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Effect of Chickpea-Wheat Rotation on Yield and Soil Productivity

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EXECUTIVE SUMMARY

The purpose of this project is to improve wheat production and sustain soil productivity with minimal use of inorganic fertilizers by incorporating chickpea residue in wheat based cropping system. Both field and laboratory experiments were done during the year covered by this report. ***Field experiment:*** Chickpea was grown between August 2003 and January 2004 as the first crop in the chickpea – wheat rotation program in two locations. Both green manure and mature chickpea residues were harvested and incorporated into the soil. Other measurements included soil water potential and water content at various depths and weather. Problems of weeds and disease (leaf blight) were serious in Njoro site but not in Eldoret site. Wet soil conditions and cool weather characterised the Njoro while dry weather and moist soil conditions persisted in Eldoret site. Our preliminary observations indicate that chickpea yields better under dry weather and moist soil conditions. ***Laboratory experiment:*** Green and mature Chickpea residues were applied to four different soils from Kenya including the two sites of the field experiments. Mineral nitrogen dynamic in the control and treated soils in constant temperature of 30°C was observed. Green residues enhanced mineral concentration in the soil relative to the control soils whereas application of mature residues decreased mineral N concentration in the soil. These preliminary observations will be used for planning more detailed laboratory study of N dynamic in soils amended with green and mature chickpea residues.

SECTION I

A) Research Objectives

1. Determine and establish the effectiveness and efficiency of chickpea residue incorporation and N and P inorganic fertilisers on wheat yield and N content in grain and straw.
2. Determine and quantify the effects of chickpea residue incorporation on soil available N, soil microbial biomass and residual N and P in soils.
3. Use computer models to predict long-term effects of different environmental conditions and management methods on the content of mineral and organic N in soil profile, soil organic matter, N and water uptake and consequent crop yield.

B) Research Accomplishments

Field Experiment: Some soil physical and chemical properties at the experimental sites are shown in Table 1. The soil texture in both locations was clay but the CEC in Njoro was almost twice that of Eldoret. Organic matter was about 30% more in Njoro compared to that in Eldoret site.

Table 1. Some soil physical and chemical properties at the experimental sites

Soil		Mechanical Composition, gkg^{-1}			CEC	Organic Matter	Available N	P	K
Location	Taxonomy	Sand	Silt	Clay	$cmol_c kg^{-1}$	gkg^{-1}	$mgkg^{-1}$		
Njoro	Haplustalf	319	340	341	25.6	37.3	16.07	7.31	130
Eldoret	Rhodox	260	140	600	12.3	27.3	6.02	5.48	50

Table 2 shows the biomass yield of the chickpea green manure and the mature dry residue. Both the green manure and the mature dry residue were about 3 times more in Njoro compared to Eldoret site. In general the yields were lower than those reported in the literature probably due to the observed dry weather in Eldoret and the cool weather in Njoro. Moreover there was a serious disease attack in Njoro.

Table 2. Dry matter yield of the chickpea at flowering and maturity at the two sites.

Location	Green manure	Straw	Grain
	Mgha^{-1}		
Njoro	1.43	1.11	0.01
Eldoret	0.42	0.36	0.26

Figure 1 shows the changes in soil water potential and the volumetric water content in the soil profile at 35cm during the growing season. Njoro site was wet and Eldoret site was moist.

