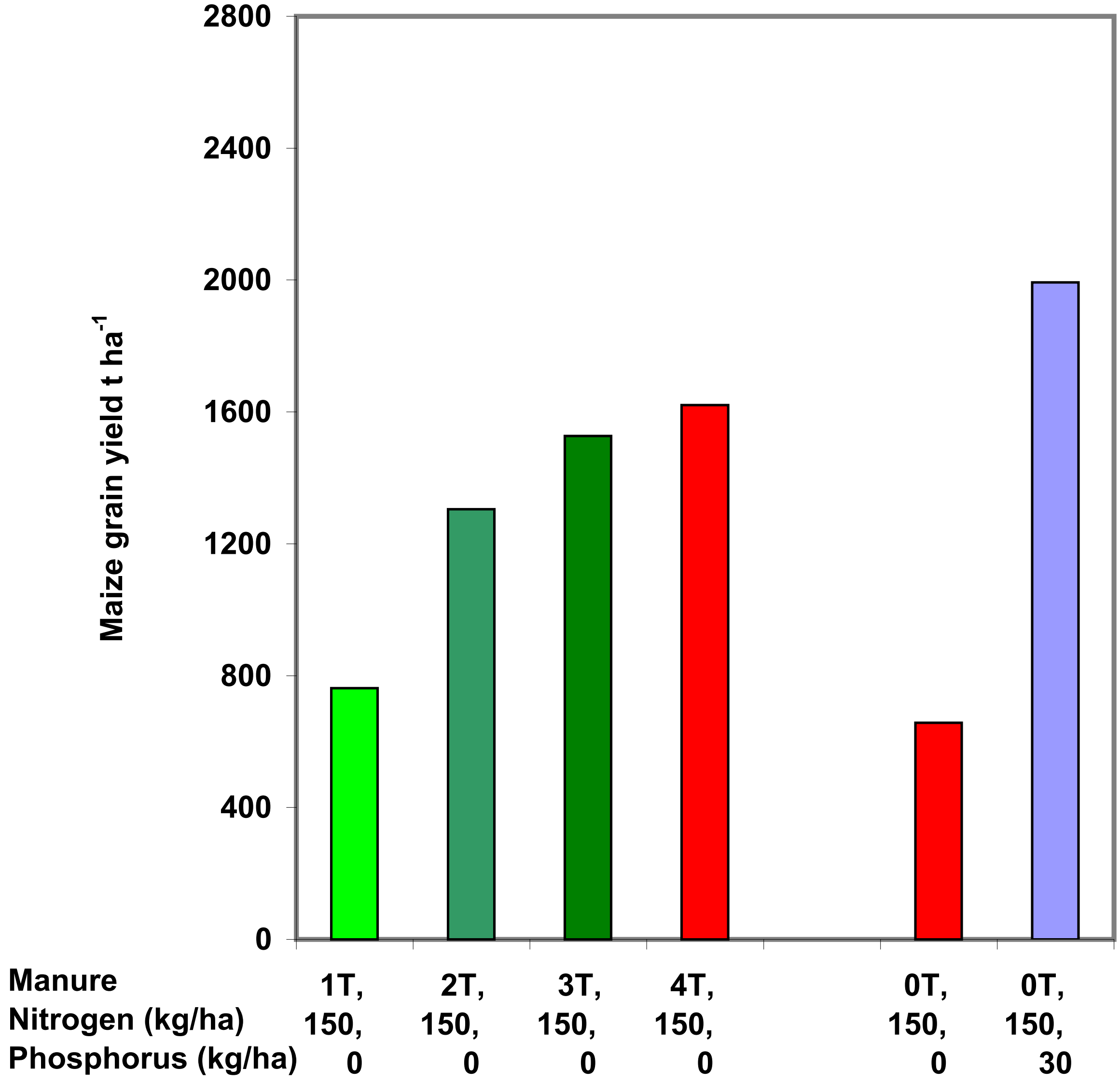


Fig 6. Maize yield response (1st 4 bars) to application of 1, 2, 3 and 4 Tons ha^{-1} of low quality manure (<1%N) showing abilitity of such manures to contribute significantly to alleviating P deficiency to maize crops Maseno, western Kenya, 2001

