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# Grain Yield Response of Sorghum (Sorghum bicolor) to Tied Ridges and Planting Methods on Entisols and Vertisols of Alemaya Area, Eastern Ethiopian Highlands

**Heluf Gebrekidan**[*1]

**Abstract**

Field experiments were conducted under rain-fed conditions between 1986 and 1995 to investigate the effects of soil and water conservation treatments (tied ridges and planting methods) on the yield of an improved sorghum variety (ETS-2752) grown with and without $N$ and $P$ fertilizers on two major soils of Alemaya area, eastern Ethiopian highlands. The yield responded significantly ($P \leq 0.01$) to the treatments both under fertilized and unfertilized conditions of the soils studied. However, the magnitude of the yield response and the relative efficiency of the tied ridges and planting methods varied with soil type, fertilization, and total rainfall and its distribution during the cropping season. Regardless of the type of tied ridge used, furrow planting, specifically, closed end tied ridge planting in furrows gave the highest yield in three of the four sets of experiments. Flat bed planting produced the lowest grain yields on all sets of experiments except under the unfertilized condition of Entisols in which open end planting on ridges produced the lowest sorghum yield. Within the tied ridges, closed end performed better than open end in all except the Vertisols without $N$ and $P$ fertilizers. Compared with the traditional (flat bed) planting method, the highest yield increment of 1361 kg/ha (34.5%) due to tied ridges was obtained on the Entisols with NP followed by 1255 kg/ha (48.5%) on the Alemaya black clay soils (Vertisols) under fertilized condition, indicating that the yield response to water conservation treatments was higher under fertilized than under unfertilized conditions on the two soils. Fertilization increased the yield of sorghum by as high as 1576 kg/ha (69.5%) on Vertisols and by 1468 kg/ha (38.3%) on Entisols both from planting in the furrows of closed end tied ridges. The study also revealed that the yield response was higher in seasons with low or poorly distributed rains and on shallow and coarse textured soils. The results indicate that in areas with low and erratic rainfall such as the Alemaya area, soil and water conservation is indispensable for increasing crop yield.

**Keywords:** Entisols, Flat bed planting, Furrow planting, NP fertilizer, Ridge planting, Tied ridge, Vertisols

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## 1 Introduction

Periodic low soil moisture due to erratic and poorly distributed rainfall, severe soil erosion and runoff loss of water and the resultant low soil fertility are the prominent causes for the low agricultural productivity in the Ethiopian highlands (>1500 meters above sea level (masl) which form 46% of the total land area and where over 95% of the regularly cropped lands are found (Tamirie Hawando, 1986; Heluf Gebrekidan and Yohannes Uloro, 2002). Accordingly, about 50% (27 million ha) of the highlands are significantly eroded, 25% (13.5 million ha) seriously eroded and over 4% of the former farmlands are severely eroded and converted to rock outcrops (EHRS (Ethiopian Highlands Reclamation Study), 1984). The rates of annual loss of soil due to erosion for Ethiopia vary from almost zero on lowland grasslands to over 200 tons/hectare/year (t/ha/yr) on steep slopes of the highlands cultivated with erosion promoting crops such as maize or sorghum (Getachew Teklemedhin, 1998). In addition to accelerated soil erosion and the alarming rate of land degradation, the loss of water as runoff coupled with periodic drought during the cropping season on degraded lands supporting rain-fed crop production was also equally important (Tamirie Hawando, 1986; Asfaw Belay *et al.*, 1998; Heluf Gebrekidan and Yohannes Uloro, 2002).

These problems are mainly attributed to the inadequate efforts and absence of technologies proved to conserve the soil and water resources, the consequence of which is the need to increase productivity on limited and marginal land and water resources. Soil and water conservation is called upon to alleviate both the problems of erosion and drought which are symptoms of two different extremes of rainfall conditions. As rainfall erosivity, soil erodibility and landform are inherent properties of climate, soil and land, respectively, only little can be done to modify their effects appreciably. Therefore, control of soil erosion and runoff water depends on judicious soil and crop management practices (Lal, 1977a,b; Hudson, 1977). The practice of judicial water conservation undoubtedly plays a significant role in increasing agricultural production in arid, semi arid and sub-humid areas where agriculture is hampered by periodic droughts and low soil fertility (Tamirie Hawando, 1986; Heluf Gebrekidan, 1989; Heluf Gebrekidan and Yohannes Uloro, 2002).

Soil or land management practices to reduce soil loss and runoff to negligible amounts are usually based on a combination of practices which help to maintain soil infiltration rates at sufficiently high levels and on measures which help safe disposal of runoff water from the field, should rainfall exceeds the infiltration capacity of the soil (Lal, 1977a). Cultural practices, which maintain a high soil infiltration rate and feasible in cultivated lands are essentially based on farming techniques, which maintain a mulch or live vegetation (stubble mulching and no- or minimum-tillage and use of cover crops) on the soil. The safe disposal of runoff may involve physical manipulation of soil including land shaping, contour bunds, terraces, waterways and ridges. However, although the methods of conservation may be either known or could be predicted, more local and/or regional level studies are justified for their demonstrative values (Lal, 1977a; Hudson, 1977).

An erosion-promoting crop such as sorghum can be grown without causing serious soil erosion provided that proper soil and water conservation techniques are used than a soil-conserving crop grown with erosion-promoting practices (AINA *et al.*, 1976; LAL, 1977a,b). AINA *et al.* (1976) observed 221 t/ha/yr of soil loss and 30% of runoff from monoculture cassava, and a soil loss of 137 t/ha/yr and runoff of 19% from Nigerian Alfisols on 15% slope in a cassava-maize mixed cropping system. Management of crop residues on the farm lands increased the grain yields of maize, sorghum and wheat crops both by improving soil fertility and conserving water on the two major soils of Alemaya area that are used in the present study (HELUF GEBREKIDAN, 1989; ASFAW BELAY *et al.*, 1997, 1998; HELUF GEBREKIDAN *et al.*, 1999; HELUF GEBREKIDAN and YOHANNES ULORO, 2002). LAL (1977b)Lal observed a runoff of 1.2% and a soil loss of 0.05 t/ha with mulch at a rate of 6 t/ha and a runoff water of 50% and a soil loss of 4.83 t/ha without mulch.

Although the economic variability, availability of labor and the social factors involved in getting widespread acceptance of suitable methods for a specific region require much more attention, mechanical measures in controlling soil erosion are well studied (KOWAL, 1970a,b; MACARTNEY *et al.*, 1971; MOLDENHAUER and ONSTAND, 1977; FAUCK, 1977; HELUF GEBREKIDAN and YOHANNES ULORO, 2002; ASFAW BELAY *et al.*, 1998). Among these, tied ridging is an effective practice particularly in lands with slopes less than 3-4% and by adding terrace on steeper slopes (MOLDENHAUER and ONSTAND, 1977) in increasing crop yields by increasing the time for the water to penetrate into the soil. PHILIPS and YOUNG JR. (1973) showed zero to 40% increases in maize yield for no tillage sod planting over the conventional plow-disk-harrow system. HELUF GEBREKIDAN and YOHANNES ULORO (2002) observed maize yield increments of 15 to 50% due to tied ridges on the soils reported in this paper and 15 to 38% for sorghum on different soil types of eastern Ethiopia. KOWAL (1970a,b) reported that ridges that are not tied at intervals were not effective in controlling runoff and soil loss in the Savannah region of northern Nigeria. In Upper Volta, tied ridges led to only 0.9% runoff as compared to 6.3% with open graded ridges and 12.2% in the case of flat cultivation (FOURNIER, 1967).

Proper mechanical soil and water conservation schemes increased maize and sorghum yield by 700-3400 kg/ha in the eastern Ethiopian highlands (TAMIRIE HAWANDO, 1986; TAMIRIE HAWANDO *et al.*, 1986; ASFAW BELAY *et al.*, 1998; HELUF GEBREKIDAN and YOHANNES ULORO, 2002). ASFAW BELAY *et al.* (1998) reported maximum maize yield increases of 10, 18 and 23% on Entisols and 54, 35 and 26% on Vertisols of eastern Ethiopia, with crop residue, with residual NP and with both crop residue and residual NP, respectively, due to the combinations of tied ridges and furrow planting over flat planting. Thus, the efficiency of the physical soil and water conservation techniques depends on the soil type, climate, the crop grown and the cropping methods followed.

However, despite the significance of the problems of soil erosion and drought in the Ethiopian highlands, research aimed at generating soil and water conservation techniques and farming practices that reduce soil erosion and harvest rain water for use by plants, on cultivated lands in the country, is inadequate. Therefore, the present studies were initiated to evaluate the relative efficiency and effectiveness of tied ridges and planting methods and their interaction on sorghum yield on Entisols and Vertisols of Alemaya area both under fertilized and unfertilized conditions. Such information is particularly scanty for the Alemaya region of eastern Ethiopian highlands.

## 2 Materials and methods

### 2.1 Site description

Four sets of field experiments were conducted between 1986 and 1995 both on fertilized and unfertilized conditions on Entisols and Vertisols of Alemaya area, eastern Ethiopian highlands at the Alemaya University Research Station. The Research Station is located at 9° 26' N latitude, 42° 2' E longitude and an altitude of 1970-1980 masl. The area is characterized by low and highly variable rainfall requiring a thorough understanding of the climate if increased and sustained crop production with the use of improved farming technologies is to be realized. The average monthly rainfall (1979-1994) for these highlands revealed a bi-modal pattern with small rains in March-May and big rains in July-September. The long-term total annual rainfall at the study area indicates the occurrence of rainfall fluctuation from year to year and displays a decreasing trend over the years. Hence, the yearly mean rainfalls at the site were 807 mm for 1957-1994 and 774 mm for 1979-1994 (Alemaya University of Agriculture, 1998). The average annual potential evapotranspiration (PET) is 1427 mm. Rainfall is greater than PET only for about 45 days (in July and August) in a given year. The long term mean annual, mean monthly minimum and mean monthly maximum temperatures at Alemaya are 16.9, 10.0 and 23.5°C, respectively (Alemaya University of Agriculture, 1998). Entisols and Vertisols are the major agricultural soils in the area. Attributed to continuous nutrient depletion resulting from intense soil erosion, cereal mono-cropping, complete removal of crop residues and very low mineral and organic fertilizer use, both soils are poor in fertility. Formed in situ (residual) mostly on truncated erosional surfaces (eroded phase) on landscapes with slopes of 3 to 15% or greater and covering 50 to 65% of the total land area in the Alemaya region, the Entisols are reddish brown in color, sandy loam to sandy clay loam in texture and very shallow in depth, with the combined thickness of the A and AC horizons ranging from 30 to 40 cm. They are low in organic matter (1.5-2.0%), total $N$ (0.08-0.11%), Olsen extractable $P$ (6.9 mg/kg) and cation exchange capacity (Eylachew Zewdie, 1994). As a result of these and other factors, the Entisols are unproductive unless supplied with considerably high amounts of mineral fertilizers, especially $N$.

The Vertisol (Alemaya black clay) meets the requirements of depth, cracking, intersecting slickensides, churning or argillipedoturbation and other characteristics to be classified as Typic Pellusterts (Eylachew Zewdie, 1994). This soil occurs on slopes ranging from 0-3% mostly on valley bottoms and plateaus in the region. It is clayey ($>$ 50% clay to a depth of 2m) in texture, has low permeability, high $P$ retention capacity and presents very hard physical conditions for the plant roots to develop and to work with both when dry and wet. It is very droughty and produces only little sorghum or maize crop yield if rainfall during the cropping season is less than 600 mm (Tamirie

Hawando, 1986; Heluf Gebrekidan and Yohannes Uloro, 2002). The $N$ level of this soil is moderate ranging from 0.1 to 0.2%, $K$ and $P$ contents are fairly low but CEC is high and $Ca$ and $Mg$ are abundant (Eylachew Zewdie, 1994). Generally, unless properly managed, the comparative capacity of this soil for the production of food crops is low in most years.

### 2.2 Experimental Design and Procedure

Field experiments were conducted on Entisols (Typic Ustorthents) and Vertisols (Typic Pellusterts) at the Alemaya University Research Station to investigate the effects of soil and water conservation (tied ridges and planting methods) treatments on the yield of sorghum. The field experiments on both soil types were conducted one without and another with the application of recommended rates of $N$ and $P$ fertilizers side by side. Throughout the study period, each experiment was laid down in a randomized complete block design with four replications. The treatments considered were (a) flat bed planting (control); (b) open end tied ridge, planting on ridges; (c) open end tied ridge, planting in furrows; (d) closed end tied ridge, planting on ridges; and (e) closed end tied ridge, planting in furrows (Fig. 1).

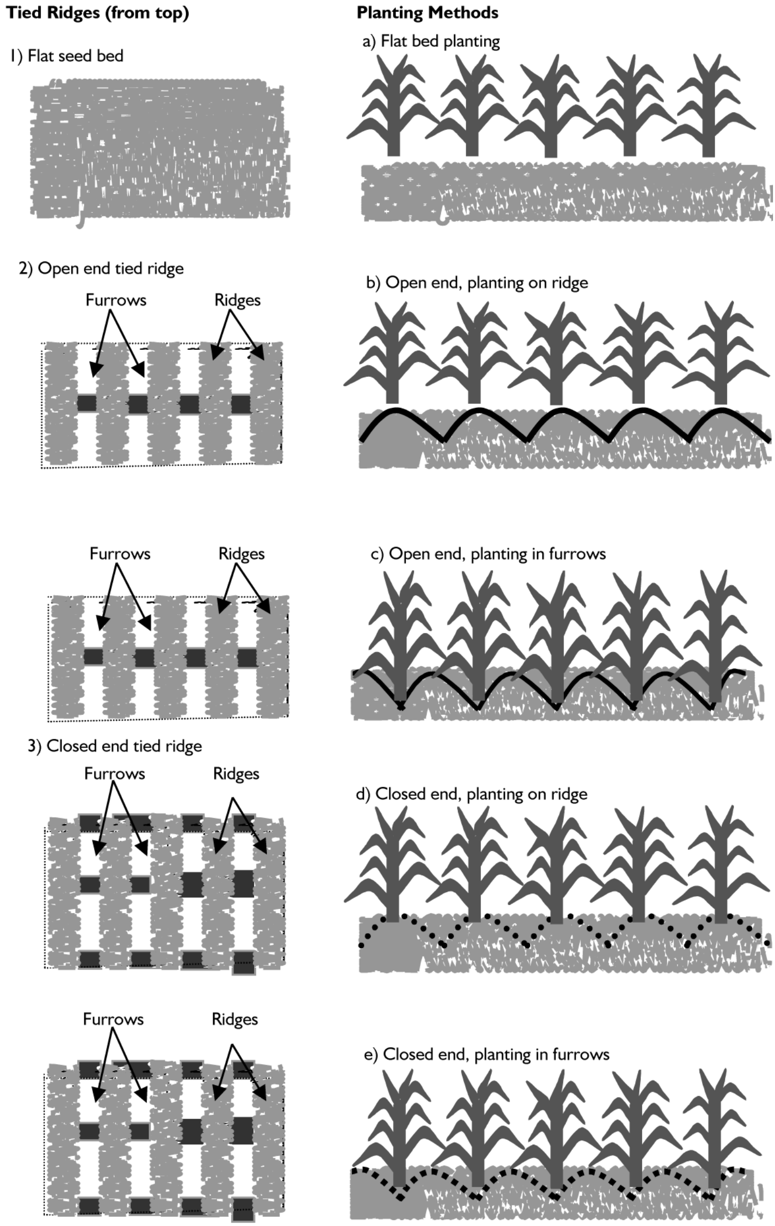
The improved sorghum variety ETS-2752 was used as a test crop on all of the four sets of trials whereby planting was made at the onset of the short rains in April on which a dry spell occurs in June several weeks after the establishment of the seedlings. Each set of experiment was conducted for six to eight seasons between 1986 and 1995. The crop was planted on a plot size of 4.5m x 4.5m (20.25m$^2$) in rows of six per plot at a spacing of 75 by 25 cm. The rates of fertilizers applied for the crop on the plots of the fertilized set of trial on the Entisols were 138 kg $N$ and 30 kg $P$/ha, and 92 kg $N$ and 40 kg $P$/ha on the Vertisols. Half of the rate of $N$ and the full rate of the $P$ fertilizers were applied 5 cm below the seed at time of planting as urea (46% $N$) and as triple super phosphate or TSP (20% $P$), respectively. Whereas the second half of the $N$ fertilizer was applied 30-40 days after planting at 7-10 cm away from the plant as two side dressing at about 5 cm below the surface. Grain yields and all other desirable data and samples were collected from the four central rows of each plot. Apart from grain yield data, total above ground biomass, agronomic characters and soil samples at 0-25 and 25-50cm depths (for soil moisture and NP determinations) were also collected from each treatment and used in interpreting the grain yield data. The mean yield data were subject to statistical analysis using MSTAT computer software appropriate to the design and significantly differing treatment means were separated using the least significant difference (LSD) test.

## 3 Results an discussion

### 3.1 Sorghum Grain Yields on Entisols without $NP$ Fertilizers

The average grain yield (1986-1995) data of sorghum (ETS-2752) produced under rain-fed conditions without NP fertilizers on Entisols as influenced by tied ridges and planting methods are depicted in Table 1. The mean grain yield of sorghum was significantly different ($P \leq 0.01$) due to the effects of soil and water conservation (tied ridge and

**Figure 1:** Sketch diagram of the different tied ridges and planting methods used in the study.



planting method) treatments. Among the treatments considered in the study, planting in the furrows of closed end tide ridge produced the highest sorghum grain yield (3836 kg/ha) followed by open end tied ridge, planting in furrows (3559 kg/ha). However, there was no significant difference ($P > 0.01$) between the yields produced on the furrows of closed end and furrows of open end tied ridges and between the yields produced on open end planting in furrows and closed end planting on ridges (Table 1).

The lowest sorghum grain yield (3026 kg/ha), among the treatments considered in the study, was obtained when the crop was planted on the ridges of open end tied ridge (Table 1). However, the mean yield due to this low yielding treatment did not significantly differ from the yield produced on the flat bed planting treatment. In general, the maximum increments in yield of sorghum obtained due to tied ridge and planting method treatments were 675 and 810 kg/ha over the traditional (flat bed) planting and over the least effective water conservation technique. Regardless of the type of the tied ridge used, furrow planting methods produced higher grain yield of sorghum than ridge and flat bed planting methods. Similarly, within the same planting method, closed end tied ridges gave higher yields of sorghum than open end tied ridges.

**Table 1:** Mean grain yield (kg/ha) of sorghum (ETS-2752) grown without $NP$ fertilizers on Entisols as influenced by tied ridges and planting methods between 1986 and 1995 crop seasons.

| *Tied ridge treatment* | *Replication* | | | | *Mean** |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | |
| Flat bed planting (control) | 3169 | 3153 | 3090 | 3231 | $3161^{ab}$ |
| Open end, planting on ridges | 2871 | 3192 | 2933 | 3106 | $3026^{a}$ |
| Open end, planting in furrows | 3608 | 3537 | 3647 | 3443 | $3559^{cd}$ |
| Closed end, planting on ridges | 3396 | 3373 | 3490 | 3467 | $3432^{bc}$ |
| Closed end, planting in furrows | 4118 | 3655 | 3796 | 3773 | $3836^{d}$ |

* Means followed by the same letter are not significantly different at $P = 0.01$.

The higher yields of sorghum recorded for planting in the furrows and for closed end tied ridges over ridge planting and open end tied ridges, respectively, are attributed to the higher water harvesting and retaining capacities of the former as compared to the latter treatments and the flat bed planting. Closed end tied ridges and furrow methods gave more time to penetrate and infiltrate rain water than open end tied ridges and flat beds and than ridge planting methods and therefore allow crop plants to use the water that could have been lost as runoff. The impacts of closed end tied ridges and furrow planting method in improving crop growth and yield were significantly higher during crop seasons with low total rainfall and/or with poorly distributed rains and were in agreement with similar findings reported by Macartney *et al.* (1971); Moldenhauer and Onstand (1977); Heluf Gebrekidan (1989); Asfaw Belay *et al.* (1998); Heluf Gebrekidan and Yohannes Uloro (2002).

Analysis of the four years mean yield data of sorghum produced on the Entisols clearly indicated that the yield and monetary benefits accrued due to water conservation were surprisingly high and encouraging. Among the different soil and water conservation techniques evaluated, one can recommend based on the grain yield data, the use of closed end planting in furrows as the first and open end planting in furrows as the second efficient methods of tied ridges for this specific condition. Generally, the results indicate that the use of proper soil and water conservation practice is imperative on areas like the Alemaya region, which is characterized by erratic and generally low total rainfall, and on the Entisols, which is characterized by shallow root depth, coarse texture and low water holding capacity.

### 3.2 Sorghum Grain Yields on Entisols with $N$ and $P$ Fertilizers

The mean yield data of sorghum (ETS-2752) produced on Entisols with the application of $N$ and $P$ fertilizers and as influenced by different soil and water conservation treatments varied from 3943 to 5304 kg/ha (Table 2). The differences in mean sorghum yield due to the different soil and water conservation treatments were significant ($P \leq 0.01$). In accordance with the unfertilized set of the experiment conducted side by side under similar other conditions (Table 1), planting in the furrows of closed end tied ridge followed by open end planting in furrows produced the highest yield of sorghum. In this experiment, the mean yield differences between the first three high yielding tied ridge and planting method treatments were highly significant. However, unlike the unfertilized set of the same experiment, open end planting on ridges yielded better than flat bed planting although the yield difference due to these treatments was not significantly different ($P > 0.01$).

Regardless of the type of tied ridges, furrow planting methods produced comparatively higher yields of sorghum than their counterpart ridge and flat bed planting (Table 2). Taking the same planting methods into account, closed end tied ridges performed better than open end tied ridges. In general, the data recorded over the years of field investigations clearly indicated that the grain yield and the monetary benefits obtained from the use of water conservation practices on cultivated land of Entisols along with $N$ and $P$ fertilizers are high and encouraging. The higher maximum sorghum yield increment over the control (Tables 1 and 2) due to tied ridges from the fertilized (1361 kg/ha) than from the unfertilized set (675 kg/ha) indicated that soil, especially water conservation practice on nutrient poor, coarse textured, shallow and droughty soils such as the Entisols of Alemaya area is more effective when used with fertilization. Furthermore, it should be expected that the benefits obtained from water conservation will be much higher in regions and crop seasons with erratic and low total rainfall and with crops/varieties that are more sensitive to soil moisture deficit.

The reasons that have been advanced to explain similar yield conditions in the unfertilized set of the same experiment can also be applied to explain the higher grain yield records observed in furrow planting compared with ridge planting method and in closed end compared with open end tied ridges. Many researchers (FOURNIER, 1967; KOWAL, 1970a,b; MACARTNEY *et al.*, 1971; MOLDENHAUER and ONSTAND, 1977; HELUF GE-

**Table 2:** Mean (1986-1995) grain yield (kg/ha) of sorghum (ETS-2752) grown with NP fertilizers on Entisols (Alemaya series) as influenced by tied ridges and planting methods.

| *Tied ridge treatment* | *Replication* | | | | *Mean** |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | |
| Flat bed planting (control) | 3960 | 4024 | 3796 | 3984 | $3943^{a}$ |
| Open end, planting on ridges | 4188 | 4055 | 4055 | 4251 | $4137^{ab}$ |
| Open end, planting in furrows | 4878 | 4839 | 4549 | 4565 | $4708^{c}$ |
| Closed end, planting on ridges | 4643 | 4282 | 4094 | 4353 | $4343^{b}$ |
| Closed end, planting in furrows | 5427 | 5247 | 5192 | 5349 | $5304^{d}$ |

* Treatment means followed by the same letter are not statistically significant at $P = 0.01$.

BREKIDAN, 1989; ASFAW BELAY *et al.*, 1998; HELUF GEBREKIDAN and YOHANNES ULORO, 2002) have also reported the importance of the practice of tied ridging in increasing crop yields by increasing the time for the water to penetrate into the soil. As it is to be expected, regardless of the tied ridge treatments, the yield of sorghum produced with the applications of $N$ and $P$ fertilizers was superior compared with that produced on the same soil type without $N$ and $P$ fertilizers (Tables 2 and 1). The response of sorghum to applied $N$ and $P$ fertilizers on Entisols of the region was in agreement with similar fertility research results reported by TAMIRIE HAWANDO (1986); HELUF GEBREKIDAN (1989).

In line with the unfertilized trial, closed end planting in furrows and open end planting in furrows could be safely recommended as the first and second effective types of tied-ridges for use as a means of soil and water conservation for fertilized sorghum crop under the prevailing conditions. Apparently, it can be predicted that sorghum (ETS-2752) grown in the furrows of closed end tied ridges could give lower yields in seasons and regions receiving higher total rainfall that can create a water logged soil condition.

