IMPACT OF COMPOST USE ON CROP YIELDS IN TIGRAY, ETHIOPIA

by

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Impact of Compost Use on Crop Yields in Tigray, Ethiopia

2000-2006 inclusive

Introduction

History of crop cultivation in Ethiopia

Crop cultivation in Ethiopia has a long history of at least 5000 years (Clark, 1976), and implements for cutting and grinding seed have been found in stone age sites, such as Melka Konture by the Awash River in central Ethiopia, dating back much earlier. Just when crop cultivation started in Ethiopia has not been determined, but its long history is also reflected in the high agricultural biodiversity, including endemic crops, the best known of which is the cereal teff (*Eragrostis tef*). The high diversity in crop species and genetic diversity within crops is a reflection of the environmental and cultural diversity of Ethiopia (Engels & Hawkes, 1991).

Many crops that are known to have their centres of origin in the fertile crescent of south-west Asia, for example durum wheat (*Triticum durum*), now have their highest genetic diversity in Ethiopia. The treatment of *Triticum* for the Flora of Ethiopia and Eritrea recognizes a highly variable endemic species, *T. aethiopicum*, which is more usually considered as a subspecies or variety of *T. durum* (Phillips, 1995). Other important crops with high genetic diversity in Ethiopia include the cereals—barley (*Hordeum vulgare*), finger millet (*Eleusine coracana*) and sorghum (*Sorghum bicolour*); pulses—faba bean (*Vicia faba*), field pea (*Pisum sativum* including the endemic var. *abyssinicum*), chick pea (*Cicer arietinum*) and grass pea (*Lathyrus sativus*); oil crops—linseed (*Linum sativum*), niger seed (*Guizotia abyssinca*), safflower (*Carthamus tinctorius*) and sesame (*Sesamum indicum*); and root crops—enset (*Ensete ventricosum*), anchote (*Coccinia abyssinica*), 'Oromo or Wollaita dinich' (*Plectranthus edulis*), and yams (*Dioscorea* spp.). Over 100 plant species used as crops in Ethiopia have been identified (Edwards, 1991).

European travellers, e.g. Alvares at the beginning of the 16th century (Alvares, 1961) and later ones, describe the productivity and health of the highland agriculture—crops, domestic animals and people—and compare this with the depressed situation in much of Europe at that time. Poncet (1967), who visited Ethiopia between 1698 and 1700, described his experience with the words, "no country whatever better peopled nor more fertile that Aethiopia". He describes even the mountains he saw as all well cultivated "but all very delightful and covered with trees".

However, since 1974, Ethiopia has been portrayed as a food deficit country with its people and animals suffering from drought and famine. In January 2002, over 5 million people were identified as being food insecure, and this number had risen to around 14 million by the end of the year because of the failure of the rains in much of the eastern parts of the country.

Starting in the second half of the 19th century, efforts to build an administratively centralized Ethiopian state as a reaction to European colonialism in other parts of Africa systematically destroyed local community governance because it was suspected that such communities could become possible allies of colonialists. Loss of local governance undermined local natural resource management with loss of protection of woody vegetation, lack of repair of old terraces, and general undermining of any attempts at communal management of natural resources. The feudal landlord system was maintained with the bulk of the population existing as serfs. As Ethiopia entered into the world market, these landlords mined the land resources with nothing going back to the land. Civil war exacerbated these impacts. The most visible physical impacts have been gully formation eating away the soil with vegetation recovery prevented by free-range grazing and the unregulated felling of trees for firewood and other purposes.

There were no inputs in technologies or ideas to help these small holder farmers improve their productivity. They had to continue to rely for their survival on their indigenous knowledge and the rich agricultural biodiversity that they had developed, but were unable to continue effectively using collectively for fear of political reprisal.