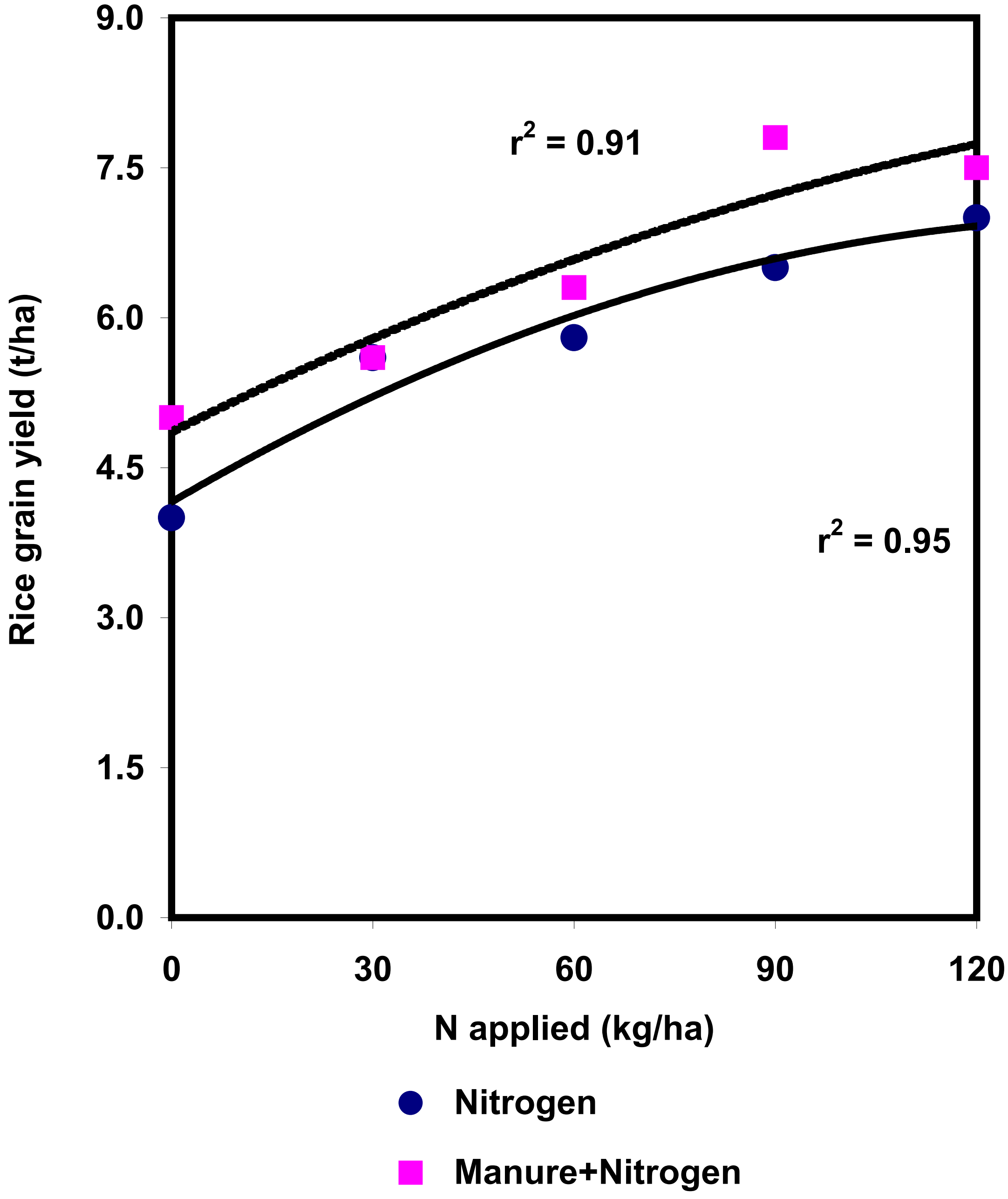


Fig 7. Rice grain yield response to manure and N levels, Kogoni, Mali, 2001

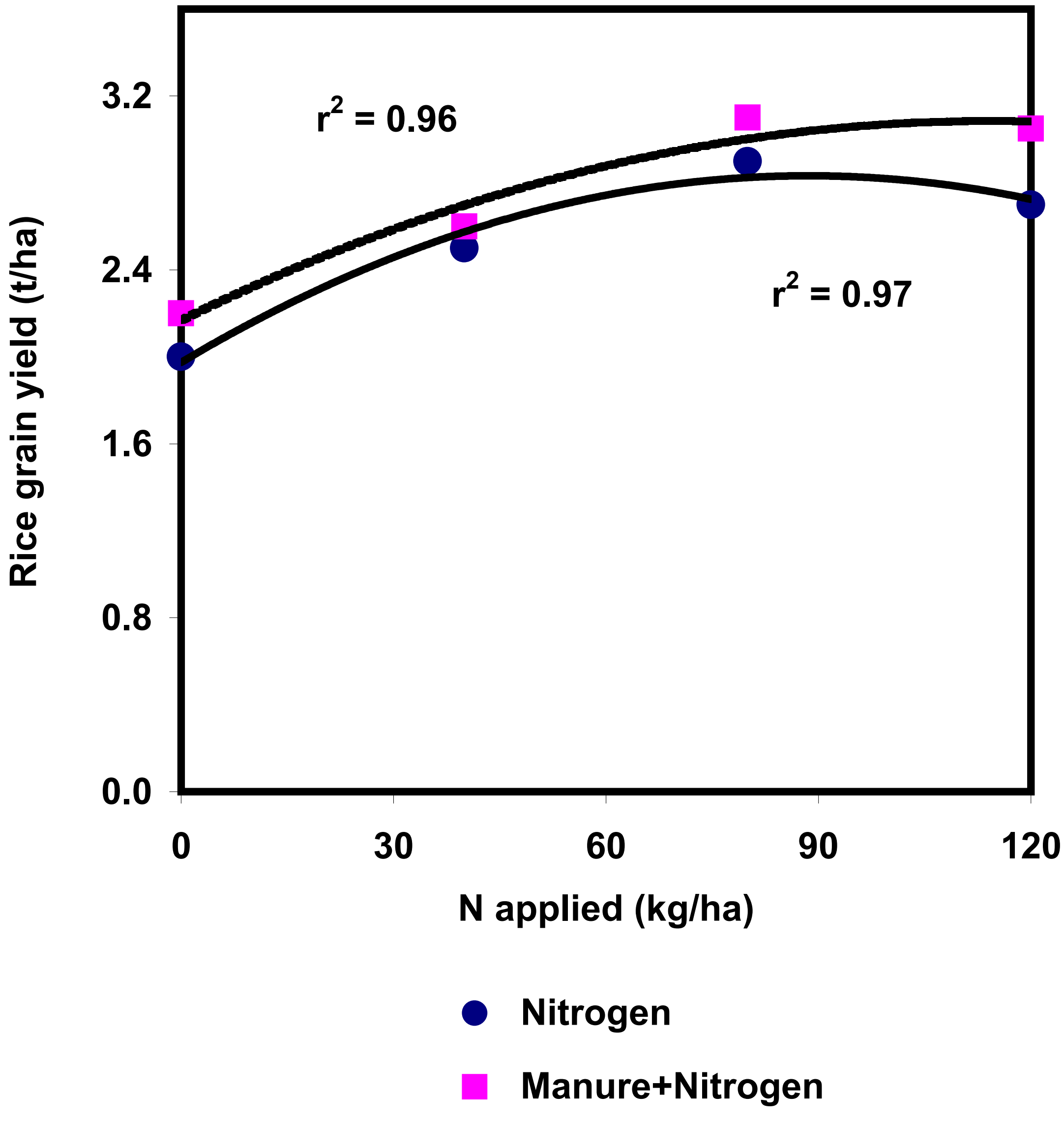


Fig 8. Rice grain yield response to manure and N levels, Kou valley, Burkina Faso, 2001