### 3.3 Sorghum Grain Yields on Vertisols without $NP$ Fertilizers

The mean grain yield data of sorghum produced on Vertisols under natural soil fertility status differed significantly ($P \leq 0.01$) due to the effects of the different soil and water conservation treatments (Table 3). The highest (2408 kg/ha) and lowest (1659 kg/ha) grain yields of sorghum were obtained when the crop was planted in the furrows of open end tied ridge and the flat bed planting treatments, respectively. However, the highest grain yield recorded for open end planting in furrows was not significantly different ($P > 0.01$) when compared with the yields obtained both from closed end planting in furrows (2267 kg/ha) and closed end planting on ridges (2180 kg/ha).

Within the same tied ridge, planting in furrows produced higher grain yields of sorghum than planting on ridges. However, the yields of sorghum attributed to the type of tied ridges (open end and closed end) were not consistent when compared either with their respective or across all planting method methods. The lowest yield of sorghum produced on the flat bed (traditional) planting method was highly significantly lower than the mean yields produced on all other tied ridge treatments, except open end planting on ridges. In this specific set of experiment, the maximum yield increment due to tied ridge treatments was 749 kg/ha (Table 3).

**Table 3:** Mean grain yield (kg/ha) of sorghum (ETS-2752) grown as influenced by soil and water conservation treatments on Vertisols (Alemaya black clay) without $NP$ fertilizers

| *Tied ridge treatment* | *Replication* | | | | *Mean** |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | |
| Flat bed planting (control) | 1608 | 1624 | 1616 | 1788 | $1659^{a}$ |
| Open end, planting on ridges | 1859 | 2071 | 1945 | 1796 | $1918^{ab}$ |
| Open end, planting in furrows | 2290 | 2196 | 2424 | 2722 | $2408^{c}$ |
| Closed end, planting on ridges | 2173 | 2141 | 2298 | 2110 | $2180^{bc}$ |
| Closed end, planting in furrows | 2220 | 2157 | 2424 | 2267 | $2267^{c}$ |

* Treatment means followed by the same letter are not significantly different at $P = 0.01$.

The higher water harvesting and retaining capacity of the furrows than the ridges and flat beds (Kowal, 1970a,b; Asfaw Belay *et al.*, 1998; Heluf Gebrekidan and Yohannes Uloro, 2002), as to supply the plants with enough available water throughout the growing period, might be responsible for the higher sorghum grain yields produced when the crop was planted in the furrows. Moreover, the higher sorghum yield production on the furrows of open end than in the furrows of closed end tied ridges suggest the optimum water retention capacity and drainage of open end than closed end furrows. This, in general indicates that the black clay soils (Vertisols) of the Hararghe highlands require a system of land preparation, which conserves water and at the same time provides optimum drainage. This is to be expected for the fact that the water conservation relaxes the soil moisture stress occurring as a result of the sparsely distributed and low total rainfall during the cropping season, which is often a typical characteristic of the region, and the drainage removes the excessive water (water lodging stress) retained by the soil. Attributed to its fine texture (high clay content, mainly montmorillonitic clays) and relatively high water holding capacity; the black clay soils are often prone to water logging stress.

### 3.4 Sorghum Grain Yields on Vertisols with $N$ and $P$ Fertilizers

The mean grain yield of sorghum produced on Alemaya black clay soil as affected by different physical soil and water conservation techniques and planting methods, and with the application of recommended rates of $N$ and $P$ fertilizers varied from 2588 kg/ha on flat bed planting to 3843 kg/ha on the furrows of closed end tied ridge (Table 4). Analysis of variance and mean difference test made on the yield data revealed a highly significant difference due to the effects of the soil and water conservation treatments. In accordance with the unfertilized set of experiment, furrow planting methods produced superior yields of sorghum regardless of the type of tied ridges involved (Tables 3 & 4). However, unlike the unfertilized set of experiment on the same soil, where planting in furrows of open end tied ridge yielded the highest grain of sorghum (Table 3), closed end planting in furrows produced the highest yield of sorghum in the fertilized experiment (Table 4).

Taking furrow and ridge planting methods independently into consideration, closed end tied ridges produced comparatively higher sorghum grain yields than open end tied ridges. As indicated in Table 4, the differences in the mean grain yield among and within each of the tied ridge and planting method including the control (flat bed planting) treatments were significant ($P \leq 0.01$). In line with the unfertilized set of experiment, flat bed planting produced the lowest grain yield of sorghum in the fertilized set of experiment. The maximum yield increment obtained as a result of the differences in the effectiveness of the tied ridges and planting methods over the control treatment was 1255 kg/ha. This increment in sorghum yield is much higher compared with its increment of 749 kg/ha obtained due to the same effect from the unfertilized set of experiment on Vertisols (Tables 3, 4 and 5) indicating that water conservation is more effective when used on fertilized than on unfertilized field condition.

**Table 4:** Mean (1986-1995) grain yield (kg/ha) of sorghum (ETS-2752) with NP fertilizers on Alemaya black clay as influenced by soil and water conservation treatments.

| *Tied ridge treatment* | *Replication* | | | | *Mean** |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | |
| Flat bed planting (control) | 2408 | 2494 | 2729 | 2722 | 2588$^a$ |
| Open end, planting on ridges | 2800 | 2824 | 2800 | 2941 | 2841$^b$ |
| Open end, planting in furrows | 3176 | 3302 | 3373 | 3247 | 3275$^d$ |
| Closed end, planting on ridges | 2933 | 3122 | 3067 | 3184 | 3077$^c$ |
| Closed end, planting in furrows | 3851 | 3733 | 3875 | 3914 | 3843$^e$ |

* Treatment means followed by the same letter are not significantly different at $P = 0.01$.

In general, from the average sorghum grain yield data produced both under unfertilized and fertilized conditions of the soil, it could be realized that considerably high yield and monetary benefits would be accrued due to water conservation practices even on soils characterized by high water holding capacities. This is to be expected for the fact that the water harvested and retained by furrows of tied ridges (Asfaw Belay *et al.*, 1998) could relax the water deficit periods' characteristic of the eastern Ethiopian highlands where the study is conducted. It could be shown that sorghum requires more available soil water and at the same time tolerates excessive soil water more when grown with fertilizers than without fertilizer applications. Moreover, the substantial yield response of the crop to tied ridging on both the fertilized and unfertilized experiments indicated that in regions with poor rainfall distributions such as the Hararghe highlands, soil and water conservation is a necessary agricultural operation even on heavy clay soils such as the Alemaya black clay (Vertisols) which suffer from poor drainage in seasons and/or regions receiving high rainfall.

### 3.5 Summary of results and conclusion

In summary, flat bed and open end planting on ridges produced the lowest grain yields of sorghum in three and one sets of the four experiments, respectively (Table 5). Generally, furrow planting produced higher grain yields of sorghum than ridge and flat bed, and closed end produced higher yield than open end tied ridges and flat bed under both soil fertility statuses of both soils. Accordingly, except on the unfertilized set of the Vertisols, which was surpassed by open end tied ridge planting in furrows, closed end planting in furrows gave the highest yield of sorghum on all experiments. As it is to be expected from the low fertility levels of the soils (Heluf Gebrekidan, 1989; Eylachew Zewdie, 1994; Asfaw Belay *et al.*, 1997; Heluf Gebrekidan *et al.*, 1999; Heluf Gebrekidan and Yohannes Uloro, 2002), the yields of sorghum produced on both soils under the influences of tied ridges and planting methods without $NP$ fertilization were lower than their respective yields with $NP$ fertilization (Table 5). The maximum yield increment due to $N$ and $P$ fertilizer applications on the Entisols was 1468 kg/ha (38.3%) and on the Vertisols it was 1576 kg/ha (69.5%) both obtained on closed end planting in furrows. Compared with flat bed planting, the Entisols gave the highest absolute increment of sorghum grain yield (1361 kg/ha) with $NP$ and the Vertisols gave highest yield (749 kg/ha) without fertilizers due to the use of water conservation practices (Table 5).

The highest sorghum yields in the furrows of closed end contradict with maize, which yielded highest in the furrows of open end tied ridges when planted under identical conditions on these and other soil types in the region (Asfaw Belay *et al.*, 1998; Heluf Gebrekidan and Yohannes Uloro, 2002). This could be ascribed to the differences of these crops in their water requirement and tolerance to periodic water logging or periodic soil moisture stress conditions. Apparently, the results thus revealed that sorghum is more tolerant both to periodic soil moisture stress and water logging conditions than maize and the latter requires a planting method which conserves enough water while providing optimum drainage. It is to be noted that the flat bed planting method that yielded the least on three of the four sets of experiments is the farmers' practice where sorghum is planted broadcast. Moreover, planting on the ridges of open end tied ridge, which gave the lowest yield on the unfertilized condition of Entisols, is the farmers' practice wherever sorghum is planted in rows. Therefore, in line with results of the studies the following conclusions could be drawn:

(1) The improved variety of sorghum responded significantly to tied ridge and planting methods both under fertilized and unfertilized conditions of the two major soils studied,

(2) The magnitude of yield response to water conservation and the relative effectiveness of the different tied ridges and planting methods tend to vary with soil type, level of soil fertility and distribution and total rainfall during the crop season,

**Table 5:** Mean grain yield (kg/ha) of sorghum (ETS-2752) grown without and with $N$ and $P$ fertilizers on Entisols (Alemaya series) and Vertisols (Alemaya black clay) as influenced by tied ridges and planting methods.

| *Tied ridge and planting method* | *Entisols with no $NP$* | | *Entisols with $NP$* | | Yield due to $NP$ | *Vertisols with no $NP$* | | *Vertisols with $NP$* | | Yield due to $NP$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Yield * | Increment | Yield * | Increment | | Yield * | Increment | Yield * | Increment | |
| Flat bed planting (control) | $3161^{ab}$ | - | $3943^{a}$ | - | 782 | $1659^{a}$ | - | $2588^{a}$ | - | 929 |
| Open end, planting on ridges | $3026^{a}$ | -4.2 | $4137^{ab}$ | 4.9 | 1111 | $1918^{ab}$ | 15.6 | $2841^{b}$ | 9.8 | 923 |
| Open end, planting in furrows | $3559^{cd}$ | 12.6 | $4708^{c}$ | 19.4 | 1149 | $2408^{c}$ | 45.1 | $3275^{d}$ | 26.5 | 867 |
| Closed end, planting on ridges | $3432^{bc}$ | 8.6 | $4343^{b}$ | 10.1 | 911 | $2180^{bc}$ | 31.4 | $3077^{c}$ | 18.9 | 897 |
| Closed end, planting in furrows | $3836^{d}$ | 21.4 | $5304^{d}$ | 34.5 | 1468 | $2267^{c}$ | 36.6 | $3843^{e}$ | 48.5 | 1576 |
| Maximum increment due to tied ridges/$NP$ over control (kg/ha or %) | 675 | 21.4 | 1361 | 34.5 | 1468 | 749 | 36.6 | 1255 | 48.5 | 1576 |

* Treatment means within a column followed by the same letter are not significantly different at $P = 0.01$.

(3) Regardless of the type of the tied ridge, furrow planting proved to be more effective in conserving water and increasing the yield of sorghum with relatively consistent effects in most seasons than ridge and flat bed methods on both soils and soil fertility levels,

(4) Within the furrows, closed end tied ridge is more efficient than open end tied ridge as indicated by increased yield, and the relative effectiveness of the tied ridges and planting methods in increasing crop yields increased with increasing level of soil fertility.

In general, the results apparently indicated that in the Alemaya region of the eastern Ethiopian highlands where the rainfall is low and erratic and the soils are degraded, low total rainfall or its uneven distribution during the cropping season is one of the principal factors limiting the yield of crops. Hence, regardless of the water holding capacity and fertility levels of the soils, soil and water conservation and particularly, in situ water harvesting practices are indispensable agricultural operations. Accordingly, efforts have to be made to extend the results of the present studies to the end users and, giving priority, further research on this field is imperative if boosting crop yield and sustainable production is to be realized in these areas.

## 4 Acknowledgements

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# Livelihoods at Risk: Coping Strategies of War-affected Communities in Sri Lanka [1]

**B. Korf**[2]

**Abstract**

Rural societies in war-affected areas can be described as 'distressed livelihoods': they experience a dramatic increase in risk and uncertainty. How does this affect land use and agricultural coping strategies of small-scale farm households? This was the key research question of a multi-disciplinary, comparative village study carried out in the war-torn areas of Sri Lanka. The study employed the analytical framework of rural livelihoods promoted by DFID. In addition, theoretical models of risk management were instrumental in illustrating behavioural patterns of households in the war zones. The study shows that changed patterns of mobility are a key response of people to adjust to the risk-prone environment. These strategies place heavy demands on the extended family network. Furthermore, access to and priority claims for resources are critical in determining differences in livelihood strategies in different communities. Limited accessibility to natural resources due to war restricts the freedom of livelihood options. Many adapting strategies of farm households thus reflect the declining entitlements to resources due to war and violence. Households gradually deplete their capital stock after each political crisis. Investment in sustainable land management is not rational for farm households that are uncertain about future developments affecting the fundamentals of their lives. Households therefore employ risk minimisation strategies to downsize possible losses and focus on cash earning (especially from overseas employment) and/or state welfare for survival.

**Keywords:** war-affected communities, Sri Lanka, rural livelihoods, risk management

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[1] This is a revised version of a paper presented at the Deutscher Tropentag 2002, Witzenhausen, October 9-11. The paper is based on a joint research venture of the Integrated Food Security Programme Trincomalee (IFSP), Sri Lanka and the Center for Advanced Training in Agricultural and Rural Development (CATAD), Humboldt-Universität zu Berlin. The study was carried out by a German-Sri Lankan interdisciplinary team of young researchers and practitioners, comprising Rathnayake M. Abeyrathne, K. Devarajah, Dharsanie Dharmarajah, Tobias Flämig, T. Sakthivel, Rohini Singarayer, Christine Schenk, Monika Ziebell, Julia Ziegler, and the author as one of the two team leaders of the research group. The author would particularly like to thank Dr. Dedo Geinitz, GTZ Team Leader of the IFSP, for initiating the IFSP-CATAD Project. The study was funded by GTZ, the German Ministry of Economic Cooperation and Development (BMZ) and the Humboldt-Universität zu Berlin.

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## 1 Background of the Study

The civil war in Sri Lanka is embedded in and is an expression of existing social, political, economic and cultural structures. It is thus not a temporary crisis, but a long-enduring feature. The discourse in humanitarian assistance uses the term complex political emergency to denote such phenomenon of post-modern warfare: These emergencies originate from political competition over resources, and are often ethnicised or ethno-nationalist in nature, characterised by loyalty to one particular communal group, accompanied by strong antipathy towards other communal groups living within the same state. In the Sri Lankan case, it is essential to understand the conflict as a multi-dimensional phenomenon, or a conflict cocktail. The fundamental issue of the macro-conflict is the grievance between the Tamil minority and the Sinhalese-Buddhist majority which has escalated into a war between the Liberation Tigers of Tamil Eelam (LTTE) and the largely Sinhalese dominated armed forces. In addition to this major line of dissent, there are other social, political and ethnic cleavages between the three main communal groups, e.g. Muslims, Sinhalese and Tamils.

In the vulnerability context of such a complex political emergency, households have to adapt to gradual deteriorating economic trends and to cope with sudden political shocks in the form of violence. Rural societies in war-affected areas can thus be described as 'distressed livelihoods': they experience a dramatic increase in risk and uncertainty. This paper seeks to outline the strategies that people make use of to secure their livelihoods under such extreme conditions based on empirical studies in the eastern part of Sri Lanka. The region has been particularly affected by warfare and inter-ethnic troubles. Understanding the livelihood strategies of people is essential to design more appropriate intervention strategies of humanitarian and development assistance in times of emergencies. Such policies should try to support and stabilise existing livelihood strategies and to widen the spaces and opportunities for people to survive instead of reducing them to simple recipients of welfare and relief.

## 2 Livelihoods, War and Vulnerabilities

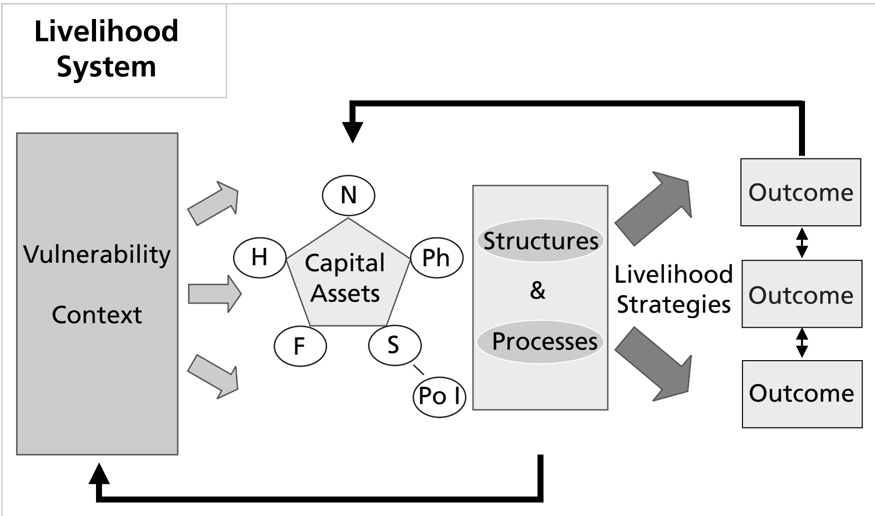
The sustainable rural livelihoods frame is a way of thinking about the scope, objectives and priorities of development that is promoted by the Department for International Development of the British Government (DFID, 1999). An important strength of the livelihoods frame compared to earlier approaches is that it emphasises people's potential in a holistic way rather than stressing on their problems, constraints and needs. It understands that livelihoods and institutions that influence and shape livelihoods are dynamic. DFID defines:

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Carney, 1998).

While DFID (1999) employs the framework to derive sustainable means of fighting rural poverty in an environmentally sustainable way, the present study uses the livelihood systems frame as an analytical tool to observe, analyse and better understand behavioural patterns of communities living in complex political emergencies, thus under extreme social, economic and political frame conditions.

The livelihood systems frame (Figure 1) is thus a way of looking and analysing the system of a household's internal and external factors that affect its socio-economic survival. It looks into livelihood strategies of people in a given vulnerability context (the frame conditions). People have access to six forms of capital assets (natural, physical, human, social, political, and financial). These are the resources, which people can make use of and combine in order to carry out livelihood strategies and achieve certain outcomes. These outcomes have positive as well as negative impacts on the livelihood (feedback loops).

**Figure 1:** The Livelihoods Frame




(Source: DFID, modified by the author)

Structures and processes (institutions) are dynamic and are continuously reshaped over time (Scoones, 1998). In complex political emergencies, civil institutions are largely distorted: These structures and processes largely determine the effective entitlements (access) to resources and to services, such as markets, inputs. They are part of a social and political negotiation process. In complex political emergencies, the power assymmetries favour militant actors (including both military and rebels) at the costs of 'civil(ised)' actors and institutions. The 'rule of violence', threat and fear are superimposed upon political and social institutions.

Livelihood strategies will differ with regard to whether people have to deal with gradual trends or sudden shocks: Adaptive strategies denote processes of change which are more or less conscious and deliberate in the way people adjust livelihood strategies to long term changes and challenges (trends). Coping strategies are short-term responses to periodic stress or sudden shocks of both natural and political hazards. Rural livelihoods in the war-affected areas face multiple vulnerabilities caused by environmental hazards, market-related risks and conflict-related uncertainties which enhance the threshold of vulnerability. The concept of vulnerability (Bohle, 1993; Chambers, 1989) has been mainly used to describe the livelihood risks in natural disasters. It can also be used to describe the internal and external dimensions of household vulnerability in complex political emergencies (CPE):

(i) Exposure to crises, stress and shocks: In CPE, political shocks are the most prominent feature, while we can also observe long-term declining trends (dilapidation of infrastructure, decline of agricultural production).

(ii) Inadequate coping strategies: Civilians have very limited ability to cope with severe consequences of violence and fighting (political shocks). The main strategy seems to be leaving the arena of struggle (displacement, migration) by those who have the means to do so.

(iii) Severe consequences: The shocks and crises, households experience in CPE, seriously harm the recovery potential of households to prevent a deterioration of their productive potential. A reduced (mentally, socially and economically degraded) situation becomes a 'normal' state of existence.

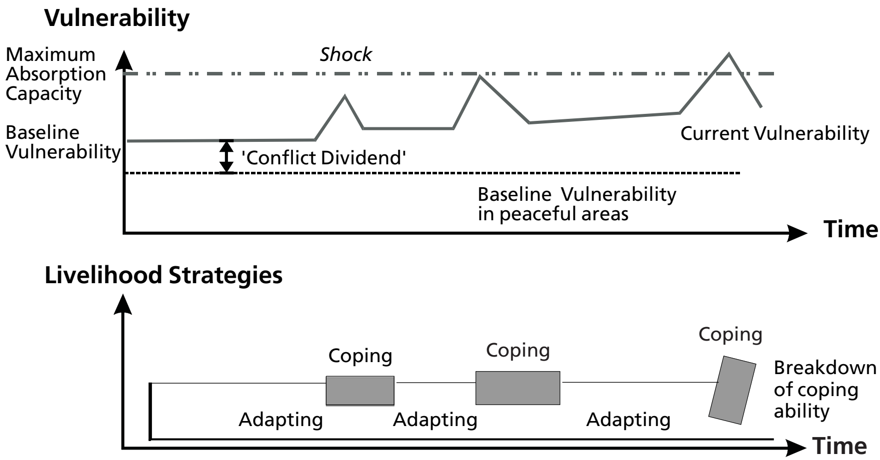
Figure 2 illustrates how exposure to stresses, shocks and crises on complex emergencies affects the vulnerability of livelihoods and how households adapt to and cope with these externally imposed conditions. In complex emergencies, the baseline vulnerability is higher than in peaceful areas due to the increased risk level – security risk and economic risk – and declining economic opportunities (negative conflict dividend).

Here people adapt their livelihood strategies to this 'reduced situation'. Short-term shocks (natural disasters, political shocks, violence) suddenly upset the precarious equilibrium and increase vulnerability (current vulnerability). People adopt coping strategies in response to livelihood crises. Slowly, the system recovers and households employ a new adapting strategy composed of elements from the former adapting strategy and the coping strategy to develop a new portfolio of livelihood activities.

## 3 Material and Methods

In summer 2001, an interdisciplinary German-Sri Lankan team investigated socio-economic livelihood strategies in four locations in Trincomalee district in the war-affected eastern region of Sri Lanka. The study was commissioned by the GTZ supported Integrated Food Security Programme Trincomalee (IFSP) and conducted in collaboration with the Seminar für Ländliche Entwicklung (SLE), Humboldt-Universität zu Berlin. The objective of this research study was to identify livelihood strategies of war-affected

**Figure 2:** Vulnerability and Livelihood Strategies




Source: Korf *et al.* (2001)

communities in order to advise the IFSP how it could improve the targeting and impact of its village projects.

All four research areas are situated at the borderline, either between uncleared (or 'grey') and cleared areas or between the settlements of different ethnic groups. Uncleared areas are those under the control of the Tamil rebel group, the Liberation Tigers of Tamil Eelam (LTTE). Entrance to these areas was until very recently subject to approval by the Ministry of Defence (MOD). The borderline areas are characterised by a high occurrence of fighting, violence, the presence of both armed parties, and intimidation. The locations were selected according to different poverty levels, agro-ecological clusters, and ethnicity in close consultation with the IFSP and included villages where IFSP had already been working and new villages.

The study predominantly used qualitative research methods based on rapid rural appraisal (RRA). The teams conducted semi-structured interviews with individuals, focused group discussions, transect walks, and employed other RRA tools where appropriate. The DFID livelihood systems frame provided the methodological background. This qualitative dataset allowed the research team to:

(1) develop livelihood system models for each research location for different households ('filling the model'),

(2) derive common and antagonistic patterns of livelihood strategies in the four case studies,

(3) categorise the livelihood strategies according to a model of three pillars:

    (i) Managing personal risk of life looks into how people cope with the increased probability of negative consequences for personal lives.

(ii) Managing household economies identifies different strategies of organising the capital assets within a household.

(iii) Accessing external support discusses how individuals or communities make use of structures and processes, i.e., how they access or influence political and military actors.

(4) differentiate coping from adapting strategies.

**Figure 3:** The Livelihoods Frame


Source: Korf *et al.* (2001); Layout Christine Schenk

## 4 Results: Coping with Risk and Uncertainty

Trincomalee is a multi-ethnic district positioned at a strategic location between the northern and the eastern provinces of Sri Lanka. Trincomalee disposes of a big natural harbour and is the proclaimed capital of a Tamil Eelam. The population ratio between the three ethnic groups is a politically contentious issue with currently roughly one third belonging to each ethnic community (Tamil, Muslims, Sinhalese). The Sinhalese mainly live in the cultivation and colonisation areas close to the interior of the island, while Tamil and Muslim villages are in close proximity at each other, located mainly at the coastal strips. The general psychological effects of war are striking all over: a lack of self-confidence, a tendency to keep a low profile, frustration in view of limited life opportunities, fear and desperation are widespread in these non-stabilised areas.