Then, in 1974, Emperor Haile Selassie and the feudal system of control over farmers and their land was removed in a revolution that organized the whole population into local, nominally self-governing, organizations with their own elected officials. Under the military government, called the 'Derg', there were massive efforts at land rehabilitation through mass mobilization for soil and water conservation, planting of tree seedlings, and the provision of external inputs through cooperatives. However, administration remained centralized and coercive—overall productivity did not increase. The farmers continued to be ordered about and exploited as had been done under the over-centralized feudal regime. There were also frequent and disruptive redistributions of land. The farmers had no possibility for taking collective decisions on natural resources management and no interest or incentives to invest in improving their land.

In 1991, the military government was overthrown. A new constitution that required decentralization of power and encouraged local community governance was adopted in 1995. In 1993, the Sasakawa-Global 2000 approach was launched to provide high external inputs—principally chemical fertilizer—to farmers. As from 1995, this program was taken up by the National Extension Program of the Ministry of Agriculture and Rural Development. At the beginning, fertilizer cost was subsidized, but as from 1998, the subsidy has been removed and the local price of diammonium phosphate (DAP) and urea, the chemical fertilizers used in Ethiopia, has doubled. Overall grain production in the country as a whole has increased each year since 1998. However, this has not benefited the people living in the drought prone areas of the northeast and east, who continue to depend on aid. These people have become chronically food insecure requiring annual inputs of aid as food. Whilst this food may save lives, it does not and cannot replenish productive assets that would enable people to reduce their poverty.

ISD's project on sustainable agriculture

It was against this background that, in 1995, the Institute for Sustainable Development (ISD) developed a project to work with local farming communities of small holder farmers in Tigray using an ecological, low external input approach. The major challenges addressed in the project were to:

- Restore soil fertility through making and using compost, and help farmers avoid debt paid for chemical fertilizer;
- Improve biological and physical water and soil conservation in crop land including the control and rehabilitation of gullies;

- Control, preferably stop, free-range grazing to allow more grass, herbs and trees to grow;
- Include grasses and fast growing legumes in areas treated for soil and water conservation. The most successful has been the small multipurpose indigenous tree, *Sesbania sesban* planted for animal forage and compost biomass in the rehabilitated gullies and on the bunds between fields. There has also been a rapid reestablishment of indigenous plants, particularly shrubs and trees, in the hillsides protected from grazing animals.
- Help local communities restore local control and effective management of their natural resources through the development and enforcement of their own by-laws.

Although Tigray has an area of over 50 thousand square kilometres, previously malaria prevented most of the population from living at the lower altitudes, but now all parts are being inhabited owing to effective malaria control measures. In 2003, the population of Tigray was estimated to be over 4 million, with most of the households being found above 1500 m altitude. Most households are rural practicing mixed crop/livestock agriculture. A socio-economic survey of some farming communities carried out by ISD in 2001 found that average cultivated land per household is less than one hectare usually distributed in 3-5 small separate parcels.

Average annual rainfall is 500-700 mm. The precipitation occurs mostly during a short summer (end of June to mid-September) rainy season, often falling as intense storms.

ISD started the project in 1996 with 4 local communities. By 2006, ISD was following up the project activities in 57 local communities in 12 of the 53 weredas (districts) in Tigray, the majority in the degraded lands of the central and eastern parts of the Region. A wereda (district), the lowest level of government administration, is divided into tabias. A tabia, with its elected representatives, runs the day-to-day affairs of the local communities under its jurisdiction.

From the beginning, the project has been implemented in partnership with the Tigray Bureau of Agriculture and Rural Development (BoARD) and has been funded by the Third World Network (TWN), an international NGO network with its head office in Penang, Malaysia. In 2006, TWN published the experiences of the Tigray Project (Hailu Araya & Sue Edwards, 2006). This included some of the data from monitoring the impact of compost and chemical fertilizer on crop yields in farmers' fields in Tigray. Up to and including 2005, yield data had been collected from 779 plots in farmers' fields.

In 2005 and 2006, the Swedish Society for Nature Conservation (SSNC) also provided funding to ISD for its work in Tigray. This included the publishing of a poster on the making compost to support the compost manual in Tigrinya (the local language) published in 2002 (Arefayne Asmelash, 1994 EC), and distributed to all 53 weredas of the Region.