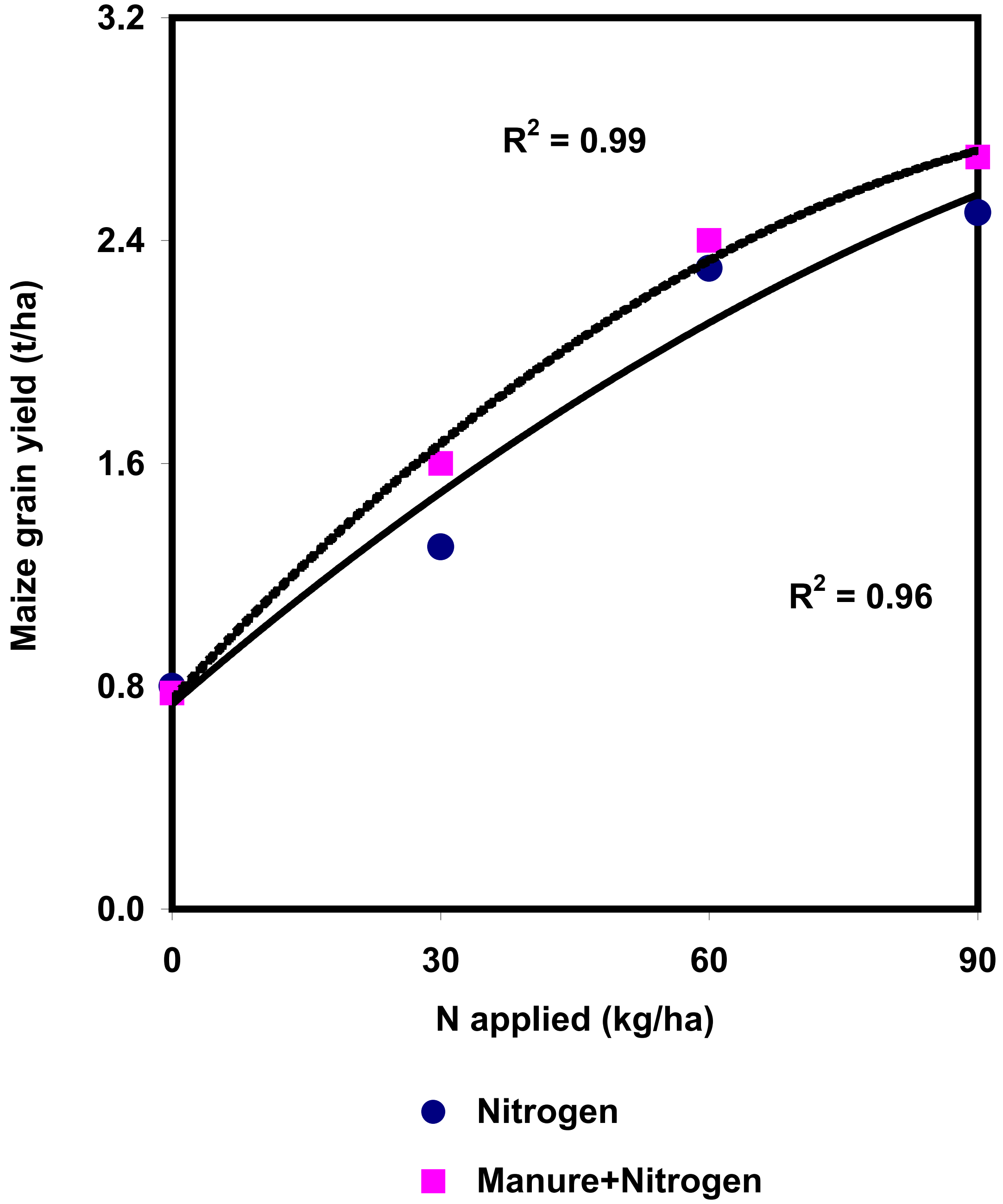


Fig 9. Maize grain yield response to manure and N levels, Zaria, Nigeria, 2001

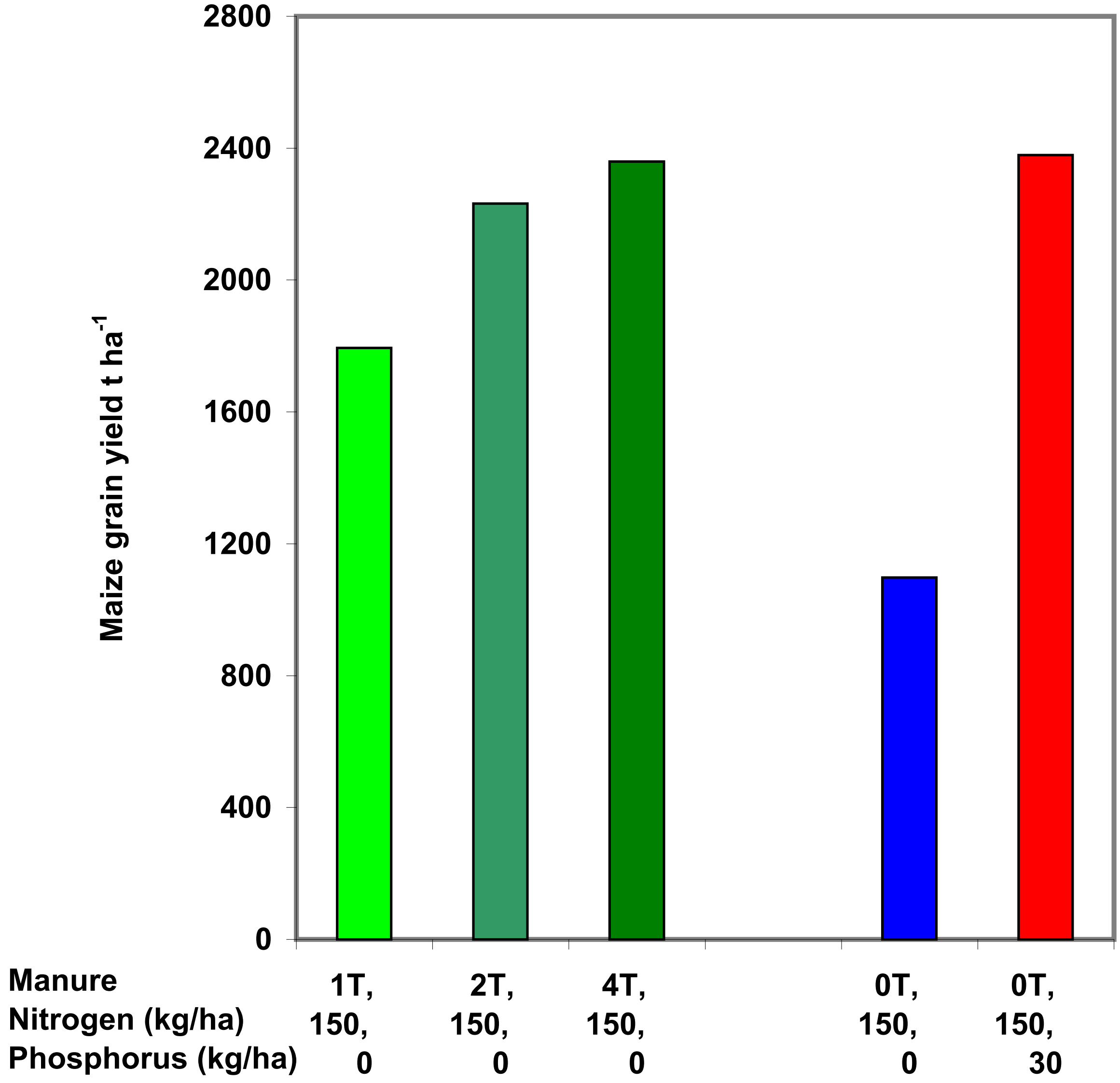


Fig 10. Maize yield response (1st 3 bars) to application of 1, 2 and 4 Tons ha^{-1} of low quality manure (<1%N) showing abilitity of such manures to contribute significantly to alleviating P deficiency to maize crops Zaria, Nigeria, 2001