**Table 1:** Village Sketches

| | *Ithikulam [I]* | *Kalyanapura [Ka]* | *Kumpurupitty [Ku]* | *Vattam [Va]* |
|---|---|---|---|---|
| *Vulnerability Context* | Tamil community in uncleared area; dilapidated public infrastructure | Sinhalese border village | Tamil settlement in 'semi-cleared' area; onion boom | Muslim border village at coastal strip |
| *Main income sources* | Highland cultivation, wage labouring | Paddy cultivation, home guards, wage labour | Wage labouring, onion cultivation, land lease | Fishing, middle east employment |
| *Key trend* | Converting threats into opportunities | Fragile prosperity at the fringe of power | Missing the onion boom | Squeezed between the lines |

Source: Own representation, compiled from (Korf *et al.*, 2001)

Conflict, war and risk, nevertheless, have quite a different impact on each of the four research locations (Table 1). In some locations, villagers still pursue their traditional livelihood activities and farming systems, even though under constraining frame conditions. In other locations, the conflict forced villagers to leave traditional resources behind due to the war and to search for alternative livelihood options. In Ithikulam, a Tamil village in the uncleared (i.e. rebel controlled area), farmers converted the security threat into new opportunities: leaving traditional paddy cultivation behind, they now earn a considerable cash income from highland cultivation and wage labouring putting them into a comparative economic advantage to traditional tenant paddy cultivators. Villagers in Kalyanapura, a Sinhalese village at the borderline and thus subject to frequent attacks from the rebels, are able to secure a fragile prosperity due to the support given to them by the army, police and the central government. In Kumpurupitty, a Tamil village in an officially cleared, but, in fact, 'grey' and disputed area, farmers are reluctant to engage in the highly profitable onion cultivation because of a lack of capital (lost during displacement) and a risk averse attitude. In Vattam, a Muslim fishing village, people prefer to keep a low profile, because they are just trapped in the middle between the two fighting parties. These four examples show the variety of contexts and responses to the circumstances which make a generalisation of findings very difficult. Nonetheless, there are certain livelihood strategies which are common to all four locations, while others are typical for a particular community only.

Table 2 outlines the different livelihood strategies in the four case studies categorised according to the three pillar model. All in all, livelihood strategies of households in

Trincomalee comprise a portfolio of short-term coping and long-term adapting strategies. The study shows that changed patterns of mobility are a key response of people to adjust to the risk-prone environment (GOODHAND *et al.*, 2000). These strategies place heavy demands on the extended family network. Many adapting strategies deal with declining income earning opportunities and the risk of investment, which is higher in conflict areas compared to peaceful areas. Households gradually deplete their capital stock after each political crisis. Cash income is more easily acquired through outside funds (state payments for home guards, welfare) or overseas employment (remittances cash flows) than through cultivation. Relief-oriented aid offered by the state and NGOs might have supported a reorientation of household strategies towards tapping these funds instead of investing scarce assets in an insecure environment. Adapting strategies reflect the declining entitlements to resources, e.g. the disrupted access to land, water and jungle resources, that restricts the choice of livelihood options. Investment in sustainable land management is not rational for farm households that are uncertain about future developments affecting the fundamentals of their lives. Households therefore employ risk minimisation strategies to downsize possible losses and focus on cash earning (especially from overseas employment) and/or state welfare for survival.

Has the conflict accentuated poverty and thus livelihood strategies? How different are the livelihoods in conflict areas from those in peaceful areas of Sri Lanka? Coping and adaptive strategies are the outcome of an interplay of various factors and impacts - not one single one such as the conflict - on the different elements of livelihood. It is therefore difficult to make a firm distinction between poverty and conflict coping. However, the first pillar in our model - managing personal risk of life - is clearly linked to the conflict and the increased personal risk related with conflict. Apart from that, uncertainty and insecurity also increases the economic risk of investment, and this factor is mirrored in various coping strategies of the second and third pillar. In this regard, increased economic risk can also be caused by macro-economic conditions, e.g. through national open-market policies, and coping with such induced risks might be similar to coping with economic risks induced by the security situation. Some argue that state welfare and relief could prevent a large-scale decline of the population into deep poverty (O'SULLIVAN, 1997). In the research locations, government welfare in the form of Samurdhi food stamps, dry rations, and resettlement aid are an important food and income source and people have adapted strategies for tapping these resources. This could also be a sign of the erosion of household capital assets due to the protracted duration of the war: Households gradually deplete their capital stock after each shock and thus increase their dependency on outside assistance.

It is important to note that power and reciprocity in vertical networks of support more and more determine survival strategies of people in the war-torn areas of Sri Lanka (third pillar of livelihood strategies: accessing external support). We can observe ethnicised interactions in political and economic terms: entitlements to agricultural resources and markets are unequally distributed among the three ethnic groups. Especially the Tamil population suffers from a comparative disadvantage, since the armed forces suspect them of collaboration with the rebels. Sinhalese and Muslims largely dominate trade

**Table 2:** Three Pillars of Coping Strategies in Civil Wars: Examples from Trincomalee

| Managing personal risk | Managing household economics | Accessing external support |
|---|---|---|
| *Minimising risk*<br>• leaving places of residence or cultivation permanently or temporarily [all],<br>• fleeing to the jungle during sudden eruption of fighting [I, Ka],<br>• residing with relatives in the peaceful areas of Sri Lanka and returning for cultivation only [Ka],<br>• sending children to relatives in more secure places for schooling and safety [all],<br>• sending women and elderly persons through checkpoints for marketing, because young men are more likely to become harrassed [I],<br>• working in fields in groups and seeking protection by the army [Ka].<br>*Risk taking (for economic survival)*:<br>• collecting firewood in the jungle even though this is a very risky place,<br>• trespassing in the restricted fishing areas imposed by the navy, when fishermen expect a big catch of fish. | *Securing income*:<br>• migrating for income opportunities to Middle East [all, Va],<br>• confing to key income sources due to reduced life choices [Ka, Ku, Va],<br>• seeking home guard employment for Sinhalese farmers [Ka],<br>*Organising the family*:<br>• handling traditional gender roles and tasks more flexibly: women take a more active role in marketing, trading and cultivation [I],<br>• re-sizing and re-uniting the family according to security and economic needs, e.g. sending vulnerable family members to more secure places [all].<br>*Managing expenditure and investment*:<br>• avoiding investment in tangible assets (e.g. boats, houses) [Ku], even though in two locations, people started building new houses [Va, I],<br>• reducing expenses for entertainment and consumption patterns [all]. This is often coupled with a partial degradation of social status,<br>• using informal food markets (incl. smuggling and illegal liquor production). | *Alliancing with power holders (active)*:<br>• establishing good relationships with local government officers [Ka, Ku, Va],<br>• seeking alliances with armed actors to get personal advantages (e.g. for trading) [Ka],<br>• keeping a low profile in order not to cause trouble [I, Va]<br>*Satisfying claims of armed actors (passive)*:<br>• giving the necessary as bribe (in avoidance of being forced to give) [I, Ku],<br>• by-passing taxation and bribery wherever possible with tricks etc. [I, Ku]<br>*Qualifying for state and NGO support*:<br>• forming community-based organisations to access NGO support [Ka]. However, many local institutions are falling apart due to the reluctance of local leaders to become too noticable [I, Ku],<br>• concealing economic facts in order to qualify for state welfare [Va, Ku].<br>*Accessing formal and informal economic institutions*:<br>• pawning jewellery to receive credit from banks, money lenders or mudalali (traders), relatives,<br>• practicing traditional group savings (seetu) for small-scale expenses [Va, Ka]. |

Comments: I = Ithikulam; Ka = Kalyanapura; Ku = Kumpurupitty; Va = Vattam

Source: Own representation, compiled from KORF *et al.* (2001)

networks, since they can form alliances with the military and thus easily pass through military checkpoints while Tamil traders face a lot of troubles in transporting their goods. In addition, the central government provides generous assistance to Sinhalese farmers in the border villages to encourage them to remain living in these areas. The government employs a large number of young Sinhalese in these villages as home guards to protect their community. This provides considerable and stable income which would otherwise not be available in these villages. On the other hand, the rebels levy taxes on Muslim traders and thus expropriate part of the gained profits from them.

Such interactions develop into a form of 'war economy' where economic businesses and interactions involve military power holders. In the long term, this has serious consequences: Social capital (support through community networks) is gradually undermined by the dominance of political capital and patronage: entitlements are attributed to those with a stronger link to political and military power holders. The problem with such political and economic practice is that it reinforces those grievances among the ethnic groups which fuelled the escalation of social conflict into civil war.

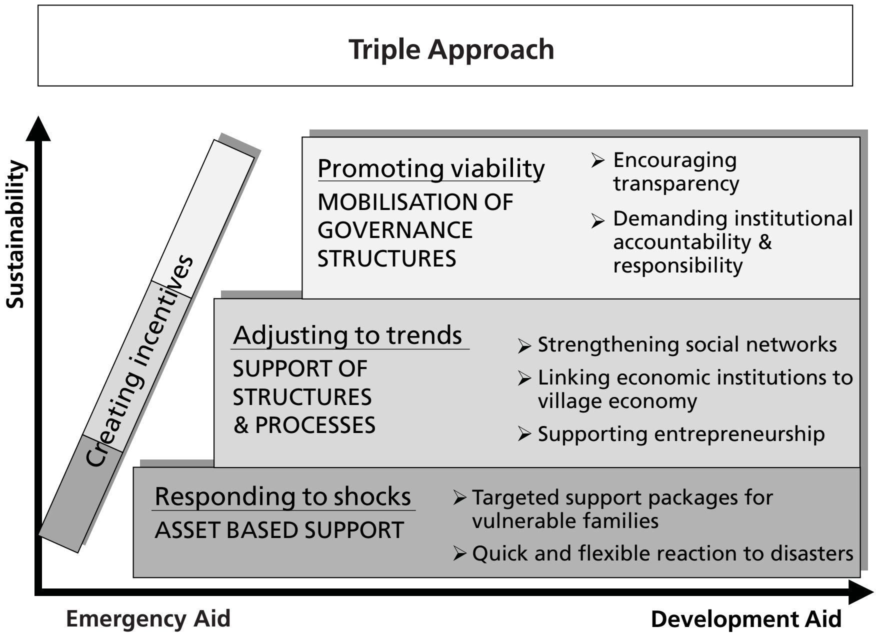
## 5 Implications for Development-oriented Emergency Aid

Development-oriented emergency aid at community level should focus on supporting livelihood strategies of people, especially those of vulnerable groups. In the past, aid agencies in the war zones of Sri Lanka have often superimposed micro-projects that did not correspond to the local livelihood strategies and were thus doomed to failure. If we look at the livelihoods frame, it becomes clear that aid agencies can hardly change the vulnerability context in a civil war, since the fighting parties follow their own strategies and tactical considerations. Within this limited opportunities frame, however, community development can focus on two levels of interventions: on the one hand, agencies can strengthen available household assets through improved training (human assets), financial transfers (financial assets) and the facilitation of processes that support reestablishing social ties witin communities (social assets). On the other hand, livelihood opportunities are largely determined by structures and processes that determine how households can make use of their assets. Development agencies can support the establishment of more effective and more inclusive institutions.

Bigdon and Korf (2002) point out that 'empowerment' goes beyond capacity building, since empowerment depends upon the context in which someone or a social group is to be empowered. In the logic of the livelihoods frame, we can define 'empowerment' as the ability or the power of individiuals (or social groups) to pursue their livelihood strategies and activities sustainably which depends on the institutional environment in place. In the context of a civil war, local institutions are often biased towards clientelist networks that determine who receives access and influence on the utilisation of natural resources. Aid agencies thus work in an arena of negotiation where different actors bargain for strategic resources (Bierschenk, 1988). These struggles for power and resources take place on the community level as well as on the intermediate level of government and non-governmental organisations. In civil wars, it is furthermore the fighting parties that influence decisions in favor of their clientele and that put pressure on decision-makers. In such an environment, aid agencies must be careful not to reinforce the logic of grievances that drive war, and thus to do harm.

While most aid agencies in the war zones of Sri Lanka have focused on short-term relief and rehabilitation measures, I argue that development-oriented emergency aid must also take the institutional level into consideration to remove constraints on the level of structures and processes in the livelihood system. This approach shares its

**Figure 4:** The Triple Approach of Intervening in Livelihoods




Source: Korf *et al.* (2001)

conceptual thinking with various GTZ concepts, such as the concept of development-oriented emergency aid (GTZ, 1998) and the concept on food security (BMZ, 1998). The experience from Sri Lanka shows that agencies can start implementing development-oriented approaches and institutional development already during war, instead of waiting until the wars are over (Korf and Bauer, 2002). In line with the livelihoods thinking, such an approach could be based on three pillars (Korf *et al.*, 2001):

(i) Responding to shocks (asset-based support): Resource-poor, vulnerable households may be unable to cope with shock and need temporary support to overcome an acute crisis. Assistance could focus on vulnerable households with support packages for income generation.

(ii) Adjusting to trends (support of structures and processes): Institutional development and capacity building is the core of the triple approach. In addition to the organisational development of governmental partner institutions, strengthening social networks (neighbourhood support) and encouraging transparent and accountable community institutions are essential steps to establish social capital and trust of people in their community institutions. Furthermore, it is essential to link economic institutions (e.g. banks) to the village economy.

(iii) Promoting viability (mobilisation of governance structures): Demanding institutional accountability and responsibility is a challenging task: donor agencies and international NGOs should urge their partner institutions and other involved organisations to take action in a way which is transparent and understandable to all stakeholders. Good governance, trust of people in their governmental institutions, is a pre-condition for peaceful co-existence of the three communal groups in Trincomalee.

'Coping' is often associated with defensive, re-active behavior. However, this study has shown that people in war zones are not all helpless victims, but actively develop livelihood strategies to survive under such difficult circumstances. It should hence be the task of aid agencies to stabilise and support those coping strategies that engage in constructive and sustainable livelihood activities instead of further undermining these with a relief-oriented approach.

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# Nutrient Composition of some Tropical Legumes Capable of Substituting Fish Meal in Fish Diets

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**Abstract**
Sword beans (*Canavalia gladiata*); Jackbean (*Canavalia enciformis* (L)); Mucuna bean (*Mucuna pruriens*); *Mucuna cochiunensis*; Bambara (*Voandzeia subterranea*) and Limabean (*Phaseolus lunatus*) are the tropical legumes considered in this paper. They have been used in the feed of ruminants but very scarcely considered in fish feed. Information about their nutrient composition are also scarce. Results from this study show that the protein contents of the test seeds ranged from 19.94% dry matter (DM), (Bambara) to 36.95% DM (*Mucuna cochiunensis*). Considering the high protein level required by fish for maximum growth and the presence of some ANFs, the seeds may not be able to be used in isolation without supplementing them with other food stuffs having higher protein value. The relatively high content of Nitrogen Free Extract (+ fibre) seem to suggest that the test seeds can be used in a semi-intensive setting to supply carbohydrate in fish diets. The seeds contain considerable amount of linoleic acid (18:2 n-6). The highest occurring in Lima beans. Sword beans and Jack beans are rich in oleic acid (18:1n-9). Palmatic acid (16:0) is high, while stearic acid (18:0) and myristic acid (14:0) are low. The amino acid compositions of the test seeds are not very adequate. Sword beans had a better amino acid profile though it seems deficient in some of the amino acids. The amino acid contents of Jack bean, Mucuna bean, Bambara and Lima bean look inadequate to provide a possible alternative to fish meal on individual basis. If to be used in fish feed formulation, combinating them with other protein sources, possessing higher contents of the limiting amino acids is strongly suggested. The potentials of these seeds in fish feed formulation seem high.

**Keywords:** Swordbean, Canavalia gladiata, Jackbean, Canavalia enciformis, Mucunabean, Mucuna pruriens, Bambara, Voandzeia subterranea, Limabean, Phaseolus lunatus, fish diet

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## 1 Introduction

Tropical legume grains represent a potentially important source of protein and energy for farm animals. Many varieties have been identified for use in animal feed because of their rich protein composition, mineral content and widespread distribution in the tropics. Only a few however, have been utilised (Adeparasi, 1994).

In practical feed formulation wheat has been used as a supplementary feedstuff in European agriculture. The aim is to ensure that essential components of fish feed are not used as energy sources, but only for growth. Legumes have a high content of carbohydrate and can become good energy sources in fish feed just like wheat.

The general poor amino acid profile and deficiencies of some specific essential amino acids in some of these legumes have restricted their exploitation in non ruminant feeding. The occurrence of diverse range of natural compounds capable of precipitating deleterious effects in animals have also been identified in these legumes. These substances, arising principally from secondary metabolism in plants, are commonly referred to as anti nutritional factors (ANF). They reduce food intake and nutrient utilization in animals. They may also be hepatotoxic, neurotoxic and even lethal (D´Mello, 1991).

The above setbacks not withstanding, nutritionists have continued in their efforts to make these pulses viable for use in animal feed. Supplementation with the limiting amino acids is an obvious method of upgrading the amino acid profile of the legumes and thereby maximize utilization of leguminous seeds. Thermal treatment confers significant nutritional advantages to the legumes, it is also an essential component of a more complex detoxification procedure. A proportion of the anti-nutritional factors present in plant proteins can be destroyed and inactivated by heat treatment process (Tacon and Jackson, 1985).

Sword beans (*Canavalia gladiata*); Jackbean (*Canavalia enciformis* (L)); Mucuna bean (*Mucuna pruriens*); *Mucuna cochiunensis*; Bambara (*Voandzeia subterranea*) and Limabean (*Phaseolus lunatus*) are the tropical legumes considered in this paper. They have been used in the feed of ruminants but very scarcely considered in fish feed. Information about their nutrient composition are also scarce. This paper therefore attempts to provide the basic information about nutrient composition of these tropical legumes while studies on their potentials to substitute fish meal in fish feeds continue.

## 2 Materials and Methods

Seeds from the test legumes were collected and planted at the Michael Okpara University of Agriculture, Umudike - Umuahia , Nigeria. to obtain enough seeds for proximate, amino and fatty acid analysis. After harvest dried raw seeds were homogenised, freeze dried and used for the respective chemical analysis at the Institute of Freshwater Ecology and Inland Fisheries.

Protein ($N \times 6.25$) was determined by the Kjeltec System (Tecator); crude fat by Soxtec System HT (Tecator) using petroleum ether, and ash by burning in a muffle furnace at 750°C for 4 hours. For the amino acid analysis, 5mg of the freeze dried samples were hydrolysed with 6 $NHCl$ at 110°C for 24 hours. No protecting reagents were added to avoid destruction of sulphur amino acids. Other procedures for the analysis have been reported (OGUNJI and WIRTH, 2001). Fatty acid composition of the samples were analysed using gas-liquid chromatography (with omega-wax capillary column Supelco, USA), as described by WIRTH and STEFFENS (1985). The lipid classes were separated by thin layer chromatography on silica gel G 60 (Merck, Darmstadt), using n-hexane/ethylether/acetic acid (73/25/2/v/v/v) as developing solvent. The fatty acids of phospholipids and triglycerides were transformed with sodium methylate into methylesters.

## 3 Result and Discussion

Table 1 shows the proximate analysis of the test tropical legumes. The protein contents of the seeds ranged from 19.94% dry matter (DM; Bambara) to 36.95 % DM (*Mucuna cochiunensis*). The values are lower than the recorded content of raw soybean (46.44% DM) but higher than the content of groundnut cake that was used to substitute fish meal in the feed of tiliapia *Oreochromis nitoticus* (OGUNJI and WIRTH, 2001). The protein requirements of cold water fishes and of many warm water fishes are generally high; more than 30% of the diets (WILSON, 1985; NATIONAL RESEARCH COUNCIL (NRC), 1981, 1983). Considering this high protein level required by fish for maximum growth and the presence of some ANFs the test seeds may not be able to be used in isolation without supplementing them with other food stuffs with higher value of protein. OSUIGWE *et al.* (2002) mixed only 9.80% of Jack beans seed meal boiled for 60 minutes with 17.60% fish meal in their diet formulation for *Clarias gariepinus* thus substituting fishmeal by 20%. By boiling, some of the ANFs were inactivated. The relatively high content of Nitrogen Free Extract (+ fibre) seem to suggest that the test seeds can be used in a semi-intensive setting to supply carbohydrate in the diet of fish. This possibility needs to be examined. The seeds are low in fats.

**Table 1:** Proximate analysis of test tropical legumes.

| *Sample No.* | *Dry Matter* | *Ash** | *Fat** | *Protein** | *NFE [1] ** |
|---|---|---|---|---|---|
| Swordbean | 88.98 | 4.00 (3.56) | 0.89 (0.79) | 33.60 (29.90) | 61.51 (54.73) |
| Jackbean-W | 85.30 | 3.00 (2.56) | 1.96 (1.67) | 32.24 (27.50) | 62.80 (53.57) |
| Jackbean-R | 88.22 | 3.06 (2.70) | 1.58 (1.39) | 34.59 (30.52) | 60.77 (53.61) |
| Mucuna Bl | 89.44 | 3.58 (3.20) | 2.40 (2.15) | 33.19 (29.68) | 60.83 (54.41) |
| M. cochi | 88.96 | 3.56 (3.17) | 3.39 (3.01) | 36.95 (32.87) | 56.10 (49.91) |
| Bambara | 91.32 | 3. 26 (2.98) | 5.78 (5.28) | 19.94 (18.21) | 71.02 (64.85) |
| Limabean | 87.49 | 4.26 (3.73) | 0.97 (0.85) | 28.17 (24.64) | 66.60 (58.27) |

* Values in brackets are presented on wet weight basis.

[1] NFE = Nitrogen Free Extract

**Table 2:** Amino acid composition (% dry matter) of test tropical legumes.

| | *Sword Bean* | *J-Bean W* | *J-Bean R* | *Mucuna Bl* | *M. cochi* | *Bambara* | *Limabean* |
|---|---|---|---|---|---|---|---|
| Aspartic acid | 1.25 | 0.86 | 0.82 | 0.66 | 0.62 | 0.67 | 0.80 |
| Glutamic acid | 2.52 | 2.01 | 1.74 | 1.48 | 1.57 | 2.22 | 1.78 |
| Serine | 0.73 | 0.47 | 0.43 | 0.30 | 0.36 | 0.43 | 0.45 |
| Glutamin | - | 0.10 | 0.13 | 0.08 | - | 0.14 | 0.09 |
| Histidine[1] | 0.67 | 0.70 | 0.77 | 0.48 | 0.53 | 0.84 | 0.60 |
| Glycine | 0.90 | - | 0.32 | - | - | - | - |
| Threonine[1] | - | 0.96 | 1.01 | - | - | - | - |
| Arginine[1] | 2.02 | 0.76 | 0.66 | 0.58 | 0.63 | 0.83 | 0.68 |
| Taurine | 0.69 | 0.57 | 0.68 | 0.27 | 0.33 | 0.49 | 0.55 |
| Alanine | 0.40 | 0.16 | 0.20 | 0.29 | 0.23 | 0.09 | 0.15 |
| Tryptophan1 | 0.68 | 0.35 | 0.30 | 0.40 | 0.27 | 0.23 | 0.27 |
| Methionine1 | - | - | - | - | - | - | - |
| Valine1 | 0.94 | 0.64 | 0.73 | 0.52 | 0.50 | 0.60 | 0.64 |
| Phenylalanine[1] | 1.10 | 0.75 | 0.62 | 0.61 | 0.57 | 0.74 | 0.80 |
| Isoleucine[1] | 0.90 | 0.61 | 0.63 | 0.51 | 0.51 | 0.56 | 0.65 |
| Leucine[1] | 2.15 | 1.78 | 1.85 | 1.16 | 1.15 | 1.50 | 1.63 |
| Ornitine | - | 1.08 | 0.79 | 0.83 | 0.83 | 0.85 | 1.03 |
| Lysine[1] | 1.42 | 0.87 | 0.76 | 0.61 | 0.62 | 0.86 | 0.83 |

[1] Essential amino acids

The Amino acid composition of the test tropical legumes are shown in Table 2. Among the test seeds, sword beans had a better amino acid profile. It seems deficient in some of the amino acids. However, this is dependent on the amino acid requirement of the fish for which the diet will include sword bean. For instance sword bean can be used in tilapia diet while methionine will be supplemented. Santiago and Lovell (1988) investigated the amino acid requirements for the growth of nile tilapia using purified diet. Reported as percentage dry matter the requirements are: Arginine 1.14, histidine 0.48, isoleucine 0.87, leucine 0.95, lysine 1.43, methionine 0.75, phenylalanine 1.05, threonine 1.05, tryptophan 0.28, and valine 0.78. The digestibility of the feed needs to be put into consideration. The essential amino acid composition of alternative protein sources for fish are not comparable with that of fish meal. The amino acid content of Jack bean, Mucuna bean, Bambara and Lima bean looks inadequate to provide any possible alternative to fish meal on individual basis. When using them in fish feed formulation, combination with other protein sources which may possess different limiting amino acids is strongly suggested.