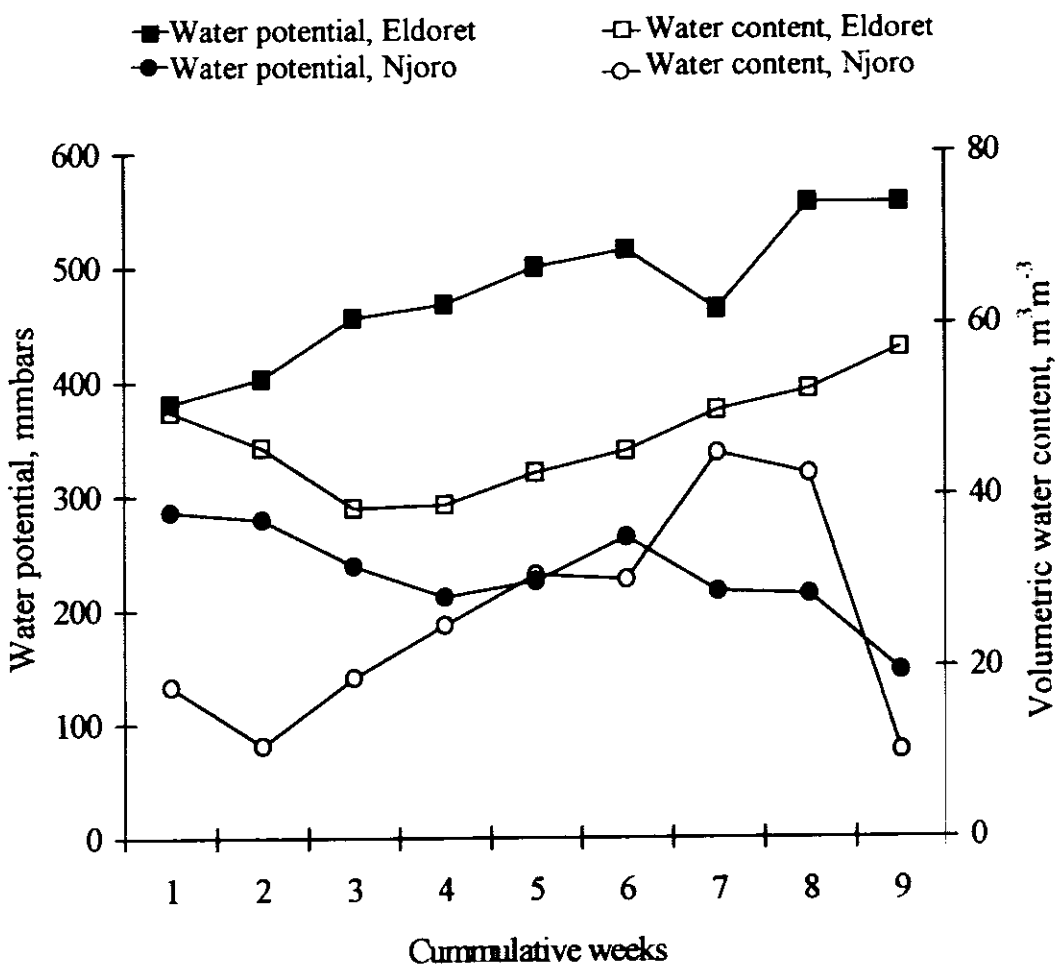

Figure 1. Weekly soil water potential and water content in the control treatment for the two sites.

Table 3 shows the nutrient content of chickpea green manure and mature dry residue that was incorporated into soil.

Table 3. Nutrient content of chickpea green manure and mature residue.

	N	P	K
		%	
Green Manure	1.2	0.1	1.5
Dry Residue	1.4	0.1	2.1

Laboratory Experiment:

A short incubation experiment with four soils from Kenya and two chickpea residues was carried out in order to estimate the amount and rate of N release from chickpea residues. These data will be used to plan more detailed experiments with different rates of residue amendments and to determine the required time intervals for measurements. The green material was obtained by growing chickpea in pots for several weeks until flowering. The mature straw of chickpea was harvested from a field in Israel at ripe grain stage and the grains were removed from the straw. Both residues were oven dried at 60°C temperature and grind before mineral analysis and application to the soils. The mineral analysis of the two residues is presented in Table 4.

Table 4. Nutrient content of chickpea green manure and mature residue in the laboratory experiment in Israel.