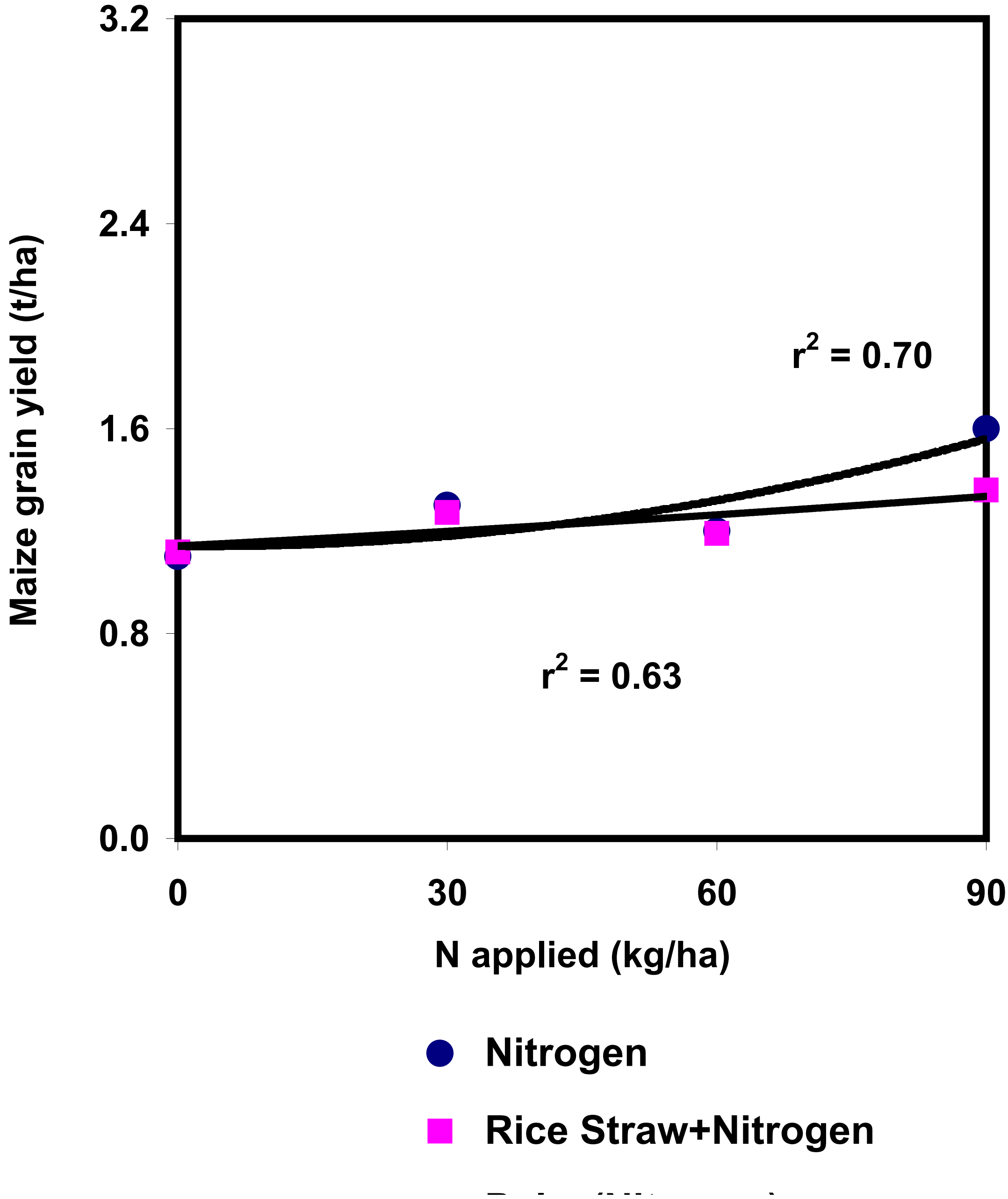
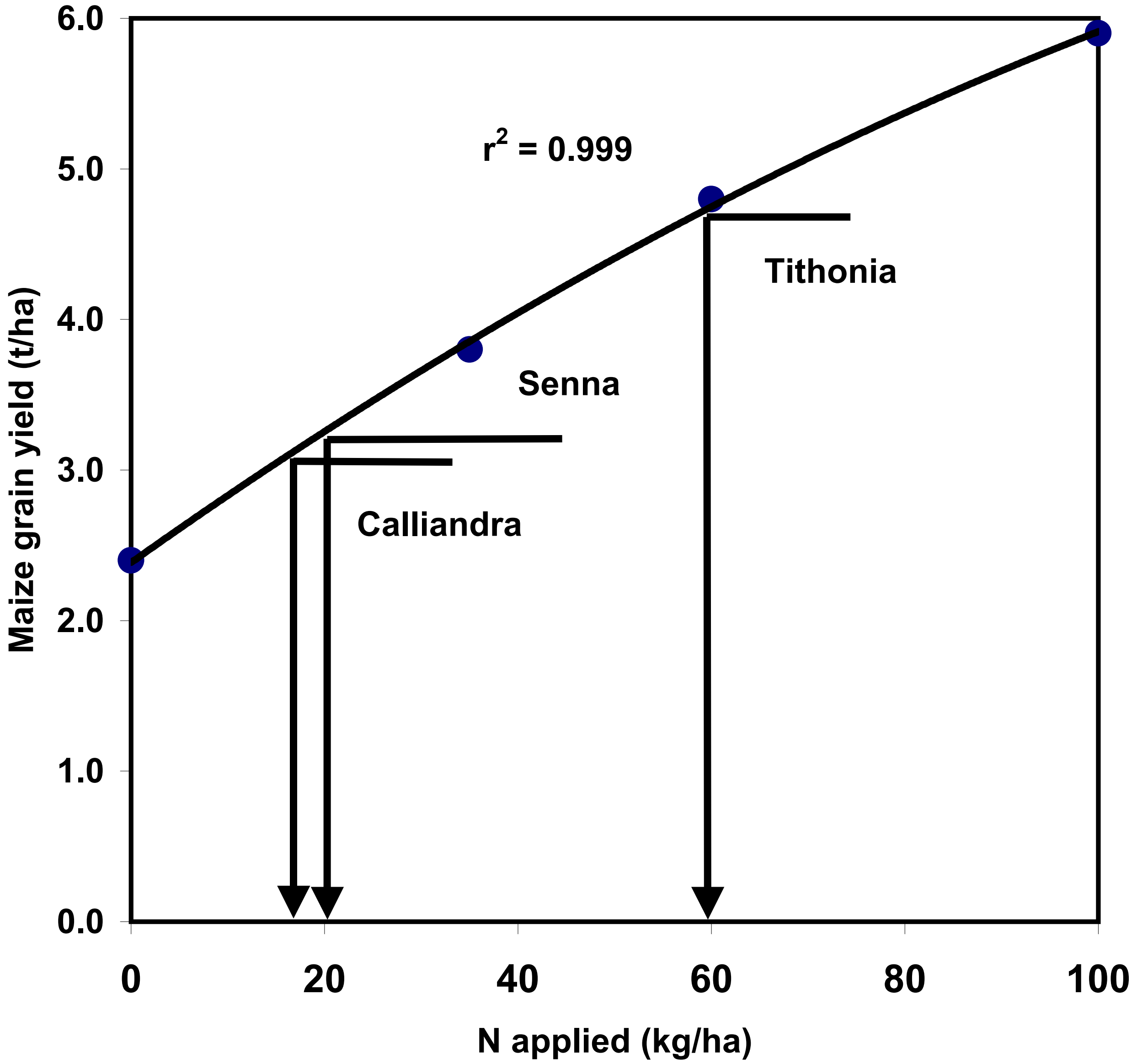