Legumes similar to oil seeds like sunflower seed and linseed are rich in linoleic and linolenic acid. They may be deficient in long-chain polyunsaturated fatty acids. The fatty acid compositions (%) of phospholipids and tryglycerides from the test tropical legumes are presented in Tables 3 and 4. The test seeds contain a considerable amount

**Table 3:** Fatty acid composition (%) of phospholipids from the test tropical legumes

| *Fatty acid* | *Sword Bean* | *J-Bean W* | *J-Bean R* | *Mucuna Bl* | *M. cochi* | *Bambara* | *Limabean* |
|---|---|---|---|---|---|---|---|
| 14:0 | 0,2 | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 |
| 15:0 | 0,5 | 0,2 | 0,3 | 0,1 | 0,1 | trace | 0,2 |
| 16:0 | 20,3 | 17,9 | 18,2 | 31,8 | 30,7 | 24,4 | 25,6 |
| 16:1 n-9 | trace | 0,5 | trace | trace | trace | 0,1 | 0,1 |
| 16:1 n-7 | 1,0 | 1,2 | 0,6 | 0,2 | 0,2 | 0,1 | 0,1 |
| 17:0 | 0,1 | 0,2 | 0,1 | 0,2 | 0,1 | 0,1 | 0,4 |
| 17:01 | 0,2 | trace | 0,3 | 0,1 | trace | 0,1 | 0,2 |
| 18:0 | 0,3 | 0,4 | 1,2 | 4,7 | 7,9 | 4,3 | 2,9 |
| 18:1 n-9 | 0,4 | 0,3 | 58,3 | 4,6 | 4,6 | 26,5 | 10,1 |
| 18:1 n-7 | 50,8 | 62,1 | trace | 1,3 | 1,2 | 0,1 | 0,1 |
| 18:2 n-6 | 19,8 | 12,6 | 16,3 | 49,5 | 48,4 | 37,0 | 47,8 |
| 18:3 n-6 | trace | trace | trace | trace | trace | trace | trace |
| 18:3 n-3 | 5,1 | 3,4 | 3,3 | 3,8 | 3,1 | 1,0 | 10,6 |
| 18:4 n-3 | trace | trace | trace | trace | trace | trace | trace |
| 20:0 | 0,1 | 0,1 | 0,1 | 0,3 | 0,6 | trace | trace |
| 20:1 n-11 | trace | trace | 0,1 | trace | trace | 0,5 | 0,2 |
| 20:1 n-9 | 0,2 | 0,3 | 0,1 | 0,1 | 0,1 | 0,3 | 0,1 |
| 22.3 n-6 | trace | trace | trace | 0,3 | trace | 0,2 | 0,3 |
| 22:4 n-6 | 0,1 | trace | 0,1 | 0,2 | 0,1 | trace | 0,1 |
| 24:0 | 0,2 | 0,2 | 0,2 | 0,2 | 0,3 | trace | 0,5 |
| 24:1 n-9 | 0,1 | trace | trace | trace | 0,3 | 1,5 | trace |

of linoleic acid (18:2 n-6). Higher concentration was found in the Mucuna species, Bambara and Lima bean both in phospholipids and triglyceride. Sword beans and Jack beans are rich in oleic acid (18:1n-9) while the highest content of linolenic acid (18:3n-3) were found in Lima beans. Palmatic acid (16:0) is high in the test seeds while stearic acid (18:0) and myristic acid (14:0) are low. 14:0 and 16:0. Fatty acids are however, not important for the growth of fish. It should be noted, that 18:2 (n-6) or 18:3 (n-3) as with other vertebrate, cannot be synthesised by fish *de novo*. Hence one or both of these fatty acids must be supplied preformed in the diet depending on the essential fatty acid (EFA) requirements (National Research Council (NRC), 1993). Based on the foregoing, the test seeds can be used to provide the fatty acid source in fish feed provided their inclusion level is not exceeded.

The following aspect of work on these test leguminous seeds are in progress: determination of the dietary inclusion level of these seeds in feed of different fish species; determination of the best processing method to deactivate the ANFs. The potentials of these seed in fish feed formulation seem high.

**Table 4:** Fatty acid composition (%) of triglycerides from the test tropical legumes

| *Fatty acid* | *Sword Bean* | *J-Bean W* | *J-Bean R* | *Mucuna Bl* | *M. cochi* | *Bambara* | *Limabean* |
|---|---|---|---|---|---|---|---|
| 14:0 | 0.6 | 0.3 | 0.3 | 0.1 | 0.2 | 0.1 | 0.2 |
| 15:0 | 0.3 | 0.1 | 0.2 | trace | trace | trace | 0.1 |
| 16:0 | 16.9 | 13.5 | 14.7 | 27.3 | 28.2 | 17.6 | 20.3 |
| 16:1 n-9 | trace | trace | trace | trace | trace | trace | trace |
| 16:1 n-7 | 2.5 | 2.6 | 1.5 | 0.4 | 0.3 | 0.1 | 0.2 |
| 17:0 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 |
| 17:01 | 0.1 | trace | 0.2 | trace | trace | trace | 0.1 |
| 18:0 | 1.9 | 1.7 | 4.2 | 8.1 | 7.9 | 9.0 | 9.1 |
| 18:1 n-9 | 46.3 | 52.9 | 49.8 | 8.8 | 8.5 | 23.0 | 10.4 |
| 18:1 n-7 | 3.1 | 3.6 | 2.4 | 4.3 | 3.8 | 0.1 | 1.1 |
| 18:2 n-6 | 14.1 | 10.9 | 14.3 | 43.2 | 45.2 | 37.3 | 40.0 |
| 18:3 n-6 | trace | trace | trace | trace | trace | trace | trace |
| 18:3 n-3 | 7.8 | 7.9 | 6.2 | 1.6 | 1.5 | 2.2 | 11.8 |
| 18:4 n-3 | trace | trace | trace | trace | trace | trace | trace |
| 20:0 | trace | trace | trace | 1.5 | 1.1 | trace | trace |
| 20:1 n-11 | 0.8 | 0.7 | 1.5 | 0.2 | 0.2 | 2.6 | 0.9 |
| 20:1 n-9 | 1.7 | 2.7 | 1.6 | 0.1 | 0.1 | 0.6 | 0.2 |
| 22:3 n-6 | 0.2 | 0.1 | 0.2 | 0.2 | 0.1 | 0.2 | 0.4 |
| 22:4 n-6 | 0.1 | trace | trace | 0.1 | 0.1 | trace | 0.1 |
| 24:0 | 1.4 | 1.6 | 1.7 | 0.8 | 0.9 | 1.7 | 2.2 |
| 24:1 n-9 | 0.1 | 0.1 | trace | trace | trace | trace | trace |

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# Effects of Compound Fertilization on Growth and Alkaloids of Datura (*Datura innoxia* Mill.) Plants.

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**Abstract**
The effect of 0, 100, 200, 400, 600 and 800 kg ha$^{-1}$ of Sangral, a complex chemical fertilizer at rates, on growth, alkaloid content, drug yield and nutrient uptake of datura (*Datura innoxia* Mill.) plants was studied during two successive seasons. The plant height, the number of branches and leaves/plant, the fresh and the dry weights increased with increasing fertilizer rates up to 800 kg ha$^{-1}$; however, the maximum increase was recorded at 600 kg ha$^{-1}$. Total alkaloid and drug (hyoscyamine + scopolamine) contents also increased with increasing the fertilization level to a peak value of 600 kg ha$^{-1}$. It then, decreased at 800 kg ha$^{-1}$ level. Plant leaves and fruits were the most valuable organs for alkaloid and drug accumulation followed by stems, roots and crowns, respectively. $N$, $P$ and $K$ in the leaves were linearly increased by increasing fertilizer level. It seems that compound fertilizers increase the availability of essential nutrient elements necessary for datura growth and metabolism, causing vigorous vegetation and high chemical production.

**Keywords:** Datura, NPK fertilization, alkaloids

## 1 Introduction

Datura is an annual wild plant belonging to the family Solanaceae and it is considered one of the most important medicinal plants, known as a main source of a variety of alkaloids required for pharmaceutical industries. Several compounds, important for drug manufactory, are present in datura plants. Daturine, hyoscyamine, atropine, scopolamine and essence materials used as antispasmodic, narcotic, neuro-sedative and anti-asthmatic drugs were found in datura (CHIEJ, 1984). Therefore, a wide range of studies to improve the growth and productivity of datura was made.

The effects of environmental factors such as temperature and light have been extensively examined (SIVASTAVA and LUTHRA, 1993). Cultural practices to improve growth, yield and chemical compounds such as watering and fertilization have also been investigated but on a more limited scale (EL-KADY *et al.*, 1980; MAZROU *et al.*, 1988; EL-MASRY *et al.*, 1996). Most studies were done in clay soils which are less permeable to water and can hold the nutrients for relatively long time. Moreover, most fertilizers used in

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these studies were generally highly water-soluble single fertilizers consisting of only one or two of $N$, $P$, or $K$; therefore, fertilization recommendations were inconsistent.

Under Al-Qassim conditions, the major problem in using single fertilizers is that the dry sandy soil is highly permeable to water and nutrients, due to low organic matter and clay contents as well as low cation exchange capacity (CEC). This often causes a great leaching and a huge loss of nutrients and may also create a potential groundwater contamination problem. In this regard, PETROVIC (1990) reported that around 80% of the nutrient elements found in single-fertilizers can be leached in sandy soils.

Micronutrients are often neglected in using the single-fertilizer form, although vigorous plant growth and crop production require an adequate supply and balanced amounts of all nutrients (MENGEL and KIRKBY, 1987) in order to maximize plant health and vigor by optimizing the plant nutrient-uptake. This can be only achieved if the nutrient content of the fertilizer is appropriate to the needs of the plants. Compound-fertilizers, containing both macro- and micro elements, may possess this characteristic and in several studies have been found to escape leaching losses of nutrients when applied in chelating form (BROWN *et al.*, 1982; SNYDER *et al.*, 1984; MANCINO, 1991).

Sangral compound fertilizer is frequently supplied with 20% - 20% - 20% $N$-$P$-$K$ and with other macro and nearly all micro elements necessary for plant growth in adequate, balanced and chelating form. Not enough research is available regarding the effect of "Sangral" fertilizer on datura plants or of any specific factors that might be relevant to its requirement for the medicinal plants. Besides, very limited information is available concerning fertilization requirements for field production of datura in Saudia Arabia. An early article by MAZROU *et al.* (1988) described the influence of nitrogen nutrition on field datura grown under conditions different from those prevailing in Al-Qassim provided limited guidelines for datura production.

The present study was undertaken to determine how the compound fertilizer "Sangral" affects growth, chemical composition and nutrient uptake of datura (*Datura innoxia* Mill.) plants grown under the environmental conditions of the Al-Qassim region, Saudi Arabia.

## 2 Materials and Methods

Two field experiments were initiated during two successive years to determine the response of datura plants to the compound-Sangral fertilizer applied at 6 rates (0, 100, 200, 400, 600 and 800 kg ha$^{-1}$). The chemical composition of Sangral (Sinclair Horticulture LTD, England) compound-fertilizer is as follows: $N$, 20%; $P$, 20%; $K$, 20%; $S$, 0.4%; $Mg$, 0.02%; $Fe$, 70 ppm; $Zn$, 14 ppm; $Cu$, 16 ppm; $Mn$, 42ppm; $B$, 22 ppm and $Mo$, 14 ppm.

By the end of December, 2000 and 2001, seeds of Al-Qassim locally growing *Datura innoxia* were planted in pans and, ten weeks later, the seedlings with three leaves were transplanted 50 cm apart in 2×4 m plots in sandy soil. The chemical and physical properties of the soil at the field site are shown in Table 1. At the beginning of April, plants were fertilized four times with four equal portions of the proposed fertilizer rate, in monthly intervals, as side dressing treatments. Both experiments were designed in a complete randomized block design with three replications. During the experimental period, all normal agricultural practices were performed.

**Table 1:** Chemical and Physical Properties of the Soil.

| *Chemical Properties* | | |
|---|---|---|
| pH | | 8.2 |
| ECe (mS) | | 2.6 |
| Soluble Cations (meq $L^{-1}$) | | |
| | $Na^+$ | 11.00 |
| | $Ca^{2+}$ | 4.35 |
| | $Mg^{2+}$ | 2.50 |
| Soluble Anions (meq $L^{-1}$) | | |
| | ${CO_3}^{2-} + {HCO_3}^-$ | 2.99 |
| | ${SO_4}^{2-}$ | 11.70 |
| | $Cl^-$ | 7.60 |
| | $CaCO_3$ | 4.00 % |
| | O. M. | 0.23 % |

| *Physical Properties* | | |
|---|---|---|
| Fractions (%): | | |
| | Sand | 95.30 |
| | Silt | 3.60 |
| | Clay | 1.10 |
| | Texture | Sandy Soil |

Throughout the growth period, the plant height, the number of the branches and leaves, the fresh and dry weights of leaves, stems, roots, crowns, flowers, and fruits/plant were determined.

At the fruiting stage ($1^{st}$ of Sept.), plants were harvested and their parts were separated and dried individually at 70°C to a constant weight. Then the following chemical analysis was performed using finely powdered materials: (a) total alkaloid percent was determined according to Karawya *et al.* (1975), (b) hyoscyamine and scopolamine were measured according to Miraldi *et al.* (2001), (c) total nitrogen was measured using Micro-Kjeldahl method as described by Chapman and Pratt (1978), (d) phosphorus was measured colorimetrically using the Stannus chloride method described by Frie *et al.* (1964), (e) and potassium using the Flame Photometry method described by Jones and Steyn (1973).

All statistical analyses were performed according to Snedecor and Cochran (1980) with the aid of the COSTAT computer program for statistics. Differences among treatments were tested with LSD at a 5% level of significance.

## 3 Results and Discussion

### 3.1 Vegetative Growth Analysis

Data recorded during the two experimental seasons showed that fertilization with the compound fertilizer "Sangral" in a suitable dose is very important to produce healthy and vigorous datura plants with sufficient foliage, branches, flowers, fruits and roots (Tables 2 & 3).

**Table 2:** Effects of fertilization regime on plant height, number of branches and leaves of datura plants during the two experimental seasons.

| *Fertilizer Rate (kg ha$^{-1}$)* | *Plant Height (cm)* | *No. Branches per Plant* | *No. Leaves per Plant* | *No. Leaves per Branch* |
|---|---|---|---|---|
| First Experimental Season | | | | |
| 00 | 060.5 | 3.63 | 095.33 | 26.26 |
| 100 | 071.6 | 4.04 | 112.14 | 27.75 |
| 200 | 085.2 | 5.75 | 132.60 | 23.06 |
| 400 | 097.4 | 6.50 | 164.50 | 25.30 |
| 600 | 111.4 | 7.25 | 180.24 | 24.86 |
| 800 | 072.0 | 4.00 | 106.15 | 26.54 |
| L.S.D (5%) | 4.9 | 1.03 | 21.15 | 1.45 |
| Second Experimental Season | | | | |
| 00 | 058.4 | 3.72 | 087.15 | 23.42 |
| 100 | 065.5 | 4.66 | 108.11 | 23.20 |
| 200 | 077.8 | 6.94 | 121.07 | 17.45 |
| 400 | 093.5 | 8.37 | 147.50 | 17.62 |
| 600 | 107.6 | 9.17 | 160.27 | 17.48 |
| 800 | 067.6 | 4.87 | 100.30 | 20.59 |
| L.S.D (5%) | 6.11 | 1.42 | 15.12 | 1.10 |

Vegetative growth, represented by plant height, number of branches and leaves per plant, fresh and dry weights of plant parts increased linearly by increasing Sangral rate of application and reached their maximum values at 600 kg ha$^{-1}$ (Tables 2 & 3) then, all parameters tended to decline at 800 kg ha$^{-1}$ level. The 93% and 98% increases in the dry weights of the aerial part observed at 600 kg ha$^{-1}$ during the first and second season, respectively, were met by 51% and 24% increases in the dry weight of the roots, as compared with the control (Table 3). While at 800 kg ha$^{-1}$, the corresponding increases in the aerial part were 12.5% and 16%, respectively, the roots increased by

**Table 3:** Effects of fertilization regime on fresh and dry weights (g) of datura plant organs during the two experimental seasons.

| *Fertilizer Rate (kg/ha)* | *Leaves/Plant* | | *Stems/Plant* | | *Crowns/Plant* | | *Flowers/Plant* | | *Fruits/Plant* | | *Aerial Part/Plant* | | *Roots/plant* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | f.wt | d.wt | f.wt | d.wt | f.wt | d.wt | f.wt | d.wt | f.wt | d.wt | f.wt | d.wt | f.wt | d.wt |
| First Experimental Season | | | | | | | | | | | | | | |
| 00 | 140.8 | 42.55 | 130.5 | 45.44 | 40.5 | 09.85 | 06.55 | 1.88 | 169.4 | 42.33 | 0487.7 | 142.1 | 045.4 | 15.75 |
| 100 | 155.5 | 44.08 | 220.2 | 70.58 | 52.5 | 10.00 | 07.00 | 1.40 | 205.7 | 50.65 | 0640.9 | 176.8 | 050.6 | 16.00 |
| 200 | 167.2 | 46.82 | 272.4 | 87.11 | 61.6 | 11.74 | 08.65 | 1.55 | 350.5 | 77.42 | 0860.3 | 224.5 | 072.4 | 18.61 |
| 400 | 195.7 | 48.11 | 299.6 | 90.24 | 82.5 | 17.54 | 10.44 | 1.73 | 436.5 | 87.20 | 1024.6 | 224.6 | 089.5 | 19.58 |
| 600 | 240.4 | 49.12 | 375.8 | 93.70 | 88.7 | 24.62 | 12.35 | 1.82 | 537.2 | 105.51 | 1254.6 | 274.7 | 119.3 | 23.81 |
| 800 | 156.3 | 47.70 | 262.7 | 78.24 | 62.9 | 19.45 | 09.88 | 1.54 | 325.2 | 97.66 | 0819.9 | 244.2 | 056.8 | 16.85 |
| LSD(5%) | 11.54 | 1.88 | 38.50 | 12.45 | 9.16 | 1.12 | 1.22 | 0.25 | 45.15 | 7.11 | 95.45 | 28.40 | 12.15 | 1.11 |
| Second Experimental Season | | | | | | | | | | | | | | |
| 00 | 118.5 | 33.24 | 125.8 | 40.24 | 36.7 | 09.11 | 06.12 | 1.75 | 160.6 | 39.45 | 0203.4 | 123.8 | 051.5 | 17.05 |
| 100 | 137.5 | 37.50 | 179.5 | 55.20 | 40.4 | 09.65 | 07.24 | 1.50 | 210.2 | 45.50 | 0574.8 | 149.5 | 063.2 | 17.20 |
| 200 | 152.4 | 39.67 | 251.4 | 74.65 | 55.4 | 11.22 | 08.52 | 1.66 | 280.4 | 59.54 | 0588.6 | 145.8 | 070.5 | 17.55 |
| 400 | 175.3 | 42.07 | 277.5 | 82.45 | 75.5 | 16.61 | 09.70 | 1.82 | 329.5 | 66.80 | 0818.5 | 199.5 | 085.4 | 18.75 |
| 600 | 210.4 | 62.61 | 314.2 | 86.72 | 82.3 | 21.42 | 11.55 | 1.91 | 467.4 | 93.26 | 1014.4 | 241.7 | 102.7 | 21.06 |
| 800 | 147.7 | 43.71 | 212.5 | 74.70 | 40.2 | 17.52 | 09.52 | 1.45 | 272.6 | 70.75 | 0846.9 | 238.9 | 050.6 | 14.88 |
| LSD(5%) | 22.15 | 2.05 | 26.50 | 12.60 | 6.65 | 1.11 | 0.85 | 0.22 | 33.20 | 6.95 | 101.4 | 32.18 | 9.16 | 0.98 |

only 7% at the first season and even decreased at the second season, compared with the control. Therefore, at the 800 kg $ha^{-1}$, the shoot/root ratio suddenly increased by about 60% of the control (on dry weight bases), during the $1^{st}$ and exceeded 100% at the $2^{nd}$ season (Fig 1). It is interesting to notice that the shoot/root ratio recorded at 800 kg $ha^{-1}$ increased by about 16% over that recorded at 600 kg $ha^{-1}$, in spite of the negative effect of the former fertilizer dose, on all growth parameters, when compared with the later dose. Two reasons may explain this phenomenon. The first, it seems that the high fertilization ratio affected the roots much more negatively than it did to the aerial parts. In this connection, at 800 kg $ha^{-1}$ root dry weight decreased by 41% of that recorded at 600 kg $ha^{-1}$, while the corresponding decrease in the shoot dry weight was only 12%. The second reason might be related to the relatively higher RWC% of the roots than that recorded for the shoots at the 800 kg $ha^{-1}$ (Fig 2). This high amount of water within root tissues might affect their dry matter content, upon drying, much more than the effect on the shoots, leading to higher dry weight of the shoots than the roots. In this respect, an early study by TISDALE *et al.* (1992) showed that the excess amount of fertilizers caused burning and death of the root hairs, affecting negatively the root growth by inhibiting the elongation and enlargement of the root cells, consequently limited the extension of the roots in the soil as they became week, short, and fluffy. In another study, MENGEL and KIRKBY (1987) found that, the overloaded dose of fertilization increased the soil osmotic pressure and thus, soil water became tightly held within the soil granules causing dehydration of the plant organs, particularly the aboveground parts because of the less water uptake and translocation to the stems, leaves and other aerial plant parts. In addition, nitrogen fertilization was found to increase the growth, yield and alkaloid content in *Datura innoxia* (RUMINSKA and EL-GAMAL, 1978) at moderate fertilizer doses, while at high doses these variables were decreased. In a further study, BARKER and COREY (1990) reported that the extreme fertilization regime may enhance ethylene evolution and affect the plant growth negatively. Data recorded in this study confirm these findings since the highest dose of fertilization caused substantial reductions in the plant height, number of branches and leaves per plant (Table 2) as well as fresh and dry weights of leaves, stems, crowns, flowers and fruits of treated plants (Table 3). On the other hand, maximum values of growth variables were positively correlated ($R^2$=92%) with the 600 kg $ha^{-1}$ dose of Sangral.

It is not surprising that plants without or with low fertilizer application grew very slowly and showed poor characteristics because of the essential role that nutrient elements play in plant structure and biology. The increase in the vegetative and reproductive growth with the optimum ratio of Sangral fertilization (600 kg $ha^{-1}$) might be due to the effective role of the balanced amounts of the nutrient elements in enhancing plant growth and physiological activity. In this regard, it is well known that the root and shoot morphogenesis of plant species is affected by the level and form of a fertilizer (ALBREGTS *et al.*, 1991). The significant roles of nitrogen and sulfur in amino acid formation, protein synthesis and phytohormone production (WAGNER and MICHAEL, 1971; MENGEL and KIRKBY, 1987; LING and SILBERBUSH, 2002); phosphorus in the nucleic acids formation, cell membrane structure and ATP generation (Garton and Widders, 1990; Ling and Silberbush, 2002), potassium and calcium in enzyme activity, stomata movement, meristematic zone formation, cell-membrane integrity, and plant water relations (Salisbury and Ross, 1992; Kaya *et al.*, 2002) made it very important for these elements to be found in suitable quantities in the fertilization practices and that was the case for Sangral fertilizer added to datura plants. In this regard, FeiBo *et al.* (1998) and Sawan *et al.* (2001), reported that $N$, $P$, and $K$ are the nutrients that have the largest effect on the physiology and yield of crops. They are essential for photosynthesis and dry matter production. Moreover, the micro-elements found in a reasonably balanced level and chelated form gave the fertilizer a good opportunity to play an important role in the physiological activities of a plant. In this concern, the majority of the micro elements were found to enhance the activity of many enzymes within plant cells (Liptay and Arevalo., 2000). In addition, $Fe$, $Mn$ and $Zn$ somehow participate in chlorophyll formation (Salisbury and Ross, 1992). $Mo$ is essential for $N$ fixation in the soil and for nitrate reductase enzyme in the plant (Mengel and Kirkby, 1987). $Cu$ and $B$ are essential factors for phytohormone synthesis, carbohydrate translocation, and nucleic acid formation (Bernier, 1988).