	N	P	K
		%	
Green Manure	3.98	0.50	3.20
Dry Residue	0.78	0.31	2.20

Two of the soils used for the laboratory experiments were taken from the Njoro and Eldoret sites and additional two soils from Molo and Rongai. All these soils are acid or slightly acid, containing Kaolinite as the main clay mineral and amorphous minerals and metal oxides as the main components of their clay fraction. The list of the soils is given in Table 5.

Table 5. Some relevant characteristics of the soil used in the laboratory experiment in Israel.

Soil Site	Definition[&]	WHC*	Inorganic N	
			$N\text{-}NO_3$	$N\text{-}NH_4$
		%	mg kg^{-1}	
Njoro	Mollisols	23	1.39	44.12
Eldoret	Rhodic Ferralsols	21	1.02	10.80
Molo	Mollic Andosols	27	0.45	13.51
Rongai	Ferric Andosols	23	0.56	7.28

& Definition - Soil survey staff, 1982

*WHC - Water holding capacity

Twelve 2-l glass jars (156 cm^2 x 12.8 cm) were used for the four soils X three treatments, control, green and mature residues. In each jar a mixture of 100 g of soil and 2 g dry residue was prepared. The soil was wetted with distilled water to reach its water-holding capacity (WHC). The WHC had been determined previously by equilibrating saturated soil samples placed on a dry soil for 48 h. Then the jars were covered with a polyethylene film with a few needle holes, in order to reduce water losses but to allow gas exchange, and were placed in an incubation chamber at 30°C. The incubation experiment lasted 56 d. The soil water content was kept at WHC by two irrigations per week, calibrated according to loss of weight. Mineral N concentration was determined periodically throughout the 56 days of incubation by sampling 3 g of soil. Soil samples were extracted in 1:5 1M KCl and tested for ammonium and nitrate with the Lachat Autoanalyzer.

The results of inorganic N (extractable nitrate and ammonium) accumulation are presented in Fig. 2. In all soils the application of mature chickpea straw caused a decrease in the amount of inorganic N relative to control soils. The inorganic N decreased sharply in the first week following the residue application indicating N immobilization. Only in the Molisol soil a net mineralization was observed from 4 weeks following the application and on. In this soil also the accumulation of inorganic N in the control was the fastest among the control soils, about 150 mg N kg-1 soil was released in incubation period of 56 days. The application of green chickpea resulted in a fast release of inorganic N in the four soils, about 400 mg N kg-1 soil was released in two weeks and the inorganic N continued to

accumulate in much slowlier rate, about 100 to 200 mg N kg-1 soil in the following four weeks.