Fig 11: Maize grain yield response to rice straw and N levels, Davie, Togo, 2001



<u>Fertilizer Equivalency</u>

Tithonia = 100% Senna = 43% Calliandra = 38%

Fig 12. Maize response to N application at Kabete, Kenya, 2001.

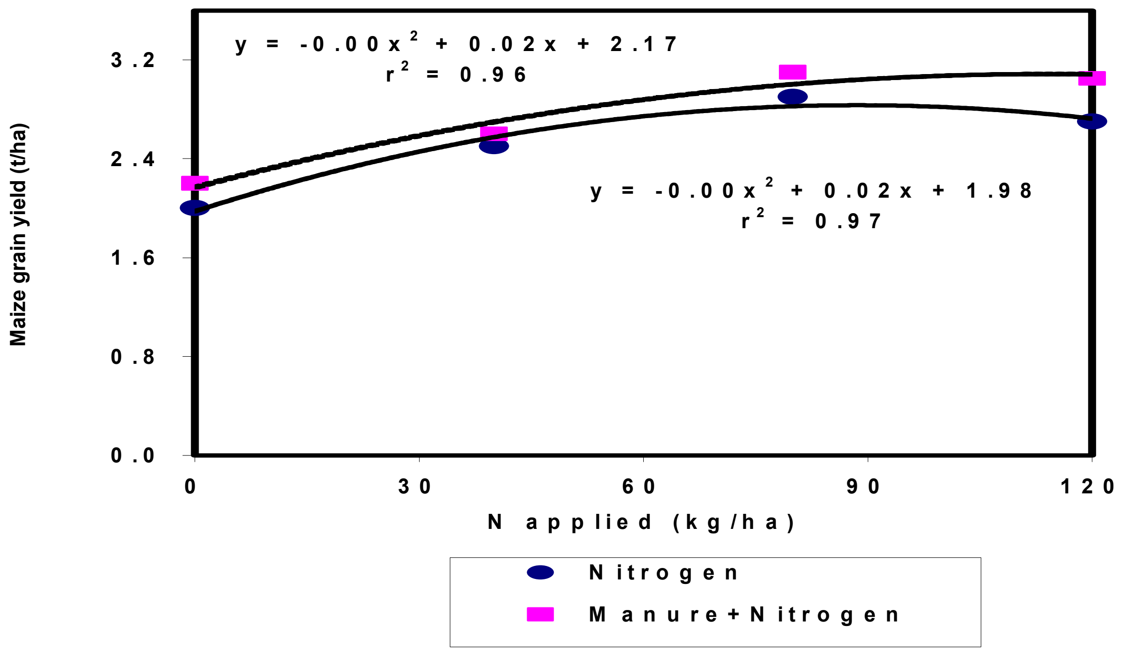
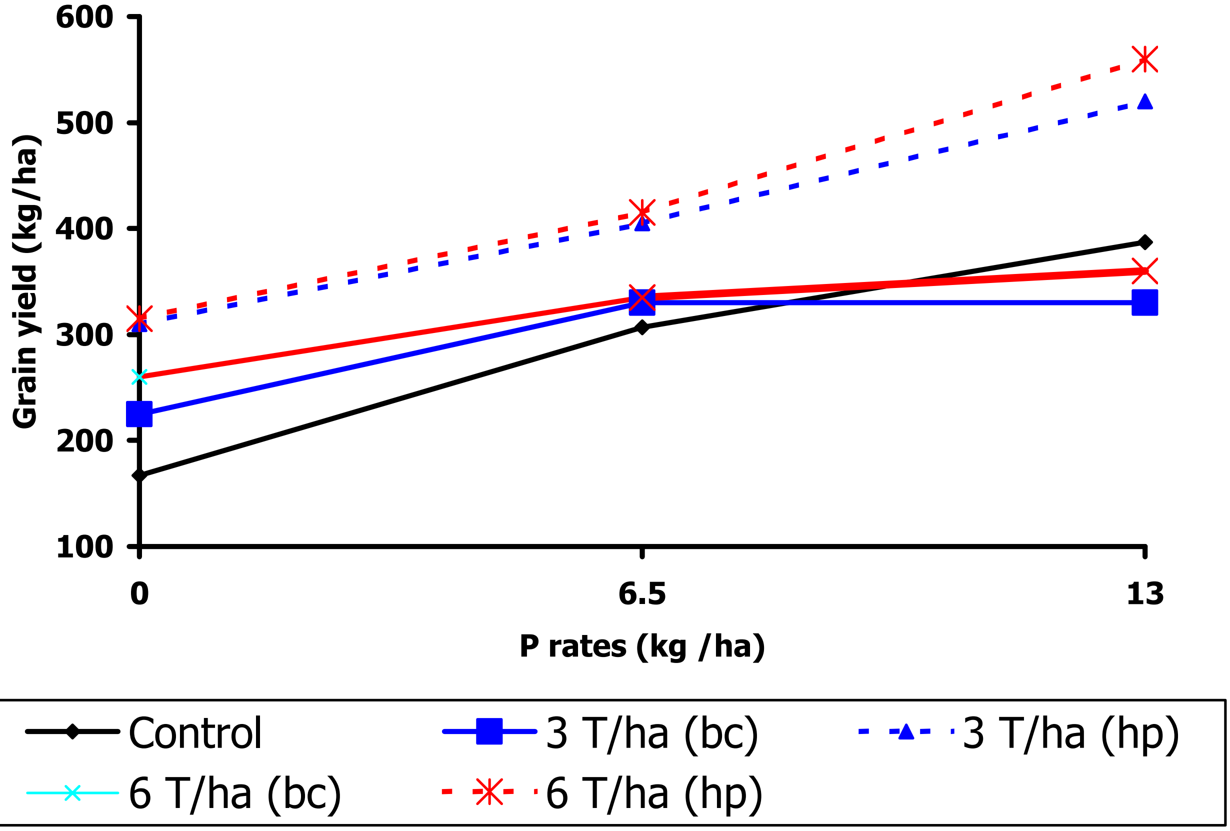