**Figure 1:** Effects of fertilization rate on the shoot/root ratio of datura plants.

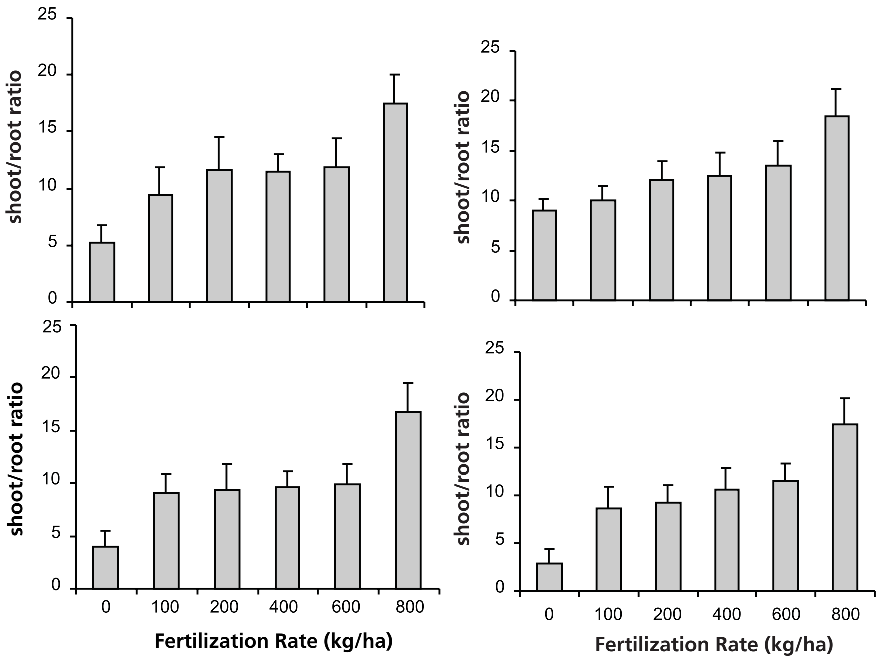
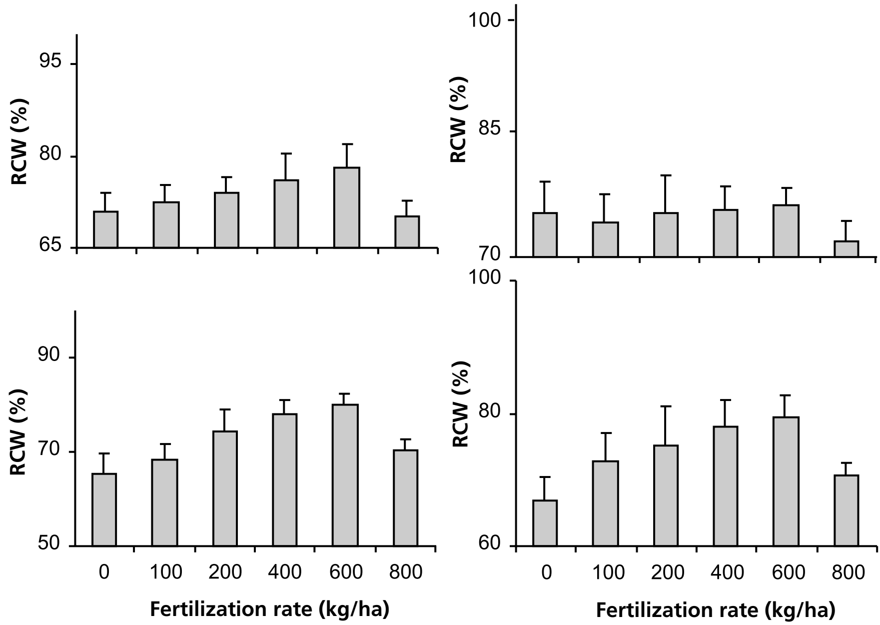


**Figure 2:** Effects of fertilization rate on the relative water content (RWC (%) of datura plants.




### 3.2 Chemical Analysis

#### 3.2.1 Total Alkaloid Content

The production of alkaloids in *Datura innoxia* has been investigated in the different plant parts at different fertilization ratios (Table 4). Total alkaloid in most plant parts were consistent and positively correlated with the ratio of fertilizer application up to 600 kg ha$^{-1}$, and then tended to decrease at 800 kg ha$^{-1}$. The maximum contents of total alkaloids were found in the leaves and fruits as compared to other organs. The maximum value was recorded at 600 kg ha$^{-1}$, at which total alkaloids in the aerial part increased by about 79% and 60% of the control in the first and second season, respectively. These increases were due to the increases in alkaloid contents of different plant parts particularly fruits a 120% increase as compared to the control.

Roots and crowns showed also some increase in their total alkaloids with fertilizer application; however, their alkaloids were less than those recorded in the other plant parts. Concerning fruits, early studies by Robins and Abraham (1997) and, Miraldi *et al.* (2001) showed that the pericarp of either closed or mature capsules of *Datura stramonium* contained a very low alkaloid content, while in the seeds, the alkaloid content strongly increased during maturation. In the present study, the increase in the alkaloid content with fertilizer application might be attributed to the increase in seed yield within fruits.

**Table 4:** Effects of fertilization regime on total alkaloid content (mg/plant) and concentration (mg/(g DM)) in datura plant organs during the two experimental seasons.

| *Fertilizer Rate (kg/ha)* | *Leaves* | | *Stems* | | *Crowns* | | *Fruits* | | *Aerial Part* | | *Roots* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *mg/plant* | *mg/g DM* | *mg/plant* | *mg/g DM* | *mg/plant* | *mg/g DM* | *mg/plant* | *mg/g DM* | *mg/plant* | *mg/g DM* | *mg/plant* | *mg/g DM* |
| | | | | | | First Experimental Season | | | | | | |
| 00 | 171.3 | 4.02 | 50.3 | 1.12 | 7.63 | 0.77 | 92.4 | 2.17 | 321.6 | 2.30 | 09.12 | 0.58 |
| 100 | 186.2 | 4.22 | 67.4 | 1.25 | 7.76 | 0.78 | 148.2 | 2.19 | 409.6 | 2.34 | 11.23 | 0.70 |
| 200 | 195.3 | 4.17 | 74.4 | 1.36 | 12.13 | 1.04 | 162.2 | 2.19 | 444.0 | 1.99 | 16.20 | 0.87 |
| 400 | 228.1 | 4.75 | 109.9 | 1.38 | 16.05 | 0.92 | 188.1 | 2.16 | 542.2 | 2.23 | 17.02 | 0.87 |
| 600 | 230.5 | 4.68 | 122.2 | 1.61 | 17.22 | 0.70 | 206.2 | 2.96 | 576.1 | 2.11 | 19.78 | 0.83 |
| 800 | 207.6 | 4.34 | 104.2 | 1.33 | 17.33 | 0.89 | 114.5 | 2.05 | 443.6 | 1.83 | 11.50 | 0.68 |
| LSD | 11.5 | NS | 10.6 | 0.14 | 3.53 | 0.11 | 19.8 | NS | 32.6 | 0.26 | 1.44 | 0.14 |
| | | | | | | Second Experimental Season | | | | | | |
| 00 | 166.3 | 4.99 | 40.4 | 1.01 | 5.68 | 0.62 | 75.8 | 1.90 | 288.2 | 2.36 | 11.00 | 0.64 |
| 100 | 170.7 | 4.53 | 55.2 | 1.21 | 5.86 | 0.58 | 116.4 | 2.55 | 348.2 | 2.35 | 13.12 | 0.76 |
| 200 | 180.4 | 4.54 | 74.6 | 1.40 | 6.94 | 0.62 | 142.2 | 2.39 | 404.1 | 2.18 | 14.09 | 0.80 |
| 400 | 214.2 | 5.09 | 82.4 | 1.69 | 9.01 | 0.54 | 155.5 | 2.32 | 461.1 | 2.22 | 16.11 | 0.86 |
| 600 | 219.0 | 4.85 | 86.7 | 1.84 | 9.80 | 0.46 | 167.3 | 2.79 | 482.8 | 1.83 | 18.20 | 0.87 |
| 800 | 197.6 | 3.15 | 74.7 | 0.75 | 10.13 | 0.58 | 121.5 | 2.18 | 403.9 | 1.95 | 12.46 | 0.83 |
| LSD | 10.8 | 0.62 | 9.5 | 0.20 | 2.72 | 0.09 | 26.4 | 0.14 | 40.5 | 0.22 | 1.62 | 0.11 |

As was expected, suitable rates of fertilization enhanced the alkaloid formation, since alkaloids are aromatic nitrogenous compounds containing nitrogen on their carbon skeletons. In addition, fertilization provides the elements that contribute in the synthesis of various amino acids, the precursor of a variety of alkaloids (SALISBURY and ROSS, 1978). Thus alkaloid concentrations increased within plant parts.

The positive effect of fertilization on the growth of plant parts, discussed above, may be another reason of an increasing alkaloid content per plant. In this regard, nitrogen fertilization was found to increase the growth, yield and alkaloid content in *Datura innoxia* (RUMINSKA and EL-GAMAL, 1978) at moderate fertilizer doses, while at high doses, these variables were decreased. In the same connection, DEMEYER and DEJAEGERE (1993) explained the increase in the alkaloid as a result of increasing fertilization as that, nitrogen and other elements of the fertilizer are incorporated into amino acids which are the main precursor of the alkaloids in the roots before they translocate to the upper plant parts.

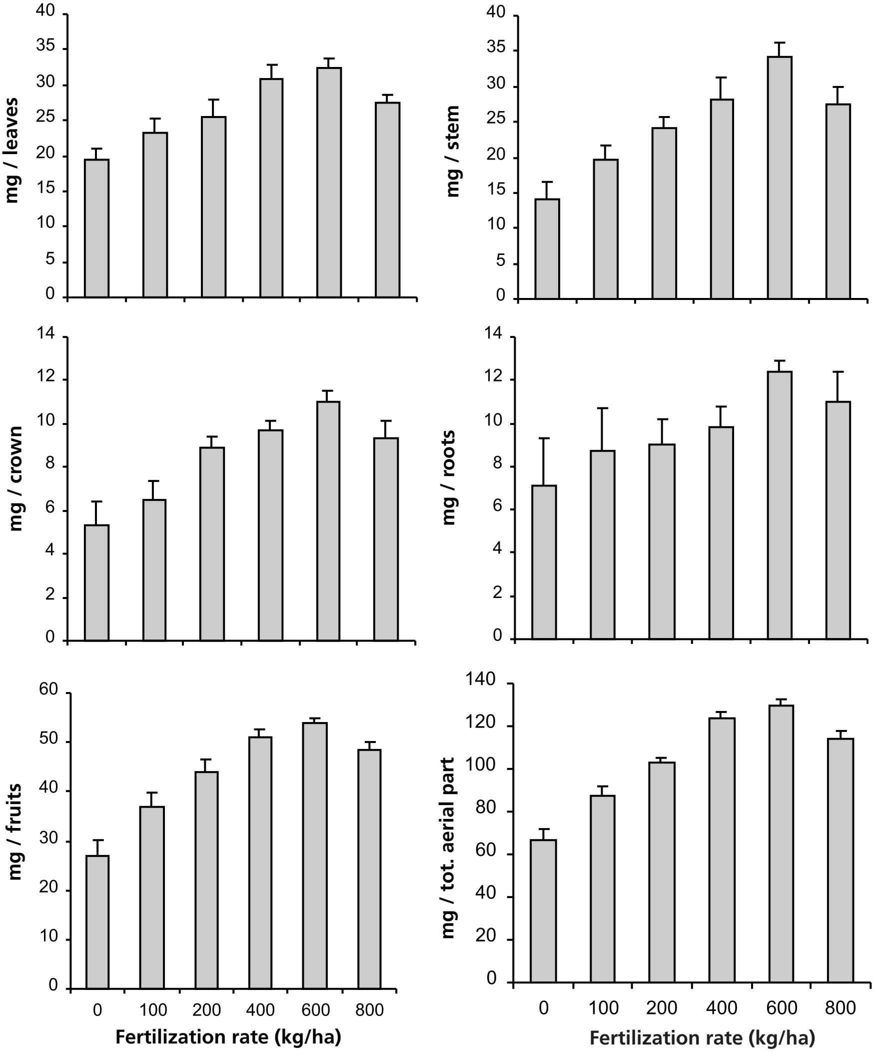
The drop in alkaloid content recorded at 800 kg $ha^{-1}$, on the other hand, might be explained mainly through the negative effect of extreme doses on roots in which alkaloids are synthesized (ROBINS and ABRAHAM, 1997). In this regard, MIRALDI *et al.* (2001) reported that the root is the principle site of alkaloid synthesis and that secondary modifications of alkaloids occur in the aerial parts. They added that, at plant maturity, alkaloids were absent in roots of adult plants. This study shows that alkaloid concentrations in the roots were very low in any treatment, compared with other plant parts.

## 3.3 Hyoscyamine and Scopolamine

The production of the most abundant alkaloids in datura, hyoscyamine (atropine) and scopolamine, has been investigated in different plant parts and at different rates of Sangral fertilization as they are included in many official pharmacopoeias because of their anti-cholinergic activities.

Regardless of the fertilization treatments, the recorded data indicated that maximum drug contents were found in the flowers followed by the leaves then stems, fruits and finally roots (Fig. 3), with hyoscyamine being always the predominant component. It is obvious that the response of these drugs to the fertilization was very much similar to that of alkaloids. In this regard, several studies indicated that suitable amounts of mineral nutrition enhanced the hyoscyamine and scopolamine synthesis in datura, as a result of influencing the formation of amino acids that are converting to the drug components (ROBINS and ABRAHAM, 1997; DEMEYER and DEJAEGERE, 1993; PINOL *et al.*, 1999). Recently, MIRALDI *et al.* (2001) reported that the levels of hyoscyamine and scopolamine within datura plant parts depend on several factors, the nutritional state is one of them, and atropine is often formed from hyoscyamine racemization and the hyoscyamine content is approximately two fold that of scopolamine.

**Figure 3:** Effect of fertilization on total hyoscyamine and scopolamine in datura plant parts as mg/dry weight of plants.




## 3.4 $N$ $P$ $K$ Concentrations

The increase in the concentration of the nutrient elements within datura leaves as a result of fertilizer application was found to be significant during the two growing seasons as compared with the control (Table 5). It is evident that the linear increase in the concentration of the nutrient elements was positively correlated ($R^2$= 0.89) with the increase in the fertilization ratio. The most increase in the elements was recorded at 600 kg ha$^{-1}$ ratio, at which the $N$, $P$, and $K$ percentages were raised by about 80%, 60% and 8% of control, respectively, during the first season. The same enhancement trend was recorded at the second growth season. As was expected, at the suitable 600 kg ha$^{-1}$ ratio roots tend to extend to a large volume (Katayama *et al.*, 1999) and most, if not all, physiological activities of fertilized plants greatly increase, particularly the absorption of water and uptake of nutrients from the soil (Boyle *et al.*, 1991).

**Table 5:** Effects of fertilization regime on $N$, $P$, and $K$ concentration (%) and content (mg/ tot dry weight) of datura leaves during the two experimental seasons.

| *Fertilizer Rate (kg ha$^{-1}$)* | *Concentration (%)* | | | *Content (mg/plant)* |
|---|---|---|---|---|
| | $N$ | $P$ | $K$ | |
| First Experimental Season | | | | |
| 00 | 0.91 | 0.45 | 2.39 | 1595 |
| 100 | 1.05 | 0.55 | 2.81 | 1945 |
| 200 | 1.08 | 0.58 | 2.44 | 1919 |
| 400 | 1.10 | 0.59 | 2.76 | 2136 |
| 600 | 1.65 | 0.71 | 2.59 | 2426 |
| 800 | 1.22 | 0.63 | 2.02 | 1846 |
| Second Experimental Season | | | | |
| 00 | 1.29 | 0.38 | 2.04 | 1232 |
| 100 | 1.25 | 0.42 | 2.25 | 1470 |
| 200 | 1.35 | 0.44 | 2.67 | 1771 |
| 400 | 1.38 | 0.50 | 2.65 | 1907 |
| 600 | 1.93 | 0.56 | 2.70 | 3249 |
| 800 | 1.58 | 0.54 | 2.48 | 2010 |

On the other hand, the harmful effect of the extreme amounts of fertilization (800 kg ha$^{-1}$) on root growth and branching, as discussed above, lowered their ability to adsorb the nutrients sufficiently. These findings were in harmony with those reported by Mazrou (1985) on *Atropa belladonna* and Mazrou and Al-Humaid (2000) on gladioli plants.

## 4 Zusammenfassung


### Düngungseinfluss auf Wachstum und Alkaloidgehalt von Datura (Datura innoxia M.)

Der Einfluss von 0, 100, 200, 400, 600 und 800 kg/ha von Sangral, einem Mischdünger, der alle essentiellen Makro- und Mikronährstoffe für Pflanzen enthält, auf Wachstum, Alkaloidgehalt und Nährstoffaufnahme von *Datura innoxia* Mill wurde während zweier Vegetationsperioden untersucht. Pflanzenhöhe, Anzahl der Zweige und Blätter pro Pflanze sowie Frisch- und Trockengewicht und N-P-K- Gehalt der Blätter haben ihr Maximum bei 600 kg/ha, ebenso der Alkaloid- und Drogen (Hyoscyamin und Scopolamin) - Gehalt. Blätter und Früchte waren die wichtigsten Pflanzenorgane für einen hohen Alkaloid- und Drogengehalt, gefolgt von Stengeln, Wurzeln und Kronen.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# Influencing Factors of Infestation of Endo and Ectoparasites on Hair Sheep in Tropical Ecuador.

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**Abstract**

120 hair sheep were tested for faecal, skin and blood parasites. After three parasitological studies in humid Sucumbíos, it was proved that the parasitic charge is influenced by different factors. In the case of air temperature and humidity there was no variation detected between the seasons, although the parasitical charge rose in the course of this study. With regard to parasitic charge some systematic differences were found between the farming systems. Prophylactic measures such as rotational grazing, guarantee the food alternatives in the case of grass shortage, the strategic treatment with de-wormers and removal of excrement and garbage were recommended.

**Keywords:** endoparasites, ectoparasites, cattle, hair sheep, rotational grazing, season, farming system, prophylactic measures

## 1 Introduction

A GTZ (German Agency for Technical Cooperation) and University of Kassel funded project aimed at examining the parasite condition of hair sheep and cattle in the province of Sucumbíos in Ecuador. Parasites can impair the health of an animal and cause high economic losses. According to the parasitologists factors like farming systems, source of water, salt additive as well as sex, age and breed of the animal play an important role. In this report the farming system, sex, breed and age of sheep are to be analysed.

## 2 Material and methods

120 hair sheep of the breeds Barbados Blackbelly, Pelibuey and the Ethiopian breed were tested for faecal, skin and blood parasites. These animals were chosen from 25 farms. The chosen farms were classified into four different farming systems: The first one, has separate grazing of hair sheep and cattle on artificial pastures; the second one has free range grazing of hair sheep on artificial pastures, mixed grazing with cattle; the third one has hair sheep grazing in coffee and cocoa plantations and the last one has a mixture between farming system 2 and 3. The climate in the survey region is perhumid as typical for tropical rainforests. The annual rainfall is between 3,500 and 5,400 mm. The average temperature is between 23.9 and 26.5 °C.

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For faecal tests flotation, sediment and migration methods were used to test for gastro-intestinal, liver and lung parasites. The WOO and IFAT tests were used to test for blood parasites. The skin specimens were microscoped directly after removal to test for ectoparasites. The above mentioned factors were analysed statistically to find out whether they are significant for the various kinds of parasite. Considering the animal management and the grassing system, the farming system was assigned to one of four groups, ranging from very good to bad. Numbers were assigned to the tree breeding types: Barbados Black belly being group one, Pelibuey the second one and the crossover between those two represented group three. Another classification parameter was the age, resulting in three groups: the first one was composed by animals aged between one and six months, the second one included animals between six and twelve months of age. The last one consisted of animals older than twelve months. We also differentiated between male and female animals each represented a separate group.

## 3 Results

### 3.1 Breed

The statistical effect of breed in the different helminths was not significant (Tab. 1a). The analysis of protozoae showed different results. *Trypanosoma spp.* revealed a high significance, while *Eimera spp.* was significant at a 5% level(Tab. 1b). The analysis of *Tabanus* in arthropods also displays a high significance (Tab. 1c).

### 3.2 Sex

We did not find significant differences between the male and female animals in arthropods and protozoae. (Tab. 1a-c).

### 3.3 Season

The fist season between July and September 1997 was dry with a relatively high humidity. In the second season from October until December 1997 the temperature and the humidity remained constant - later, rainfall increased. Due to high rainfall the development and reproduction of parasites was high between February and April 1998. Significant increase in parasite population was seen during transition from one season to another, especially in helminths, where this factor has the greatest significance (see Tab. 1a). Table 1c displays a high significance in *Eimeria spp.*, while the results in *Trypanosoma spp.* were non-significant. *Bovicola spp.* was the only ectoparasite showing non-significant results in relation to the season (see Tab. 1c). Figure 1 shows that the infestation of Hair Sheep with helminths increased along the study. The infestation with endoparasites, especially *Strongyloides spp.*, *Haemonchus spp.* and *Trichostrongylus spp.* was very high between the second and the third season, coinciding with the beginning of the rainy season. The infestation with *Bunostomum spp.* did not show variations according to weather conditions.

**Table 1:** Results of LSQ-Variance Analysis of Endo- and Ectoparasites in Hair Sheep

| *Characteristics* | *Factors* | | | | |
|---|---|---|---|---|---|
| | *Breed* | *Sex* | *Season* | *Age* | *Farming system* |
| FG | 2 | 1 | 2 | 2 | 3 |
| | | | *Helminths* (a) | | |
| Chabertia | n.s. | n.s. | *** | ** | *** |
| Bunostom. | n.s. | n.s. | *** | *** | *** |
| Oesophag. | n.s. | n.s. | *** | *** | *** |
| Strongyl. | n.s. | ** | *** | *** | *** |
| Haemonchus | n.s. | ** | *** | *** | *** |
| Ostertagia | n.s. | ** | *** | *** | *** |
| Trichostr. | n.s. | ** | *** | *** | *** |
| Moniezia | n.s. | n.s. | *** | ** | *** |
| Fasciola | n.s. | n.s. | n.s. | n.s. | n.s. |
| Dyctiocau. | n.s. | n.s. | *** | *** | n.s. |
| | | | *Protozoae* (b) | | |
| Trypanosoma | *** | n.s. | n.s. | ** | *** |
| Eimeria | * | n.s. | *** | ** | *** |
| | | | *Arthropods* (c) | | |
| Boophilus | n.s. | n.s. | *** | *** | n.s. |
| Chorioptes | *. | n.s. | *** | *** | n.s. |
| Psoroptes | n.s. | n.s. | *** | n.s. | n.s. |
| Bovicola | n.s. | n.s. | n.s. | n.s. | *** |
| Dermatobia | n.s. | n.s. | * | ** | ** |
| Tabanus | *** | n.s. | *** | n.s. | *** |

*** significant at 0,1%, ** significant at 1%, * significant at 5%, n.s non-significant

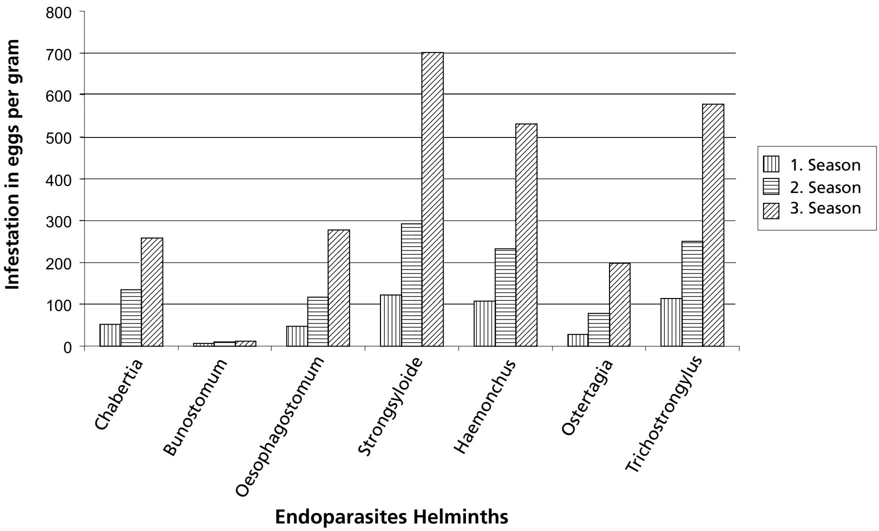
## 3.4 Age

The age of the animals played a major role (see Fig 2). *Boophilus microplus* and *Dermatobia hominis* showed the greatest significance in relation to the age (see Tab. 1c).