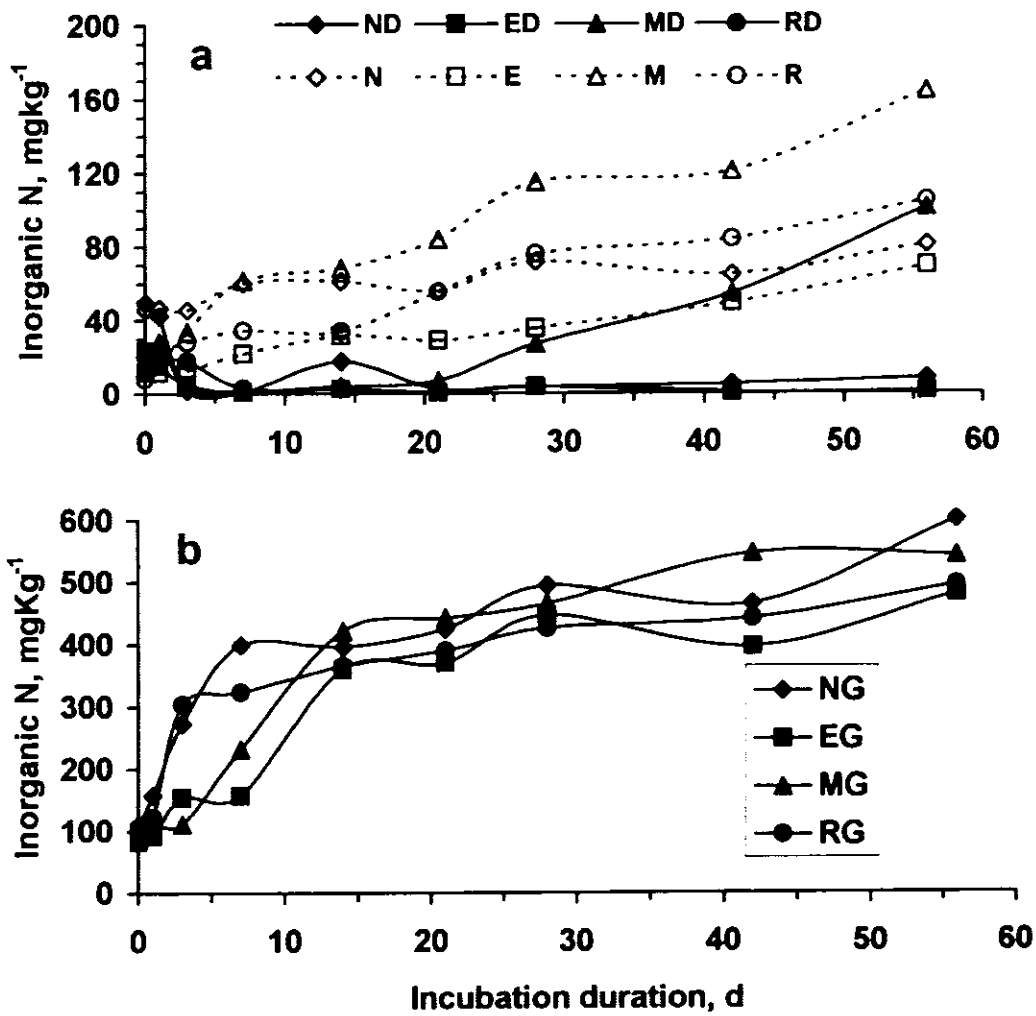

Fig. 2. The dynamics of inorganic N in four soils from Kenya in incubation study at 30°C a. control soils and amended with residue of mature chickpea plants and b. soils amended with residues of green chickpea plants. The letters N, E, M and R stand for the soils from Njoro, Eldoret, Molo and Rongai, respectively. D and G stand for mature dry straw and the young green residues, respectively.

C) Scientific Impact of Collaboration

Dr. Wakindiki visited Israel for 6 months to training on NCSOIL computer model under the guidance of Dr. Bar-Tal. Meanwhile Dr. Ouma recruited three graduate students and organised field experiment in Kenya.

D) Description of Project Impact

The wheat growers in Kenya and in other developing countries will use the results obtained from this study to sustain soil use, reduce wheat imports and boost their economies. The results will be published in journals for the wider scientific community.

E) Strengthening of Developing Country Institution

Egerton University acquired an incubator, autoclave, heating mantle and a computer. Three graduate students were recruited and Dr Wakindiki was trained on the NCSOIL model in Israel.

F) Future Work

The work is on schedule. About 25% of the work has been accomplished. Both fieldwork and laboratory work will continue. Israeli scientists will visit Kenya in summer and the PhD student will travel to Israel in summer to train for one year.

SECTION II

A) Managerial Issues

The Co- Principal Investigator Prof. Benson Mochoge did not resume duty at Egerton University as expected. He will not be available until after 2006. Therefore Dr Isaiah I.C. Wakindiki who has been acting instead is now the Co-Principal Investigator.

B) Budget

None

C) Special Concerns

None

D) Collaboration, Travel, training and Publications

Dr. I. Wakindiki from Kenya was in Israel from 17th July to 26th December 2003. He was training on the NCSOIL model with guidance from Dr. A. Bar-Tal.

E) Request for American Embassy Tel Aviv or AID Actions

None