Fig 20. Rice grain yield response to manure and N levels, Kou valley, Burkina Faso, 2001

bc: broadcast
hp: hill placement

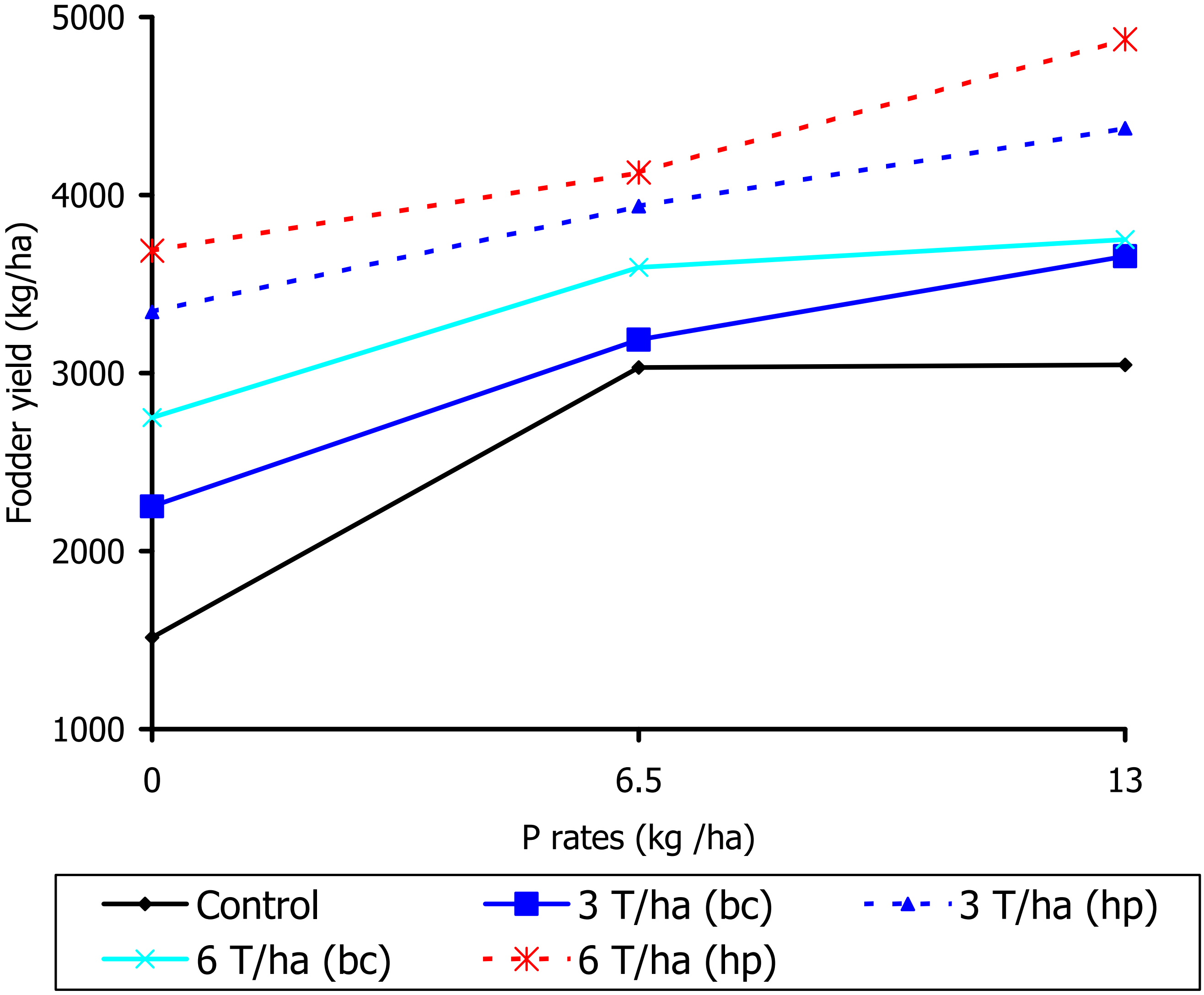
Fig 13. Millet grain yield response to P and manure applied at different rates and methods; Karabedji, Niger, 2001 rainy season.



Bc: broadcast

Hp: hill placement

Fig **14**. Cowpea grain yield response to P and manure applied at different rates and methods; Karabedji, Niger, 2001 rainy season.



Bc: broadcast

Hp: hill placement

Fig **15**. Cowpea fodder response to P and manure applied at different rates and methods; Karabedji, Niger, 2001 rainy season.