### 3.5 Farming system

Only in *Fasciola hepatica* and *Dictyocaulus spp.* the farming system had no effect on their population (Tab 1a). Table 1d shows great differences between the effect of the farming system on the populations of *Bovicola spp.*, *Dermatobia hominis* and *Tabanus spp.*.

**Figure 1:** Influence of the season in the infestation of Hair Sheep Endoparasites (Helminths).




## 4 Conclusions

Climate conditions like rain, temperature, season and humidity can positive or negative influence the development of parasites of ruminants in external conditions. These variables could have an effect on the size and form of the different parasites (Craig and Wiske, 1995). The infestation with parasites can change in dependence to climate changes. In dessert regions is the infestations with parasites low, while in the tropic and subtropic it can be high, especially endoparasites like *Cooperia* and *Oesophagostomum spp.*. In countries with seasons are *Trichostrongylus*, *Cooperia* and *Ostertagia spp.* the most common endoparasite (Suarez and Busetti, 1994). According to Delgado (1989) temperatures between 25 and 30°C and very high humidity facilitates the development of different kinds of parasites. Low or really high temperatures retard this development. In our study, the infestation with endoparasites, especially *Strongyloides spp.* and *Haemonchus spp.*, was very high between the second and the third season, coinciding with the beginning of the rainy season.

**Figure 2:** Influence of the age in the infestation of Hair Sheep Endoparasites (Helminths).

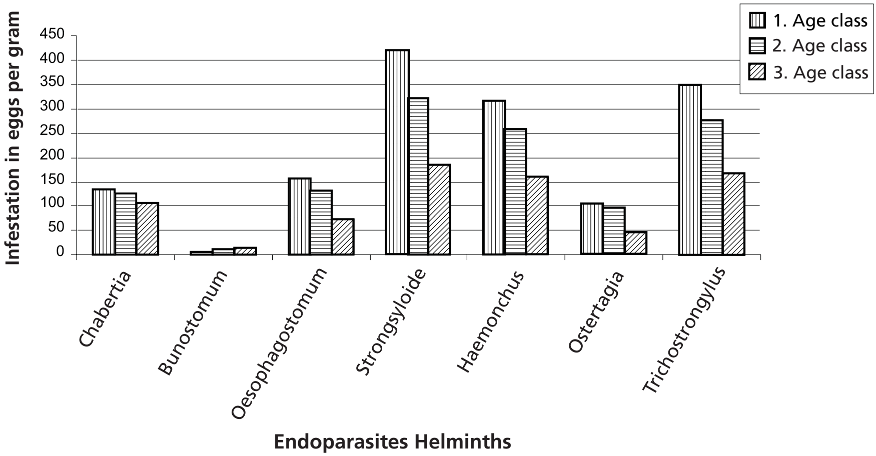
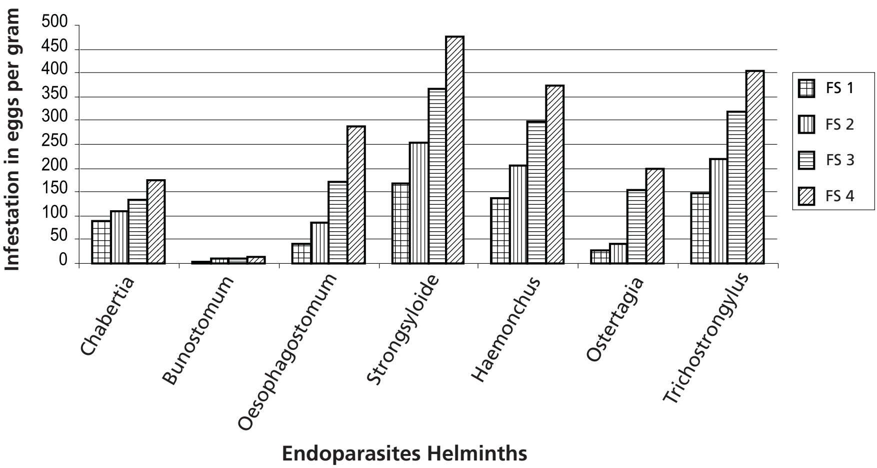



**Figure 3:** Influence of the farming system in the infestation of Hair Sheep Endoparasites (Helminths).



Animals aged between one and six months were more susceptible to acquiring parasitic diseases, since their immune system is not completely developed yet (Bowman, 1999).

One of the most important aspects for the classification of the farming systems in Sucumbíos-Ecuador was the rotational grazing, that consisted on the transfer of animals from infected grasses to dry or parasites free grasses. In the first and second farming systems, this measure took place, but not in the other two (Fischer *et al.*, 2000), that is because the parasitic charge was in the third and fourth group higher. Free range grazing was the most practised form of keeping, the labour input minimized. Scientists from Cuba (Delgado, 1989) verified a reduction of infections with *Dictyocaulus viviparus* by rotation with a standby from about 33 days.

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# The Thermal Conductivity: An Alternative Method for the Measurement of Soil Compaction.

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**Abstract**
Four treatments of tillage were compared by measuring soil thermal conductivity. Bulk density and difference between treatments pointed to the discriminatory capacity of the method. The soil thermal conductivity measure or Electrothermal Method (EM) has demonstrated to be a new and reliable indicator for the compaction state of soil.

**Keywords:** thermal conductivity, tillage, soil compaction, soybean, cocoa

## 1 Introduction

The development of appropriated tillage systems requires knowledge of mechanisms that influence compaction changes in the different tropical soils. A tillage treatment is defined by the use of different heavy machineries to prepare the land for different cultivation uses. However, the intensive use of heavy machinery has involved soil compaction problems (i.e. volume reduction of soil pores), and production decrease of different crops up to 40%. As example, we have the sugarcane cultivation in the Departamento del Valle del Cauca, Colombia (RODRÍGUEZ, 1996; TORRES, 1995). Very few experiments have studied the effects of tillage methods on soil compaction or yield in tropical crops (SWANTON *et al.*, 1999; BRANDT, 1992). There are a multitude of factors affecting soil compaction, and evaluation of these factors is important to our understanding. Therefore, a study was initiated to determine the efficient of thermal conductivity to measure impacts of tillage systems on soil compaction.

## 2 Soil thermal conductivity

One of the most important processes of heat transport in soil under normal conditions is conduction. Conduction refers to the transport of heat by molecular collisions. For a soil, the heat flow equation is given by:

$$D_T \nabla^2 T - \frac{\partial T}{\partial t} + r_H = 0 \qquad (1)$$

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where $D_T = \lambda / C_{soil}$ is the soil thermal diffusivity, $T$ is temperature, $t$ is the time, $C_{soil}$ is the soil volumetric heat capacity (assuming $C_{soil}$ constant), $r_H$ is a source or sink of heat, and $\lambda$ is a constant called soil thermal conductivity (PORTA *et al.*, 1994).

## 3 Measurement of soil thermal conductivity

The Electrothermal Method is strictly a laboratory technique and can be used in situ. The method uses a cylinder (5×5 cm), which is wrapped by a thin metal wire that is heated electrically to serve as the heat source and a thermocouple to measure the temperature rise. The thermocouple is placed inside the cylindrical tube, which is inserted into the soil. When the wire is connected to a continuous current, the wire heats up causing heat to flow radially. Due to cylindrical symmetry Eq. (1) must be expressed in cylindrical coordinates

$$D_t \left( \frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} \right) - \frac{\partial T}{\partial t} = - \frac{T_0}{D_T} \tag{2}$$

With the boundary and initial conditions:

$$\left. \frac{\partial T}{\partial r} \right|_{r=a} = qT \quad ; \quad T_{(r=a)} = T_0$$

The steady-state is obtained by Laplace Transform method:

$$T = T_0 + \frac{q}{4\pi\lambda} \ln \tau \tag{3}$$

Where $T_0$ is the temperature at time $t_0$, $q$ ($\Delta V I t$, $\Delta V$: voltage, $I$: electrical current) is the heat flowing per unit time and unit length of wire, and $\tau$ is a parameter related to time $t$. A graph of $T$ as a function of $\ln \tau$ is a straight line whose slope is proportional to the inverse of soil thermal conductivity ($\lambda$) (BUCHAN, 1991; CARSLAW and JAEGER, 1959).

## 4 Experimental design

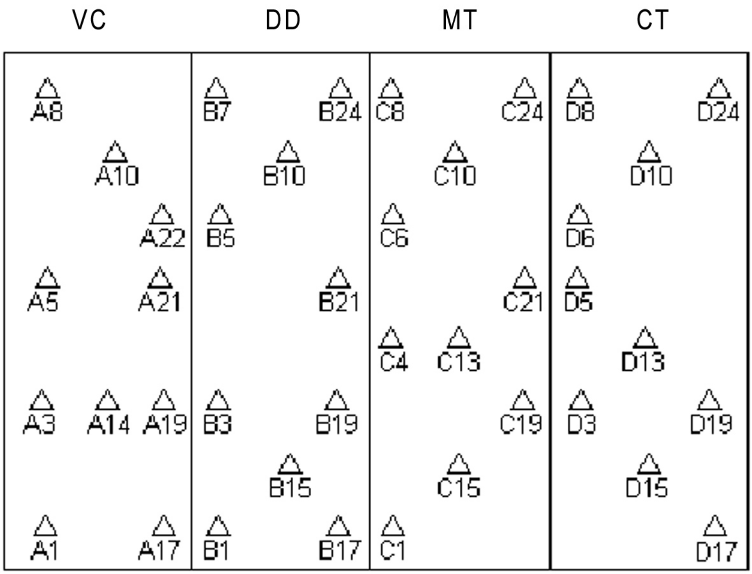
The investigation was carried out on a soybean field (Lote Number 14), at the research station of CORPOICA, Palmira (Colombia). The investigation area was 3,5 ha divided in four blocks (54 m-wide and 170 m-long). Each treatment belongs to a block. The possible relationship between thermal conductivity and soil compaction was measured on the following four treatments: Vibratory Chisel (VC), Conventional Tillage (CT), Direct Drilling (DD) and Mulch Tiller (MT).

The results were compared with a cocoa field (Lote Number 30, 2,35 ha), which was left without tillage for more than 30 years. The purpose of the cocoa field is to have a reference pattern to the variation of the physical properties such as to relate them with the different soil compaction treatments (REYES and VIERA, 2001; RUIZ, 1999). The distribution of the field design is presented in the figure 1.

## 5 Results and Discussions

Measurements were taken at two depth levels: $h_1$ from 0 cm to 10 cm and $h_2$ from 10 cm to 20 cm. Since the traditional measurement to evaluate the soil compaction grade

**Figure 1:** Distribution of the field design.




is given by bulk density ($\rho_a$), therefore this parameter was measured in order to relate it with the soil thermal conductivity ($\lambda$). Figure 2 shows the characteristic curve the heat flow for Conventional Tillage treatment.

Table 1 shows mean values for each physical properties evaluated and the corresponding significant difference. From this table we can see that there are two groups conformed in this way: Group 1, VC- and CT-treatments, and Group 2, DD- and MT-treatments have highly significant difference of soil thermal conductivity $\lambda$. However, for bulk density there is no difference; therefore you cannot efficiently infer state of soil compaction using these parameter.

By comparing the results of bulk density and soil thermal conductivity the four treatments can be divided in two groups (Table 2): Group 1, representing VC and CT; Group 2, conformed by DD and MT. For bulk density, a 2,5%-significance was obtained for $h_1$, and 0,5%-significance for $h_2$. For thermal conductivity, a 0,1%-significance was obtained; this shows that the electrothermal technique can differ statistically, with high significance (Reyes, 1980) the two groups among the studied treatments.

Table 2 shows values of soil thermal conductivity and bulk density among the treatments, to the two evaluated depths.

According to these results, soil thermal conductivity provides highly significant information for determining the degree of soil compaction. There is a high probability that the differences between treatments are highly statistically significant. This could be due to

**Table 1:** Values for soil thermal conductivity $\lambda$ and bulk density $\rho_a$ for four treatment of tillage and reference pattern and statistical variance analysis of $\lambda$ and $\rho_a$ for all treatments.

| *Treatments* | *Soil depth $h_1$* | | *Soil depth $h_2$* | |
|---|---|---|---|---|
| | *thermal conductivity* $\lambda\left(\frac{Cal}{cm\ s\ {}^\circ C}\right)$ | *bulk density* $\rho\left(\frac{g}{cm}\right)$ | *thermal conductivity* $\lambda\left(\frac{Cal}{cm\ s\ {}^\circ C}\right)$ | *bulk density* $\rho\left(\frac{g}{cm}\right)$ |
| VC | 0,85 a | 1,53 ab | 0,83 a | 1,61 ab |
| DD | 1,03 b | 1,68 c | 0,99 b | 1,70 c |
| MT | 1,05 b | 1,56 b | 1,04 b | 1,67 bc |
| CT | 0,87 a | 1,55 ab | 0,86 a | 1,65 bc |
| cocoa | 1,18 c | 1,45 a | 1,06 b | 1,56 a |
| LSD | 0,09 (1%) | 0,11 (1%) | 0,09 (1%) | 0,05 (5%) |

* LSD: Least significant difference.

Values with same letter in each column do not differ significantly.

**Figure 2:** Characteristic curve of temperature as function of logarithm of $\tau$ for the Conventional Tillage treatment.

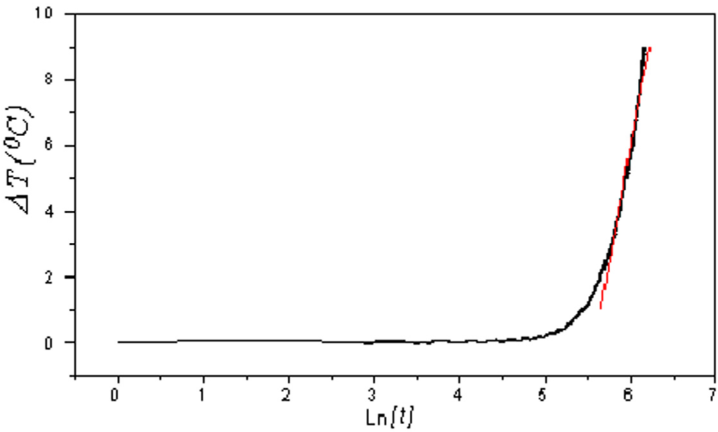


**Table 2:** Statistical values by means of t-Student test between treatments for thermal conductivity $\lambda$ and bulk density $\rho_a$.

| *Comparisons* | *thermal conductivity ($\lambda$)* | | *bulk density ($\rho_a$)* | |
|---|---|---|---|---|
| | $h_1$ | $h_2$ | $h_1$ | $h_2$ |
| VC vs. CT | NS | NS | NS | NS |
| VC vs. MT | NS | S (5,0%) | HS (0,1%) | HS (0,1%) |
| VC vs. DD | HS (0,1%) | HS (0,1%) | HS (0,1%) | HS (0,1%) |
| DD vs MT | HS (0,1%) | NS | NS | NS |
| DD vs CT. | HS (0,1%) | S (0,5%) | HS (0,1%) | HS (0,1%) |
| MT vs CT | NS | NS | HS (0,1%) | HS (0,1%) |
| VC-CT vs DD-MT | S (2,5%) | HS (5,0%) | HS (0,1%) | HS (0,1%) |

NS: no significance, S: significance, HS: high significance.

the fact that heat conductivity is controlled by all three phases (solid/liquid/gas) of the soil.

Lastly, figure 3 shows a zonification for $h_1$ and figure 4 for $h_2$, comparing the results of thermal conductivity and soil bulk density; it can be seen that thermal conductivity shows greater significant difference between the four treatments.

## 6 Conclusions

The dependence of soil thermal conductivity on all three phases that compose soil, is an advantage, in that it is affected by properties of the whole soil. As all three phases affect thermal conductivity, both static and dynamic soil properties are reflected in heat conduction measurements.

The Vibratory Chisel treatment presented lowest values of $\lambda$ because better structural conditions are found in this treatment, involving lowest values of $\rho_a$ all together. This situation coincides with the lowest packing grade between soil solid particles and thus betters aeration conditions decreasing consequently the heat conduction in soils.

Mean values of soil thermal conductivity for Direct Drilling treatment are high because of the lack of tillage which increases compaction. At the same time, the morphological structure shape of the soil remains undisturbed, thus preserving many micropores. In this case, heat conduction is high as is the contact area between soil particles, involving compaction problems.

The Mulch Tillage treatment presents an improvement in soil physical properties within the first 10 cm-depth; this is a consequence of progressive incorporation of crop residuals.

**Figure 3:** Spatial distribution to the four tillage treatments by means values of soil thermal conductivity and bulk density to $h_1$.

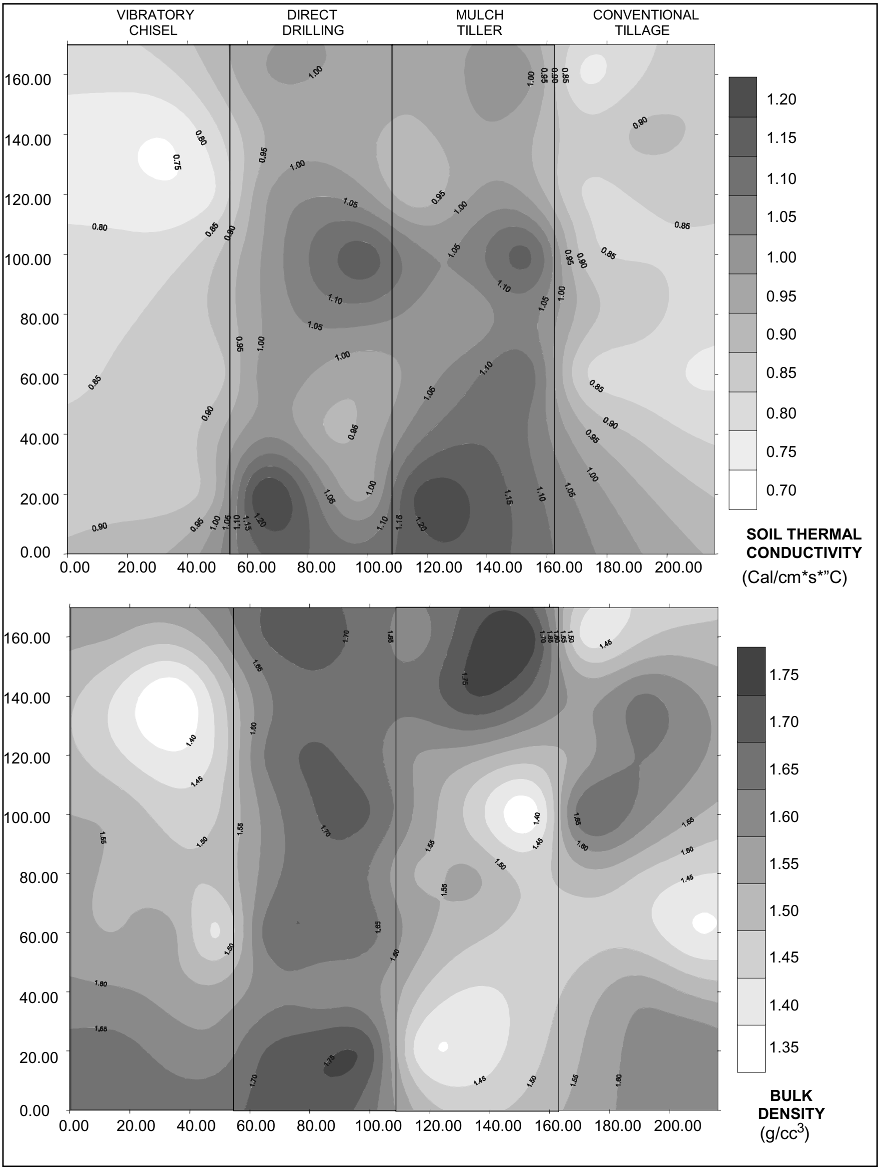
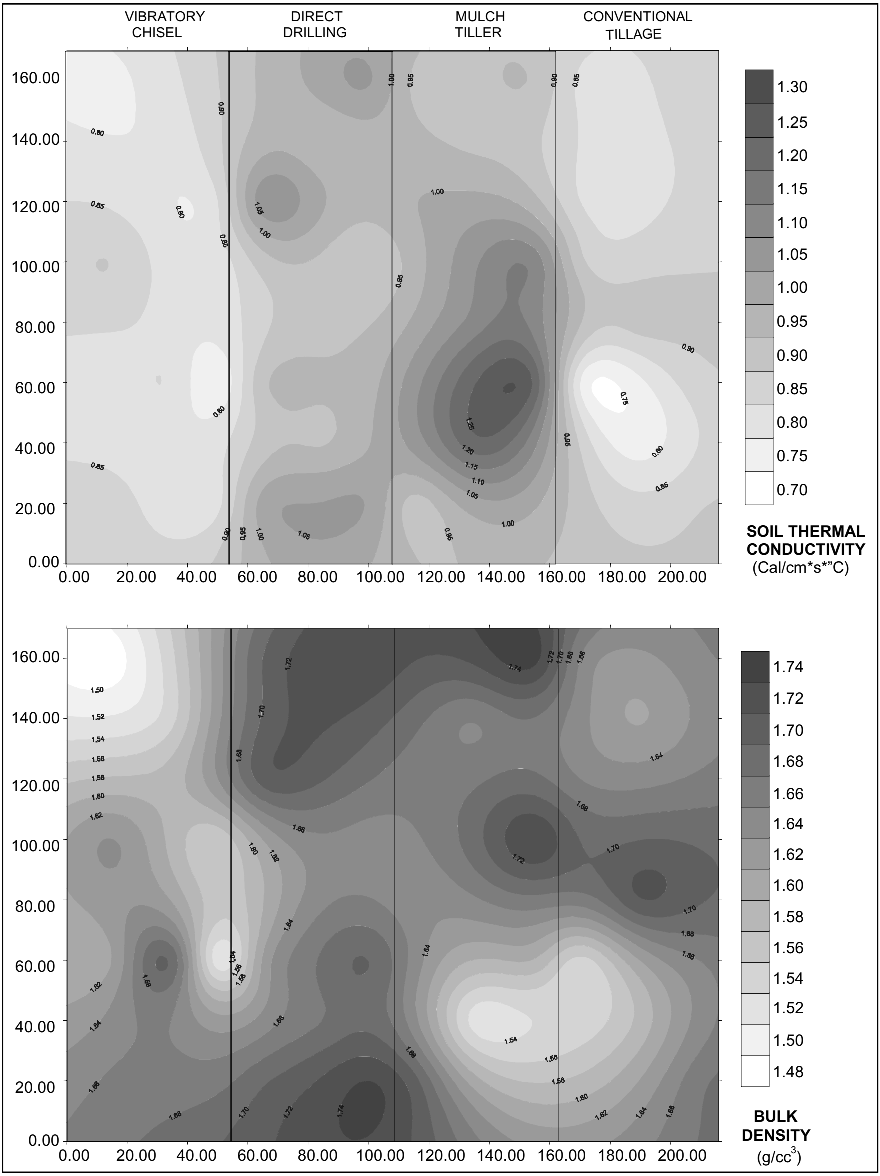


**Figure 4:** Spatial distribution to the four tillage treatments by means values of soil thermal conductivity and bulk density to $h_2$.



The thermal conductivity evaluations carried out in Conventional Tillage treatment, showed an increase of conductivity in comparison to VC treatment. This shows that CT degrades soil physical properties, as shown by the variability of the bulk density values for this treatment. However the most stable values of the thermal conductivity for this treatment show that it is a better indicator of soil physical degradation.

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# Goats Husbandry for Extensive Use

**A. Neofitides*[1], E. S. Tawfik[1]**

**Abstract**

Twenty-six crossbred dams of the $F_3$ generation and twenty Cashmere dams were surveyed with regard to their productivity, hardiness and resilience.

The endoparasite situation was recorded for both the dams and lambs of both breeding groups. Productivity data of both breeding groups included figures on reproduction and dressing percentage.

Using a scoring key, the rate of claw growth of both breeding groups was recorded as a possibility of comparison.

**Keywords:** goat breeding programme, extensive production, reproduction data, claw, endoparasites

## 1 Introduction

Most goats are mainly kept in the Tropics and Subtropics by a poorer population for subsistence reasons. Marginal locations, little know-how and an extensive production orientation characterize these locations.

Due to the goat's small stature it is possible for a poorer population in rural areas and settlements to keep goats on smaller areas or in areas where the animals are fed with collected feed. The direct income of goat keeping (the sale of milk or meat) often plays a more important role than the improvement in nutrition for the population concerned.

For successful husbandry it is important however to choose suitable stock. According to their genetics, husbandry should be adapted to the climate and marginal supply of feed.