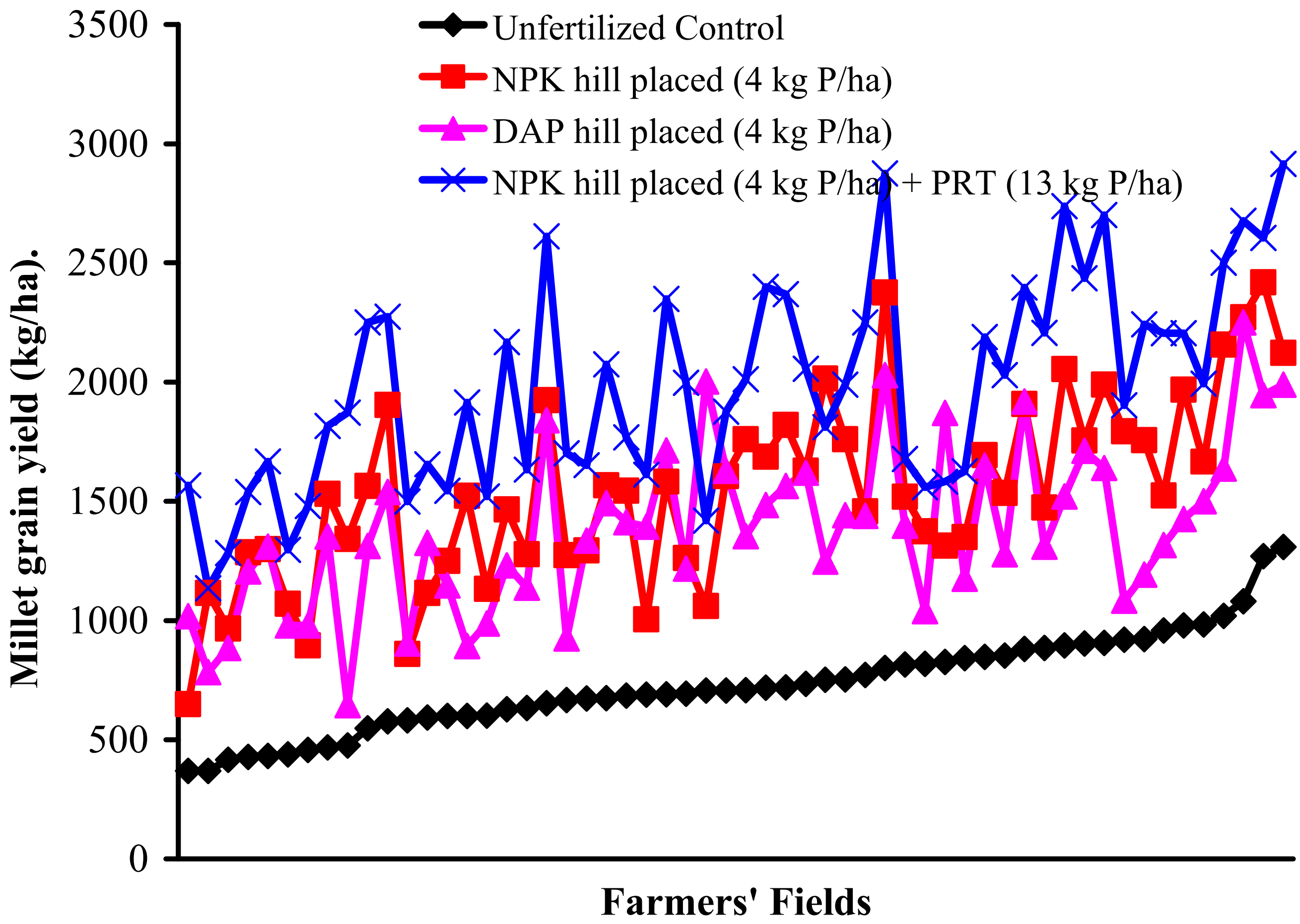


Fig **16**: Millet grain yield responses to hill placed application of different P sources, Karabedji, Niger, 2001 rainy season

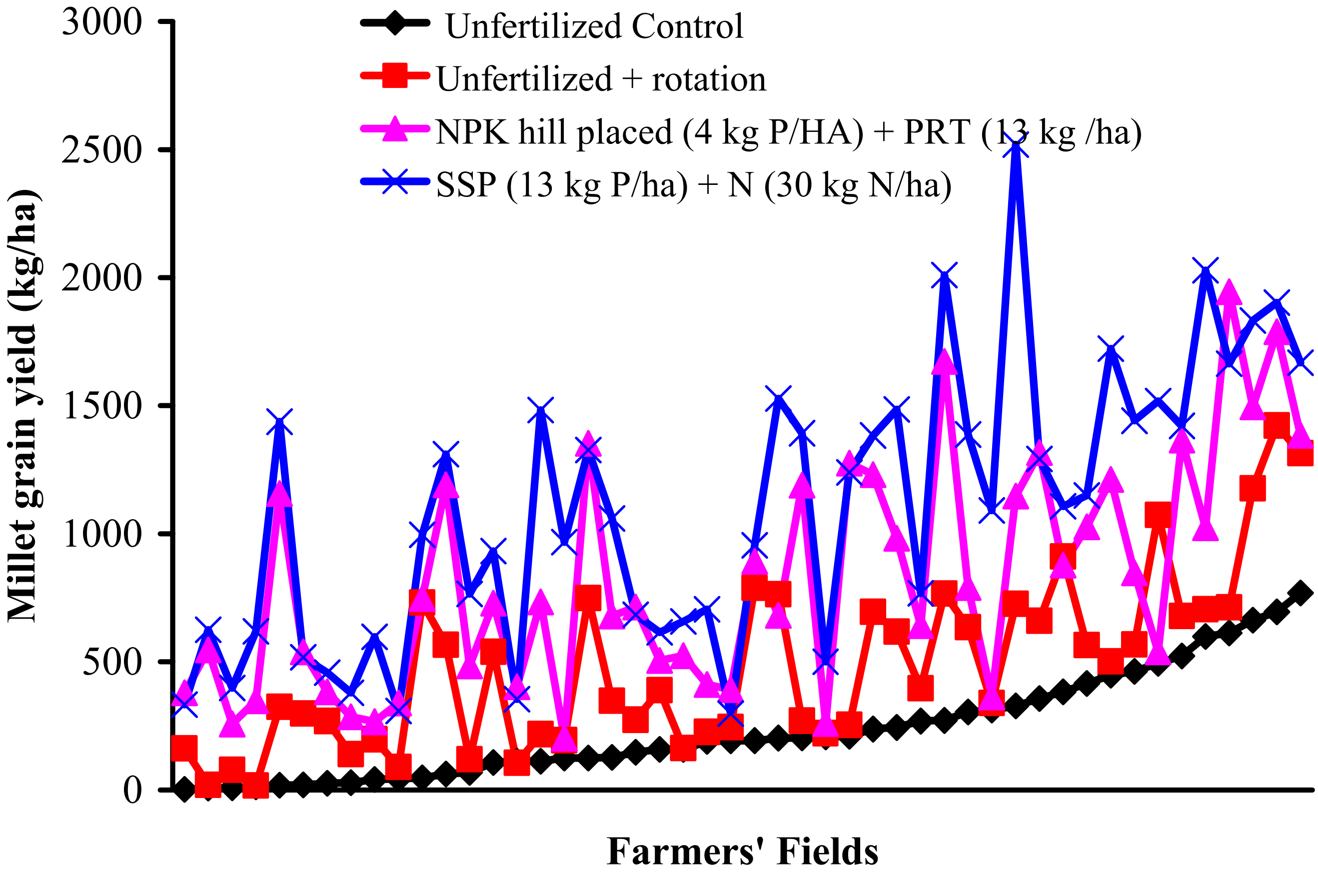


Fig **17**: Millet grain yield responses to different management practices, Sadore, Niger, 2001 rainy season