## 2 Background and aim of the study

The work for this goat breeding programme was start up in 1995 from Tawfik and Rahmann (1995). The aim of this programme was to achieve a breed by crossing for extensive production with:

- ▷ a good breeding capacity
- ▷ robustness, weather hardiness and resilience,
- ▷ an adequate muscle build
- ▷ good, frugal feeding capacity

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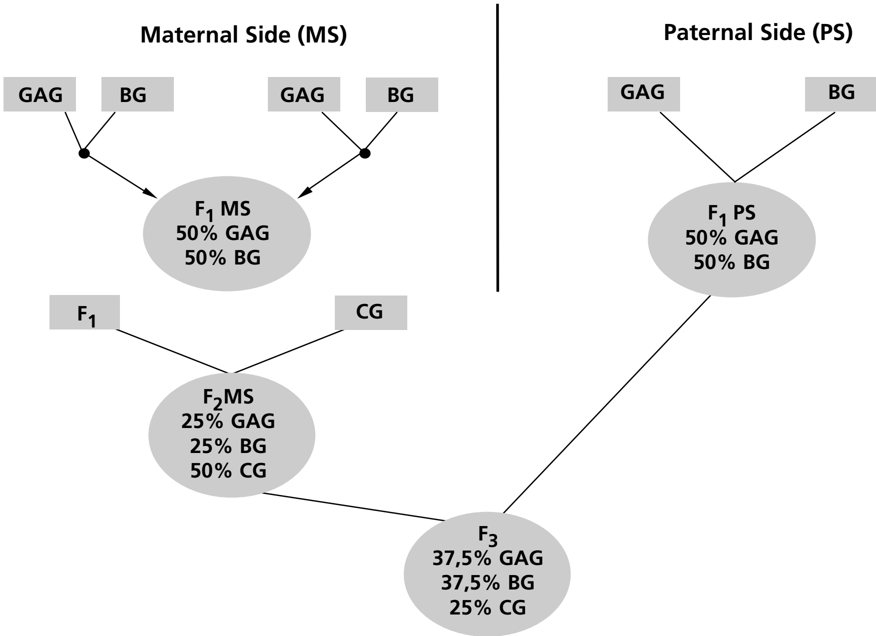
Three breeds were chosen:

- ▷ German Alpine Goat (GAG) for good milk capacity
- ▷ Boer Goat (BG) for good meat capacity
- ▷ Cashmere Goat (CG) for robustness and good fibre capacity

**Figure 1:** Graphic representation of the breeding programme.




One aspect is the surviving of the breeding capacity and robustness of the final breeding group ($F_3$ - generation) to record the current breeding level. The data to be recorded also on one of the three original breeds, i.e. the Cashmere goat. Since the Cashmere goat has been taken into the goat breeding programme due to its robustness, a comparison with this original breed is especially important to examine the breeding progress with regard to robustness.

Productivity, health and robustness are basically the most important quality characteristicts. Endoparasites are one of the most prevalent causes of small ruminant losses. The costs caused by this are immense. Infestation with various gastro-intestinal-strongylids cause the main losses. Parasites resistence and illnesses are important for economic and ecological reasons. Due to reduced or non-use of anthelmintika grazing areas are less burdened or not burdened at all by faecal residual substances.

# 3 Aspects of Investigation

## 3.1 Endoparasites

Speedy *et al.* (1992) found a possible resistance to parasites in tests with sheep. In their paper they also noticed an increasing parasite prevalence in lambs. This developed to a fairly high infestation over a longer period of time. Furthermore they pointed out the problem of parasite resistance after the use of anthelmintika (over a period of years).

Mandonnet *et al.* (2001) conducted an investigation on Creole goats in the Tropics to record the genetic variance of resistance to endoparasites. The goats became infected mainly with endoparasites, e.g. *Haemonchus contortus* and *Trichostrongylus colubriformis*. These results correspond to trials done before and confirm that breeding towards parasite resistance is possible and advantageous.

The number of eggs (or oocysts with Eimeria) per gram of faeces can be a characteristic for selection. Goats which excrete fewer worm eggs, are not so encumbered with worms (Russel, 1998).

## 3.2 Assessment of claws

The goats' claws are adapted to their original habitat, i.e. arid and stony regions. The claws are hard and the horny areas grow well (3-5 mm/month). Due to this good horny growth the claws are well adapted to the wear and tear on stony regions (Gall, 2001). However if the horn growth is more than is worn down, soil, stones and dung can be found under the growth of curved outer horn.

This material is an ideal medium for possible infections which infiltrate the horny areas and can cause foot rot (Späht and Thume, 1997). Good care of the claws and tissue is absolutely necessary. Depending on the number of animals care and management of the claws can be costly and time consuming.

## 3.3 Productivity

One of the main indicators of productivity is the reproduction capacity. Classical data for reproduction are the kidding rate and rearing results. Important is the birth weight of the kids and the development of the animals in general within a certain period of time. A series of scientific papers have confirmed the importance of high birth weights (or a negative effect with low birth weights). This plays an especially important role for survival of the new born kids (Löer, 1998; Awemu *et al.*, 1999; Husain and Horst, 1995).

The negative effect of a low birth weight can be seen by the significant longer period of time taken for the first intake of colostrum (Krogmeier *et al.*, 1990). With a later colostrum intake the antibody transfer after birth is not sufficient. This can be seen in kid losses within the first seven weeks where the immunglobulin concentration in the blood is significantly the lowest compared to healthy kids with a sufficient and timely colostrum intake (O'Brien and Sherman, 1993).

## 4 Material and Methods

### 4.1 Animal material and survey set up

All data recorded were from animals from the stock of the Department of International Animal Husbandry of the University of Kassel . They consisted of 20 Cashmere dams and 26 crossbred dams of the $F_3$ generation. The data on endoparasite infection and the monitoring of the growth of hoofs has been taking place during the whole of the year 2002 and therefore not yet completed.

### 4.2 Endoparasites

Every two months (start February 2002) the number of endoparasites was accounted for in a coproscopic trial by counting the eggs under microscopic conditions. The main point of survey was the gastro-intestinal strongyle and protozoa (see Table 1)

**Table 1:** Parasites according to family

| *Helminths* | *Protozoae* |
|---|---|
| Haemonchus contortus (round worm) | Eimeria (coccidies) |
| Strongyloides papillosus (dwarf thread worm) | |
| Cooperia oncophora (hair worm) | |

Faeces were extracted using small plastic bags. As parasites at this time are only few in number and can also be very small, the trial was facilitated with a $NaCl$-solution. Using a process of flotation which assists the buoyancy of the light stages of parasites in a heavy solution, counting took place according to McMaster. The size was in eggs per gram faecal material (Epg).

**Table 2:** Age structure and number of animals in the survey

| *Breeding group* | *Age structure* | *No. of animals* |
|---|---|---|
| $F_3$ generation | Kitze | 20 |
| | Yearlings | 1 |
| | Mother goats | 26 |
| Cashmere | Kitze | 14 |
| | Yearlings | 5 |
| | Mother goats | 20 |

Due to the poor comparability the data of the yearlings ($F_3$ generation n=1 and Cashmere n=5) have not been taken into consideration in the assessment.

### 4.3 Claw assessment

The claws of the $F_3$ generation were examined with regard to the intensity of growth and the frequency of the claw cutting. Parallel to the $F_3$ generation the condition of the claws of the Cashmere goats was recorded for reasons of comparison. Using a grading method (see Table 3) the claw condition was recorded and classified.

**Table 3:** Grading Code for classification of the growth of claws

| | |
|---|---|
| 1 - very good | Small claw growth<br>Normal clipping of claws can take place |
| 2 - good | Small claw growth, however small cavities has developed |
| 3 - bad | Quick growth of claws, hollow and cavities development |
| 4 - very bad | Very quick growth of claws. Large deformation of the claws.<br>Horny layer of claw can be separated from the outer claw wall easily |

### 4.4 Productivity

All reproduction data were recorded during the lambing season between February and March 2002. The birth weight and the weight development of the kids of both breeding groups were recorded during a period of 8 weeks. The male kids of both breeding groups were used for meat, and data was recorded for classification of slaughtering. The feeding trials for the breeding groups under marginal feeding conditions have not been completed and are therefore not mentioned further here. The conditions on a marginal feed location were investigated in a three month long trial. Both breeding groups with their female offspring were tested (kidding season 2002) without added feed to record the weight development.

## 5 Preliminary Results

### 5.1 Test of endoparasites

The preliminary results show the counts in the faecal trials during the months February, April, June and August. The kids of both breeding groups were only included in the trial group from the end of April. In the following tables the arithmetic mean values of the quantitative coprological trial for each breeding and age group have been recorded, divided up according to the months of the survey.

Striking for both breeding groups is the big difference in the egg and oocysts excretion in comparison in the age groups. The kids excrete far larger amounts of eggs and oocysts than the mother animals. Considering the excretions of the kids differentially it can be seen that in the $F_3$ generation the excretion of all parasites was lower than with the Cashmere kids. It is a similar case with the mother animals.

**Table 4:** Results of the coprological survey on the $F_3$ kids

| *Parasite* | *Mean value* | | |
|---|---|---|---|
| | *April, n=20* | *June, n=19* | *August, n=19* |
| Eimeria (Opg) | 3475.5 | 5263.16 | 5157.89 |
| Haemonchus contortus (Epg) | 710.71 | 923.08 | 842.30 |
| Cooperia oncophora (Epg) | 410.71 | 453.84 | 484.61 |
| Strongyloides papillosus (Epg) | 571.43 | 611.54 | 565.38 |

**Table 5:** Results of the coprological survey on Cashmere kids

| *Parasite* | *Mean value* | | |
|---|---|---|---|
| | *April, n=14* | *June, n=13* | *August, n=13* |
| Eimeria (Opg) | 4267.86 | 5784.62 | 5650.0 |
| Haemonchus contortus (Epg) | 1000.0 | 1292.11 | 1013.16 |
| Cooperia oncophora (Epg) | 402.5 | 442.11 | 460.53 |
| Strongyloides papillosus (Epg) | 560.0 | 665.79 | 636.84 |

### 5.2 Claw assessment

The mean value of the animals surveyed is taken for the claw assessment. The preliminary results only contain data of the mother animals and the yearlings as the kids were on average 1-2 weeks old when the first claw care took place in 2002 (March/April).

It is noticeable there is a better assessment for the group of the $F_3$ generation of the mother goats. The individual yearling of the $F_3$ generation is not sufficient for a qualitative statement. Grading with the kids of both breeding groups will show whether there is a positive trend.

**Table 6:** Results of the coprological survey on the mother animals of the $F_3$ line

| *Parasite* | *Mean value (n=26)* | | | |
|---|---|---|---|---|
| | *February* | *April* | *June* | *August* |
| Eimeria (Opg) | 425.0 | 378.85 | 373.08 | 409.62 |
| Haemonchus contortus (Epg) | 157.69 | 180.77 | 232.69 | 242.31 |
| Cooperia oncophora (Epg) | 111.54 | 167.31 | 217.31 | 209.62 |
| Strongyloides papillosus (Epg) | 109.62 | 203.85 | 265.38 | 261.54 |

**Table 7:** Results of the coprological survey on Cashmere mother animals

| *Parasite* | *Mean value (n=20)* | | | |
|---|---|---|---|---|
| | *February* | *April* | *June* | *August* |
| Eimeria (Opg) | 446.5 | 445.0 | 430.0 | 405.0 |
| Haemonchus contortus (Epg) | 120.0 | 215.0 | 292.5 | 272.5 |
| Cooperia oncophora (Epg) | 157.5 | 262.5 | 290.0 | 365.0 |
| Strongyloides papillosus (Epg) | 152.5 | 270.0 | 372.5 | 302.5 |

**Table 8:** Claw assessment of both breeding groups

| *Breeding group* | *Age structure* | *No. of animals* | *Mean values of grading ** |
|---|---|---|---|
| $F_3$ generation | Kids | — | |
| | Yearling | 1 | 1 |
| | Mother goats | 26 | 1.43 |
| Cashmere | Kids | — | |
| | Yearling | 5 | 1.86 |
| | Mother goats | 20 | 2.19 |

* 1: very good / 2: good / 3: bad / 4: very bad (see also Table 3)

## 5.3 Productivity

### 5.3.1 Reproduction data

The following reproduction data were recorded for both breeding groups

- Fertilisation = kidded mother goats / serviced mother goats
- Kidding rate = kids born / serviced mother goats
- Kidding results = kids born / kidded mother goats
- Rearing results = reared kids (after 90 days) / kidded mother goats
- Rearing rate = reared kids (after 90 days) / kids born
- Productivity = reared kids (after 90 days)/ serviced mother goats

The reproduction data show in all points excluding data for kidding results slightly increased values for the $F_3$ generation (Table 9).

**Table 9:** Reproduction data 2002

| *Reproduction data* | *Cashmere* | $F_3$ *Generation* |
|---|---|---|
| Serviced goats | 20 | 26 |
| Kidded goats | 17 | 24 |
| Kids born | 29 | 41 |
| Reared kids (after 90 days) | 25 | 38 |
| Fertilisation rate | 0.85 | 0.92 |
| Kidding rate | 1.45 | 1.58 |
| Kidding results | 1.71 | 1.71 |
| Rearing results | 1.47 | 1.58 |
| Rearing rate | 0.86 | 0.93 |
| Productivity | 1.25 | 1.46 |

### 5.3.2 Birth weights

The differences in birth weights can easily be identified between the individual breeding groups and within the breeding groups. Table 10 shows the mean values for the birth weights of both groups and sex.

**Table 10:** Birth weights of breeding groups and sex

| *Breeding group* | | *n* | *Mean values of the birth weights* |
|---|---|---|---|
| $F_3$ generation | Male | 19 | 3311.58 g |
| | Female | 22 | 2924.40 g |
| Cashmere | Male | 14 | 2595.71 g |
| | Female | 15 | 2486.43 g |

The male kids of the $F_3$ generation differ on average by 715.87 g from the male Cashmere kids, the female kids of the $F_3$ generation by 444.97 g from the female kids of the Cashmere group. The difference in birth weight between the sexes was higher in the $F_3$ generation than the cashmere group. The birth weights of the male kids were on average 377.18 g higher than both female groups. It was a similar case with the males kids of the Cashmere group.

### 5.3.3 Kids daily weight gain

The evaluation of the daily weight gain for both groups was done separately. As seen in previous trials (Haumann, 2000) the lowest daily gain for male and female kids was in the Cashmere group. The daily weight gain of both groups of the $F_3$ generation was significantly higher than the Cashmere group.

The daily weight gains were more significant according to sex within and between the groups. However the difference within the $F_3$ generation at 23.4 g was far higher than 6.33 g within the Cashmere group. Table 11 shows the daily weight gains according to breeding group and sex.

**Table 11:** Daily weight gain in the first eight weeks according to sex and breeding group

| *Breeding group* | | *n* | *Daily weight gain (g)* | *Difference* |
|---|---|---|---|---|
| $F_3$ generation | male | 17 | 167.70 | 23.40 |
| | female | 20 | 144.30 | |
| Cashmere | male | 13 | 134.81 | 6.33 |
| | female | 14 | 128.48 | |

### 5.3.4 Dressing percentage

All male kids of both breeding groups were weighed before and after slaughtering to record the dressing percentage. The age on average was 5 months. As the values in Table 12 show the difference in the dressing percentage was at 0.8% not significant. The fluctuation in the number of animals in comparison to Table 11 was due to the sale of animals.

**Table 12:** Dressing percentage of male kids of both breeding groups

| *Breeding group* | *n* | *Dressing percentage (%)* |
|---|---|---|
| $F_3$ generation | 9 | 36.39 |
| Cashmere | 7 | 35.52 |

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# Режим органического вещества в почвах естественных фитоценозах и агроценозов

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# Development of organic matter in soils of natural phytocoenoses and agrocoenoses

Y. Akramov, W. Drauschke and R. Bojmurodov

**Abstract**
The brown mountain carbonate soils covering the "yadiere" (hills) in the Gissarska valley of Tadzhikistan have relatively high humus portions. The humus content in the upper layers of sedentary soils was found to range from 2.70 to 3.18 per cent. However, in eroded soils the humus content declines from 1.35-0.83 per cent to levels as low as 0.57-0.75 per cent. The decrease of humus substances in erodible soils is mainly dependent on their slope exposure. Soils on sites sloping to north revealed the highest humus content whilst soils on east and west slopes and, in particular, on south slopes were found to have the lowest humus content.
Sprinkler irrigation applied to soils on sloping sites, following grass seeding, was found to result in swift growth and in the evolution of a natural flora what, in turn, induced intensive humus build-up. The humus content of the covering layer increased by 0.98 per cent, that in eroded soils markedly less. The increased humus content primarily leads to humic acid enrichment, this effect causing a wider SGK:SFK ratio.
Following grass seeding on these soils a marked increase in the content of dissolved and $R_2O_3$-bound humic acids can be observed.

**Keywords:** humus content, soil erosion, slope exposure, humic acid, SGK:SFK ratio, Tadzhikistan

## 1 Введение

Поступающие в почву растительные остатки подвергаются разнообразным превращениям, в результате которых значительная часть органического материала разрушается с образованием простых минеральных соединений, а другая часть, изменяясь, переходит в более устойчивую форму органического вещества почвы, получившего название гумуса. В этом разнообразии процессов прослеживаются

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два противоположных процесса, один из которых объединяет процессы разложения, а другой - процессы новообразования или синтеза (Тюрин, 1965).

Гумус - неотъемлемая часть почвы, его количество, распределение по генетическим горизонтам и качественный состав отражает сложный комплекс условий образования, эволюции почв и их плодородие (Кононова, 1963; Орлов, 1974; Александрова, 1980).

Проблема воспроизводства плодородия почв связана сгумусовым состоянием почв, за счет создаваемого в агроценозах органического вещества без высоких затрат и адаптивной системы земледелия (Шишлов и др., 1987; Кирюшин и др., 1993).

Для повышения плодородия почв, наряду с неуклонным ростом производства, использования минеральных и органических удобрений и развитием мелиоративных работ, большое значение придается биологическим процессам, в частности регулированию трансформации органического вещества. В последнее время наблюдается резкий спад поступления минеральных удобрений. Поэтому для воспроизводства плодородия весьма большое значение имеют различные методы биологизации почв.

В почвах с низким содержанием органического вещества проблема гумуса становится более актуальной, особенно в связи с влиянием орошения на органическое вещество и изменение его в процессе мелиорации и сельскохозяйственного освоения почв. Изменение органического вещества почв под влиянием антропогенного фактора изучено слабо. Недостаточно освещены особенности превращения его в эродированных почвах.

## 2 Материалы и методы

Горные коричневые карбонатные почвы распространены в низкогорной части Центрального Таджикистана и охватывают предгорья и склоны горных хребтов в пределах 800-1800 метров над уровнем моря, они развиваются под крупнотравной полусаванной растительностью ксерофитными кустарниками. Мощность гумусового горизонта достигает 25-30 см, где содержание гумуса зависит от степени эродированности и составляет 0,75-5,00 %; карбонаты выщелочены или не превышают 1-2.

Исследованные нами горные коричневые карбонатные почвы распространены на высотах 900-950 м над ур.м. на холмах Гиссарской долины. Среднегодовое количество атмосферных осадков составляет 705 мм, средняя годовая температура - 14 оС. образцы почв были отобраны до орошения (1964 г.) и в период орошения (1964 - 1997 гг.). до орошения почвы были целинными и использовались в качестве пастбищ и сенокосов. В 1964 г. на массиве (30 га) с уклоном 10-15о был заложен фруктовый сад и началось орошение сада методом дождевания и залужения без дальнейшей обработки почвы. Разрезы были заложены на почвах различной степени эродированности. Для лабораторных анализов были использованы почвенные образцы генетических горизонтов.

Определение общего количества гумуса в 3-х кратной повторности проведено по методу И.В.Тюрина (1931,1936) с фенилантраниловой кислотой в качестве индикатора (Симаков, 1957), вялового азота - по Кьеьдалю. Групповой состав гумуса определен пирофосфатным методом (Кононова, Бельчикова, 1961).

## 3 Дискуссия результатов

В результате многолетних стационарных исследований для горных коричневых почв, распространенных на высотах 900-2800 м над ур.м., выявлены закономерности распределения содержания гумуса, азота (Иловайская, 1959; Акрамов, 1987). Ими установлено, что наиболее благоприятные условия для накопления органического вещества наблюдаются при некоторой средней биогенности, в горных коричневых выщелаченных почвах Гиссарского хребта.

От горных коричневых выщелаченных почв к типичным и карбонатным почвам количество гумуса падает до 2-4 %.

Причиной сильной эродированности почв в Таджикистане является сильная расчлененность рельефа и слабая спротивляемость почв к разрушительному действию стекающей по склонам воды.

По данным М.Я.Якутилова (1965), общая площадь эродированных земель составляет 9586 тыс.га, причем свыше 8 млн.га ее приходится на сильносмытые почвы. По его данным, эродировано 64,4 % территории республики, в том числе сильно около 60 %.

В последние годы, в результате широкомасштабного исследования эродированных почв Х.М.Ахмадовым (1997), впервые, на основе параметров эколого-генетических свойств почв и диагностических показаний с использованием космических снимков, дана комплексная оценка природных и антропогенных факторов, которые определяют характерные черты развития эродированных почв в республике. Площадь эродированных земель составляет 97,9 %.

Горные коричневые карбонатные почвы разной степени смытости, исследованные нами, распространены в пределах Кафирнихонского опорного участка Института почвоведения.

До 1964 года почвы использовались как сенокосы и пастбища. В 1964 году на водоразделах (несмытые почвы), склонах (в разной степени эродированные почвы) и у подножья склонов (намытые почвы) были высажены плодовые культуры и виноградники и в тот же год было начато орошение методом дождевания и залужения (без обработки почвы), что продолжается в современный период. Степень эродированности почв определны по С.Соболеву (1948, 1960) и М.Н.Заславскому (1979).

В таблице 1 приведены параметры гумуса, азота и отношения $C : N$ до орошения (целина) и результаты их изменения под влиянием орошения и залужения.

Как показывают полученные данные в целинных почвах наибольшее содержание гумуса и азота наблюдается в несмытых почвах. Оно в гумусовом горизонте составляет 3,18 %, от которого к иллювиальному горизонту плавно уменьшается до 3,10-2,70 %. Отношение $C : N$ составляет от 8,7 до 8,3. При этом наблюдается закономерное сужение данного отношения вниз по профилю почвы.

В намытых почвах количество гумуса несколько ниже (2,45 %) по сравнению с несмытыми. Однако, оно, вниз по профилю почв, уменьшается незначительно. Отношение $C : N$ аналогично несмытым.

В целинных почвах наименьшее содержание гумуса, азота и более узкое отношение $C : N$ наблюдается в сильносмытых почвах (от 1,35 до 0,75 % и от 5,5 до 7,3, соответственно).

В сильносмытых почвах наблюдается четкая закономерность изменения содержания гумуса, азота и отношение $C : N$ в зависимости от экспозиции склона.

Наименьшее содержание гумуса, азота и более узкое отношение $C : N$ прослеживается в почвах южной экспозиции. Вышеуказанные параметры органического вещества почв от последней экспозиции возрастают к западной, восточной и северной экспозициям склонов.

В таблице 1 даны параметры изменения содержания гумуса, азота и отношение $C : N$ в исследованных почвах под влиянием орошения методом дождевания при залуживании естественной растительностью за период 1964-1997 гг.

Полученные данные показывают, что отношение целинных почв ( без обработки) приводит к резкому улучшению экологии роста и развития естественной растительности. В результате накопления большой надземной и подземной масс травянистой растительности создаются благоприятные условия для накопления большого количества гумуса во всех исследованных почвах дождевального стационара.

После орошения почв наблюдается заметное увеличение количества гумуса и азота за 33-летний период орошения. Наибольшее накопление гумуса происходит в гумусовом горизонте несмытых и намытых почвах. Степень гумусонакопления постепенно падает вниз по профилю почвы и в нижних горизонтах увеличение количества гумуса составляет 0,27 %. Здесь отношение $C : N$ несколько расширяется от 8,7 до орошения и 9,1 после длительного периода орошения.

Наивысшие параметры увеличения количества гумуса и азота приурочено в первый период орошения (1982 г.). Дальнейшее продолжение процесса ведет к накоплению их в меньшем количестве (1997 г.).

Сильно эродированные почвы менее поддаются окультуриванию под влиянием орошения. Очевидно, низкая их биологическая активность, неблагоприятные гидротермические ражимы почв не способствуют накоплению большого количества гумуса и азота. Увеличение их количества происходит медленно. В гумусовых горизонтах этих почв за 33 года накопилось 0,65-0,75; 0,50-0,56 % гумуса и 0,037-0,03-0,052 % азота. Причем, в увеличении количества гумуса и азота прослеживается четкая закономерность: максимальное накопление их в сильноэродированных почвах возрастает от почв южного к почвам западной, восточной и северной экспозиции склонов.