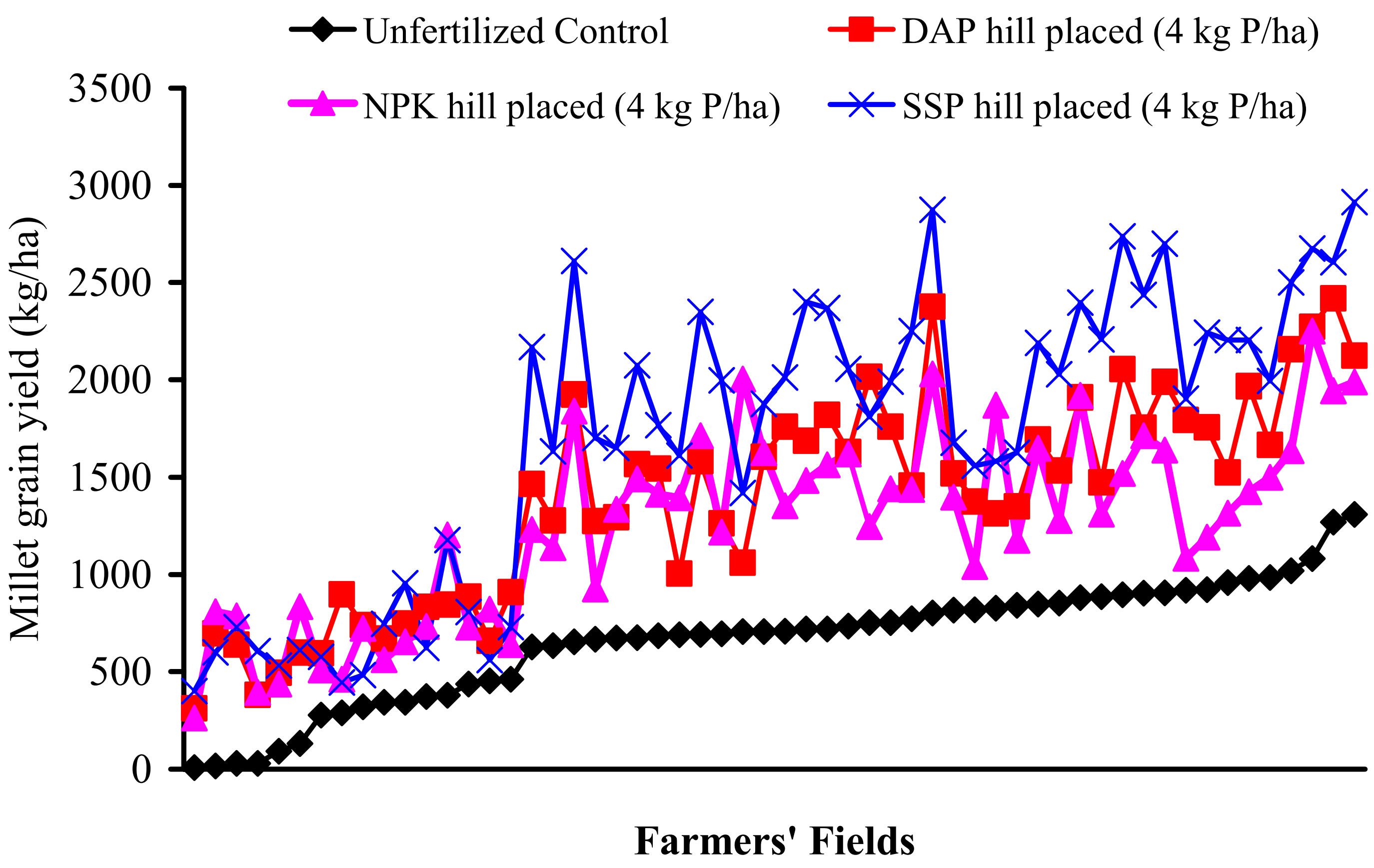


Fig **18**: Millet grain yield responses to hill placed application of different P sources, Sadore, Niger, 2001 rainy season

Nigeria, maize

	Yield		
0	0.8	0.8	0.8
30	1.3	1.6	1.6
60	2.3	2.4	2.4
90	2.5	2.7	2.7

Kenya, maize

	Yield		
0	1.10	1.33	1.33
30	1.70	1.85	1.85
60	1.50	1.68	1.68
90	1.70	1.63	1.63

Togo, maize

	Yield		
0	1.10	1.12	1.12
30	1.30	1.27	1.27
60	1.20	1.19	1.19
90	1.60	1.36	1.36

Burkina, maize

	Yield		
0	1.10	1.30	1.30
30	1.70	1.95	1.95
60	2.30	2.75	2.75
90	2.60	3.05	3.05

	0	30	60	90
Nitrogen	0.8	1.3	2.3	2.5
Manure+Nitrogen	0.8	1.6	2.4	2.7

	0	30	60	90
Nitrogen	1.10	1.70	1.50	1.70
Manure+Nitrogen	1.33	1.85	1.68	1.63

	0	30	60	90
Nitrogen	1.10	1.30	1.20	1.60
Rice Straw+Nitroge	1.12	1.27	1.19	1.36

	0	30	60	90
Nitrogen	1.10	1.70	2.30	2.60
Manure+Nitrogen	1.30	1.95	2.75	3.05

Mali, Rice

	0	30	60	90	120
Nitrogen	4.00	5.60	5.80	6.50	7.00
Manure+Nitrogen	5.00	5.60	6.30	7.80	7.50

Burkina, Rice

	0	40	80	120	
Nitrogen	2.00	2.50	2.90	2.70	
Manure+Nitrogen	2.20	2.60	3.10	3.05	