**Таблица 1:** Изменение содержания гумуса, азота и отношение $C:N$ в коричневых почвах под влиянием орошения методом дождевания и залуживания,%

| *Глубинасм cm* | *1964* | | | | *1997* | | | | *Прибав-ка гумуса* |
|---|---|---|---|---|---|---|---|---|---|
| | *Гумус* | $C$ | $N$ | $C:N$ | *Гумус* | $C$ | $N$ | $C:N$ | |
| *Несмытые почвы (водораздел) р. 40* | | | | | | | | | |
| 0-27 | 3,18 | 1,84 | 0,211 | 8,7 | 4,16 | 2,42 | 0,266 | 9,1 | 0,98 |
| 27-54 | 3,10 | 1,80 | 0,206 | 8,7 | 4,00 | 2,32 | 0,261 | 8,9 | 0,90 |
| 54-71 | 2,70 | 1,57 | 0,182 | 8,6 | 3,50 | 2,03 | 0,233 | 8,7 | 0,80 |
| 71-95 | 1,94 | 1,13 | 0,130 | 8,7 | 2,54 | 1,47 | 0,167 | 8,8 | 0,60 |
| 95-120 | 0,94 | 0,54 | 0,063 | 8,5 | 1,68 | 0,97 | 0,113 | 8,6 | 0,44 |
| 120-157 | 0,85 | 0,49 | 0,058 | 8,4 | 1,25 | 0,73 | 0,087 | 8,4 | 0,40 |
| 154-176 | 0,45 | 0,26 | 0,031 | 8,3 | 0,70 | 0,41 | 0,049 | 8,3 | 0,25 |
| *Намытые почвы, р.19* | | | | | | | | | |
| 0-25 | 2,45 | 1,42 | 0,160 | 8,9 | 3,45 | 2,00 | 0,220 | 9,1 | 1,00 |
| 25-30 | 2,11 | 1,22 | 1,139 | 8,8 | 3,01 | 1,75 | 0,197 | 8,9 | 0,90 |
| 30-41 | 1,85 | 1,07 | 0,123 | 8,7 | 2,70 | 1,57 | 0,196 | 8,9 | 0,85 |
| 41-70 | 1,51 | 0,88 | 0,100 | 8,8 | 2,31 | 1,34 | 0,154 | 8,7 | 0,80 |
| 70-100 | 1,43 | 0,83 | 0,095 | 8,7 | 1,70 | 0,99 | 0,116 | 8,5 | 0,27 |
| *Сильносмытые почвы, южная экспозиция, р.10* | | | | | | | | | |
| 0-16 | 0,75 | 0,44 | 0,073 | 6,0 | 1,25 | 0,72 | 0,110 | 6,5 | 0,50 |
| 16-42 | 0,65 | 0,38 | 0,063 | 6,0 | 1,10 | 0,63 | 0,096 | 6,5 | 0,45 |
| 42-60 | 0,57 | 0,33 | 0,058 | 5,7 | 0,97 | 0,56 | 0,089 | 6,3 | 0,40 |
| 60-80 | 0,49 | 0,28 | 0,050 | 5,6 | 0,84 | 0,49 | 0,082 | 6,0 | 0,35 |
| 80-100 | 0,34 | 0,20 | 0,036 | 5,5 | 0,54 | 0,31 | 0,051 | 6,1 | 0,20 |
| *Сильносмытые почвы, западная экспозиция, р.6* | | | | | | | | | |
| 0-5 | 0,85 | 0,49 | 0,079 | 6,2 | 1,41 | 0,82 | 0,122 | 6,7 | 0,56 |
| 5-45 | 0,80 | 0,46 | 0,074 | 6,2 | 1,30 | 0,75 | 0,112 | 6,7 | 0,50 |
| 45-65 | 0,74 | 0,43 | 0,074 | 5,8 | 1,19 | 0,69 | 0,106 | 6,5 | 0,45 |
| *Сильносмытые почвы, восточная экспозиция, р.3* | | | | | | | | | |
| 0-5 | 1,28 | 0,74 | 0,101 | 7,3 | 1,93 | 1,12 | 0,144 | 7,8 | 0,65 |
| 5-26 | 1,00 | 0,58 | 0,078 | 7,3 | 1,60 | 0,93 | 0,120 | 7,8 | 0,60 |
| 26-40 | 0,85 | 0,49 | 0,067 | 7,3 | 1,40 | 0,81 | 0,104 | 7,8 | 0,55 |
| 40-57 | 0,60 | 0,35 | 0,050 | 7,0 | 1,15 | 0,67 | 0,088 | 7,6 | 0,55 |
| *Сильносмытые почвы, северная экспозиция, р.23* | | | | | | | | | |
| 0-6 | 1,35 | 0,78 | 0,101 | 7,7 | 2,10 | 1,22 | 0,153 | 8,0 | 0,75 |
| 6-35 | 1,27 | 0,74 | 0,096 | 7,7 | 1,91 | 1,11 | 0,137 | 8,1 | 0,64 |
| 35-45 | 0,83 | 0,48 | 0,064 | 7,5 | 1,43 | 0,83 | 0,104 | 8,0 | 0,60 |
| 45-75 | 0,60 | 0,35 | 0,047 | 7,5 | 1,10 | 0,64 | 0,086 | 7,4 | 0,50 |
| 75-100 | 0,55 | 0,32 | 0,043 | 7,4 | 0,85 | 0,49 | 0,065 | 7,5 | 0,30 |

Таким образом, в этом ряду почв наиболее благоприятные условия при орошении создаются в почвах северной экспозиции, где происходит максимальное накопление гумуса и азота.

В исследуемых нами горных коричневых карбонатных почвах (табл.2) гумус относится к гуматно-фульватному типу с соотношением Сгк:Сфк = 0,85 - 0,95. В его групповом составе содержание подвижных и связанных $R_2O_3$ гуминовых кислот в верхних горизонтах составляет от 7 до 8 %, а в нижних они полностью отсутствуют. Содержание негидролизуемого остатка по профилю почвы составляет 48-51 %. Причем наблюдается его возрастание вниз по профилю почвы.

По сравнению с несмываемыми почвами в намытых почвах отношение Сгк:Сфк расширяется до 1-1,3 и гумус приобретает тип гуматно-фульватного. Здесь прослеживается резкое возрастание количества подвижных и связанных с $R_2O_3$ формы гуминовых кислот. Содержание негидролизуемого остатка падает до 31-43 %.

Изменение качественного состава гумуса под влиянием эрозии прослеживается во всех исследованных почвах, от несмытых почв к сильносмытым резкое уменьшение количества гумуса сопровождается уменьшением абсолютного количества всех групп гумусовых веществ. Гумус относится к фульватному и гуматно-фульватному типам. Отношение Сгк:Сфк сужается до 0,30-1,00. Количество подвижных и связанных с $R_2O_3$ гуминовых кислот резко уменьшается. Наоборот, во всех смытых почвах возрастает количество негидролизуемого остатка.

Вышеуказанные параметры качественного состава гумуса зависят от экспозиции склона. Наихудшими показателями обладают сильносмытые почвы южной экспозиции. От них к почвам западной, восточной и далее к северной экспозициям увеличение общего количества гумуса сопровождается возрастаением абсолютного и относительного содержания гуминовых кислот, что ведет в расширению Сгк:Сфк. В вышеуказанном ряду почв наблюдается некоторое увеличение количества свободных и связанных с $R_2O_3$ гуминовых кислот.

В целом, в составе гумуса смытых почв, очевидно, в результате создания жесткого гидротермического режима, процесс новообразования гуминовых кислот затухает, подвижные и связанные с $R_2O_3$ , частично выносятся вниз по склону.

В составе гумуса смытых почв общее содержание гуминовых кислот и фульвокислот незначительно. В гумусовом горизонте от общего углерода оно составляет 25-40 %, а гумины - 60-70 %. Подобные тенденции ранее были обнаружены по почвам Азурбайджана (Тюрина-Зейналашвили, 1972; Шакури, 1986) и по почвам Киргизии (Демченко, Рубина, 1973).

Под влиянием орошения и интенсивного залужения более чем за 30 лет в составе гумуса несмытых и намытых почв происходит относительное и абсолютное увеличение количества гуминовых кислот. При абсолютном увеличении фульвокислот, относительное их содержание уменьшается, в результате чего отношение Сгк:Сфк расширяется до 1,23-1,27. Гумус от гуматно-фульватного типа превращается в гуматный.

**Таблица 2:** Изменение группового состава гумуса под влиянием орошения в коричневых карбонатных почвах, % к общ.орг.С почвы

| *Глубина cm* | *C общ., н/о* | *Гумино вые кисло-ты* | *Фульва тные кисло-ты* | *Сгк : Сфк* | *Формы связи из общего кол-ва ГК* | | *Негидро-лизуемый остаток* |
|---|---|---|---|---|---|---|---|
| | | | | | *Свободные и связанные с $R_2O_3$* | *Связан-ные с $Ca$* | |
| Несмытые почвы, р.40, 1964 г. | | | | | | | |
| 0-27 | 1,84 | 25,36 | 26,69 | 0,95 | 7,95 | 92,05 | 47,98 |
| 27-54 | 1,80 | 24,37 | 25,97 | 0,95 | 7,0 | 93 | 49,36 |
| 54-71 | 1,57 | 24,38 | 27,09 | 0,9 | 8,54 | 91,46 | 48,53 |
| Несмытые почвы, р.40, 1997 г. | | | | | | | |
| 0-27 | 2,42 | 28,95 | 23,54 | 1,23 | 12,35 | 87,65 | 47,51 |
| 27-54 | 2,32 | 29,35 | 24,46 | 1,20 | 13,67 | 86,33 | 46,19 |
| 54-71 | 2,03 | 28,04 | 24,27 | 1,18 | 10,36 | 89,64 | 47,09 |
| Сильносмытые почвы, южная экспозиция, р.20, 1964 г. | | | | | | | |
| 0-6 | 0,44 | 8,00 | 23,52 | 0,34 | нет | 100,0 | 68,48 |
| 6-42 | 0,38 | 5,93 | 19,77 | 0,30 | нет | нет | 74,30 |
| 42-60 | 0,33 | 5,25 | 18,75 | 0,28 | нет | нет | 76,00 |
| Сильносмытые почвы, южная экспозиция, р.20, 1997 г. | | | | | | | |
| 0-6 | 0,72 | 12,35 | 22,45 | 0,54 | 7,65 | 93,35 | 65,20 |
| 6-42 | 0,63 | 13,00 | 22,41 | 0,58 | 7,00 | 93,00 | 64,59 |
| 42-60 | 0,56 | 11,43 | 20,78 | 0,55 | нет | 100,0 | 67,79 |
| Сильносмытые почвы, западная экспозиция, р.6, 1964 г. | | | | | | | |
| 0-5 | 0,49 | 10,85 | 24,11 | 0,45 | нет | 100,0 | 65,64 |
| 5-45 | 0,46 | 8,69 | 18,49 | 0,47 | нет | нет | 72,82 |
| 45-65 | 0,43 | 8,23 | 20,57 | 0,40 | нет | нет | 71,20 |
| Сильносмытые почвы, западная экспозиция, р.6, 1997 г. | | | | | | | |
| 0-5 | 0,82 | 15,61 | 24,02 | 0,65 | 10,35 | 89,65 | 60,37 |
| 5-45 | 0,75 | 14,09 | 21,63 | 0,65 | 10,25 | 89,75 | 64,23 |
| 45-65 | 0,69 | 13,71 | 22,85 | 0,60 | 8,44 | 91,56 | 63,44 |
| Сильносмытые почвы, восточная экспозиция, р.3, 1964 г. | | | | | | | |
| 0-5 | 0,74 | 16,75 | 26,58 | 0,63 | 5,93 | 94,07 | 56,67 |
| 5-26 | 0,58 | 15,95 | 24,54 | 0,65 | 5,00 | 95,00 | 59,51 |
| 26-40 | 0,49 | 14,00 | 26,92 | 0,52 | нет | 100,0 | 59,08 |
| Сильносмытые почвы, восточная экспозиция, р.3, 1997 г. | | | | | | | |
| 0-5 | 1,12 | 22,35 | 29,8 | 0,75 | 15,95 | 84,05 | 47,85 |
| 5-26 | 0,93 | 20,14 | 25,82 | 0,78 | 12,16 | 87,84 | 54,04 |
| 26-40 | 0,81 | 18,46 | 28,84 | 0,64 | 12,00 | 88,00 | 52,7 |
| Сильносмытые почвы, северная экспозиция, р.23, 1964 г. | | | | | | | |
| 0-6 | 0,78 | 30,95 | 25,16 | 1,23 | 13,35 | 84,65 | 43,89 |
| 6-35 | 0,74 | 27,62 | 27,8 | 0,99 | 15,5 | 84,5 | 44,58 |
| 35-45 | 0,48 | 25,13 | 27,92 | 0,90 | 13,63 | 86,97 | 46,95 |
| Сильносмытые почвы, северная экспозиция, р.23, 1997 г. | | | | | | | |
| 0-6 | 1,22 | 32,95 | 24,4 | 1,35 | 20,65 | 79,35 | 42,65 |
| 6-35 | 1,11 | 33,65 | 24,04 | 1,40 | 20,93 | 79,17 | 42,31 |
| 35-45 | 0,83 | 31,96 | 24,06 | 1,32 | 18,51 | 81,49 | 44,18 |

В сильноэродированных почвах изменение качественного состава гумуса зависит от экспозиции склона. Наименьшее изменение группового состава гумуса наблюдается в почвах южной экспозиции. Однако, и здесь наблюдается относительное увеличение количества гуминовых кислот с одновременным расширением Сгк:Сфк. Увеличение количества подвижных форм органического вещества происходит только в верхних горизонтах почвы.

От почв эжной экспозиции к почвам восточной происходит постепенное увеличение относительного качества гуминовых кислот и расширение отношения Сгк:Сфк. Образование подвижных форм гумуса происходит по всему профилю почвы. Подобное изменение наблюдается и в почвах восточной экспозиции, однако, от вышеназванных почв к почвам северной экспозиции прослеживается резкое увеличение относительного и абсолютного количества гуминовых кислот, что ведет к резкому расширению отношения Сгк:Сфк.

## 4 Выводы

Установлены закономерности изменения содержания группового состава гумуса целинных горных коричневых карбонатных почв в зависимости от их степени эродированности и экспозиции склонов. Наиболее гумусированными являются почвы северной, затем восточной экспозиции. От последних почв к западной и южной экспозициям количество гумуса резко падает. В вышеуказанном ряду почв в грунтовом составе гумуса возрастает относительное содержание фульвокислот, что сопровождается сужением Сгк:Сфк. При этом количество остатка увеличивается.

Орошение вышеуказанных почв методом дождевания и залуживания способствует частичному восстановлению гумусового горизонта смытых почв, с улучшением параметров гумусонакопления.

## 5 Резюме

Горные коричневые карбонатные почвы в пределах адыров (холмов) Гиссарской долины Таджикистана обладают относительно высокими показателями гумусового состояния. Содержание гумуса в верхних горизонтах несмытых почв составляет 2,70-3,18 %. В смытых, его количество резко уменьшается от 1,35-0,83 до 0,57-0,75 %. Снижение уровня гумуированностисильносмытых почв зависит главным образом от экспозиции склонов. Здесь наибольшее содержание гумуса наблюдается в почвах северной экспозиции склона, а наименьшее - в почвах восточного, западного и особенно южного склона.

При орошении склонных почв методами дождевания и залужения происходит бурный рост и развитие естетственной растительности, что приводит к интенсивному гумусонакоплению. Содержание гумуса в верхнем горизонте увеличивается на 0,98 %, а в сильносмытых - значительно меньше.

Увеличение количества гумуса способствует накоплению главным образом гуминовых кислот, что приводит к расширению отношения Сгк:Сфк. При залужении почв прослеживается резкое увеличение количества подвижных и связанных с $R_2O_3$ гуминовых кислот.

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## Buchbesprechungen

**Wurdinger, Manfred**; 2002

**Nassreisanbau auf organisch-biologischer Grundlage unter Verwendung des Wasserfarns *Azolla filiculoides* Lam. im westlichen Nestos-Delta/Nordost-Griechenland.**

170 Seiten, 51 Abbildungen, 41 Tabellen, Berichte aus dem Arbeitsgebiet Entwicklungsforschung. Heft 32. Westfälische Wilhelms-Universität Münster. Institut für Geographie. Format 29,0 x 20,4 cm. Copyright © Verlag C. Lienau. Münster 2002, ISBN 3-9803396-9-6; 29,– €.

Die Fähigkeit von *Azolla sp.*, Stickstoff zu binden und im Anbau mit Reis wieder abzugeben, ist vorwiegend in China und Vietnam längst bekannt. Außerhalb des asiatischen Raums sind hingegen nur selten Berichte über die erfolgreiche und kontinuierliche Verwendung von Wasserfarn zu finden. Eine Azolla-Matte auf dem Stauwasser verhindert nicht nur das Wachstum von Grünalgen sowie gasförmige $N_2$-Verluste, sondern auch das Wachstum von unerwünschter Vegetationsflora. Umfangreiche Publikationen sind der Anwendung von *Azolla sp.* als Gründüngung im Reisanbau zur Steigerung der Stickstoffverwendungseffizienz gewidmet. Dessenungeachtet wurde der Einfluss des Wasserfarns auf die Verfügbarkeit von anderen Haupt- und Spurennährstoffelementen und auf den Wasserverbrauch in der Fachliteratur bisher wenig beachtet. Es wird der Versuch unternommen, neue organisch-biologische Managementmethoden für den Nassreisanbau in Nordost-Griechenland zu entwickeln. Hier liegt die Stärke der vorliegenden Arbeit. Da die landwirtschaftlichen Nassreisanbauflächen des Untersuchungsgebiets eng mit ökologisch hochsensiblen Lebensräumen verzahnt sind, greift der Autor mit vorliegendem Werk in die gegenwärtige Diskussion um eine nachhaltige Gestaltung und umweltschonende Nutzung der in Schutzgebieten vorhandenen Flächen ein.

Das Werk ist in neun Kapitel gegliedert. Das erste und zweite Kapitel führt den Leser zunächst in die Problematik des Reisanbaus in Feuchtgebieten ein und gibt Auskunft über den Stand und die Schwerpunkte der Azolla-Forschung. Problemstellung und Zielsetzung der Arbeit schließen sich in Kapitel III an, und eine tiefgründige Charakterisierung des Untersuchungsgebiets ist in Kapitel IV zu finden. Der Versuchsaufbau und die Untersuchungsmethoden sowie die Anbaumaßnahmen werden in Kapitel V ausführlich dargestellt. Mit Hilfe von Tabellen und Abbildungen wird in den zwei anschließenden Kapiteln (VI und VII) eine überwältigende Masse von Daten präsentiert und diskutiert (pflanzenverfügbare Bodennährstoffgehalte, eine Gegenüberstellung der Effizienz der angewendeten organisch-biologischen und konventionellen Pflanzenschutzmaßnahmen, ausgewählte kornertragsbildende Faktoren und Ertragsergebnisse usw.). Interessant wäre jedoch gewesen, die Ergebnisse bezüglich des Gehalts an pflanzenverfügbaren Nährstoffen im Oberboden mit dem Gehalt an Makro- und Mikronährstoffen in Körnern und Pflanzen zu vergleichen. Schließlich versucht der Autor, ein Gründüngungskonzept unter Verwendung von *Azolla filiculoides* mit standortbezogener, integrierter Fruchtfolgeplanung in Kombination mit einem Bewässerungsmanagement zu entwickeln.

Aufgrund des Schreibstils des Autors gelingt es dem Leser nicht immer, auf den ersten Blick deutliche und aussagekräftige Schlussfolgerungen abzuleiten. Bei der Fülle des aufgearbeiteten Materials hätte man sich auch eine etwas kürzere Zusammenfassung (neun Seiten mit Unterpunkten) gewünscht. Insgesamt legt der Verfasser eine äußerst interessante und umfassende Arbeit vor, die als Ausgangspunkt für zukünftige organisch-biologisch orientierte Forschungsarbeiten betrachtet werden kann.

Victor Blandón Rivera, Witzenhausen

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Volume 104, No. 2, 2003, pages 203–204

# Kurznachrichten

### Stiftungsprofessur biologisch-dynamische Landwirtschaft:

### Europaweit erste Professur für biologisch-dynamische Wirtschaftsweise an einer Universität

Kassel/Witzenhausen. Die europaweit erste Professur für biologisch-dynamische Landwirtschaft wurde mit Unterschrift unter den Stiftungsvertrag am 25. August in Kassel auf den Weg gebracht. Die Stiftungsprofessur wird am Fachbereich Ökologische Agrarwissenschaften der Universität Kassel in Witzenhausen eingerichtet. Stifter sind die Rogau Stiftung mit dem Forschungsring für biologisch-dynamische Wirtschaftsweise, die Software AG-Stiftung, die Alnatura GmbH sowie die Zukunftsstiftung Landwirtschaft.
Diese Stiftungen finanzieren eine C 3-Professur bis zur Höhe von rund 1,1 Mio. Euro für einen Zeitraum von bis zu sechs Jahren. Aufgabe der Stiftungsprofessur wird sein, die Lehre und Forschung im Bereich der biologisch-dynamischen Landwirtschaft abzudecken. Zu den wissenschaftlichen Fragestellungen gehört es, (geeignete) Grundlagen und Methoden zur bio-dynamischen Lebensmittelqualität, Pflanzenernährung und -züchtung, zur Tierhaltung und -Züchtung sowie zur Betriebsorganisation weiter zu entwickeln.

„Wir unterstützen die Stiftungsprofesur, da die biologisch-dynamische Wirtschaftsweise eine Pionierrolle im Ökologischen Landbau spielt. Der Studiengang Ökologische Agrarwissenschaften an der Universität Kassel wird durch die Inhalte und insbesondere die methodischen Grundlagen des biologisch-dynamischen Landbaus hervorragend ergänzt“, begründet Cornelia Roeckl von der Zukunftsstiftung Landwirtschaft das Engagement der Stiftungen. Sie weist darauf hin, dass nur durch die Kooperation mehrerer Stiftungen und Unternehmen die Finanzierung möglich geworden ist. Dabei unterstrich Roeckl auch die weltweite Bedeutung der biologisch-dynamischen Landwirtschaft. Diese werde derzeit in 35 Ländern auf über 3000 Höfen mit mehr als 100000 ha Land praktiziert.

Dass die Initiative für die Professur von den Studierenden des Fachbereichs ausging, unterstrich der Dekan, Prof. Dr. Rainer Jörgensen, bei der Vertragsunterzeichnung. Die Studierenden hätten häufig Praktika in Demeter-Betrieben absolviert und die darauf entstandenen Fragestellungen in ihr Studium einbringen wollen. Bereits seit den 80er Jahren werden vom Verein zur Förderung der Lehre im Ökologischen Landbau und dem Fachgebiet Ökologischer Landbau Lehrveranstaltungen zur biologisch-dynamischen Landwirtschaft organisiert, die auf großes Interesse seitens der Studierenden stoßen. Bei der Ideenentwicklung des Ökologischen Landbaus habe die biologisch-dynamische Wirtschaftsweise mit ihrem grundlegenden Ansatz immer wieder eine Vorreiterrolle eingenommen, wie Jörgensen weiter erläuterte.

Bedeutung für den Standort Witzenhausen

Bisher gibt es in Europa noch keine Professur für die biologisch-dynamische Wirtschaftsweise an einer Universität, wie der Präsident der Universität Kassel, Prof. Dr. Rolf-Dieter Postlep anlässlich der Vertragsunterzeichnung betonte. Er dankte den Stiftern für ihr ungewöhnliches Engagement. Postlep:

„Die Integration der biologisch-dynamischen Wirtschaftsweise in Forschung und Lehre ist ein wichtiger Baustein zur Stärkung der Vorreiterrolle des Universitätsstandortes Witzenhausen und des Studiengangs Ökologische Landwirtschaft". Der agrarwissenschaftliche Standort der Universität in Witzenhausen habe seit jeher eine Art Pionierfunktion inne: Die erste Professur für Ökologischen Landbau bereits 1981, der erste und einzige Diplomstudiengang Ökologische Landwirtschaft auf der Welt, alternative Lehr- und Lernformen sowie wissenschaftliche Konferenzen, Tagungen und Beratung zeigten die Anstrengungen, die Ökologische Landwirtschaft zu etablieren. Der 1996 begonnene Prozess, den Fachbereich völlig auf Ökologische Agrarwissenschaften umzustellen, sei mittlerweile fast abgeschlossen. Nun lasse sich eine biologisch-dynamische Professur sinnvoll in das Gesamtkonzept des Fachbereichs einbetten.

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## Notes to authors

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