In 2006, the FAO Natural Resources Department provided funding to help collect additional yield data from 195 plots in farmers' fields during the 2006 harvesting season, and pay for entry and statistical analysis of the data.

Materials and Methods

The objective of the project was to find out if an ecological approach could help restore soil fertility and raise crop yields, particularly for farmers in degraded areas. In 1998, yields were recorded from the fields of farmers in 4 communities that started work with ISD in 1996—(O) in Table 1. The results were encouraging (Annex in Edwards, 2003), and the BoARD requested ISD to continue to monitor the impact of compost on crop yields. Hence, starting from 2000, yields have been taken from plots in farmers' fields in 19 communities in 8 of the 53 weredas of Tigray Region. The majority of the communities (17) are found in the drought prone areas: Alamata of the Southern Zone (2 communities), and all parts of the Eastern (6 communities) and Central (9 communities) Zones of Tigray. The soils of these areas are generally poor and the rainfall is erratic. However, 2 communities are found in better endowed areas: Adi Abo Mossa in the valley of Lake Hashenge of Southern Tigray where the soils are deep, rainfall more reliable and some farmers have larger cultivated areas and large herds of cattle, and Adi Aw'ala in Western Tigray where the rainy season is generally 2-4 weeks longer than the rest of the Region. Adi Abo Mossa was included in the project because of a concern that increased use of chemical fertilizer could lead to eutrophication of Lake Hashenge.

Table 1: List of local communities from which crop yield data were taken between 2000 and 2006 inclusive

Zone	Woreda	Tabia	Community
Southern Tigray	Ofla	Hashenge	Adi Abo Mossa (O)
	Alamata	Lemat	Adi Abo Golgi
		Seelam Beqalsei	Seelam Beqalsei
Eastern Tigray	Sa'esi'e Tsada Amba	Sendeda	Tsebela
		Mai Megelta	Zeban Sas (O)
		Agamat	Gu'emse (O)
	Kilte Awla'elo	Mai Weyni	Sherafo
	Atsbi-Wonberta	Hayelom	Gergera
			Enda Maino
Central Tigray	Tahtai Maichew	Mai Berazio	Adi Nefas (O)
		Akab Se'at	Adi Gua'edad
		Ruba Shewit	Adeke Haftu
		Mai Siye	Mai Tsa'ida
		Kewanit	Hagere Selam
		Adi Guara	Tselielo
		Adi Hutsa	Kenef
	Kolla Tembien	Guroro	Shimarwa
		Miwtsa'e Worki	Adi Reiso
Western Tigray	Tahitay Adyabo	Adi Aw'ala	Adi Aw'ala
Total	8	18	19

Key – (O) refers to communities where work started in 1996/7, the others joined the project later.

The fields for taking the yield samples were selected with the farmers and chosen to represent the most widely grown crops, each of which had been grown with compost, or with chemical fertilizer, or without any input (the check). The amount of compost applied ranged from the equivalent of 5 to 15 tonnes per hectare. It was assumed that farmers had applied the recommended rates of urea and DAP, i.e. 120 kg/ha.

The method used to collect the yield data was based on the crop sampling system of FAO. Three one-metre square plots were harvested from each field to reflect the range of conditions of the crop. The harvested crop was then threshed and the grain and straw were weighed separately. For comparison, all yields were converted into kg/ha.

Most cereals are harvested leaving quite a long straw in the field (up to 20 cm) because domestic animals are put to graze in these fields as soon as the harvest has been collected. The data were recorded along with the name of the farmer, the crop and the treatment, the location and the date. The farmer kept the straw and grain. The harvested straw is important because it is the main source of animal feed during the dry season, and the animal manure and straw are important raw materials for making compost.

Results and Discussion

Between 2000 and 2006, grain and straw yield data were taken separately from 974 plots. The names of the 11 crops from which observations were recorded are given in Table 2. But 4 of these were dropped from the final statistical analysis because each had less than 10 observations. This left 7 cereal and 2 pulse crops in the final statistical analysis.

Table 2: List of crops from which yield data were recorded, 2000-2006

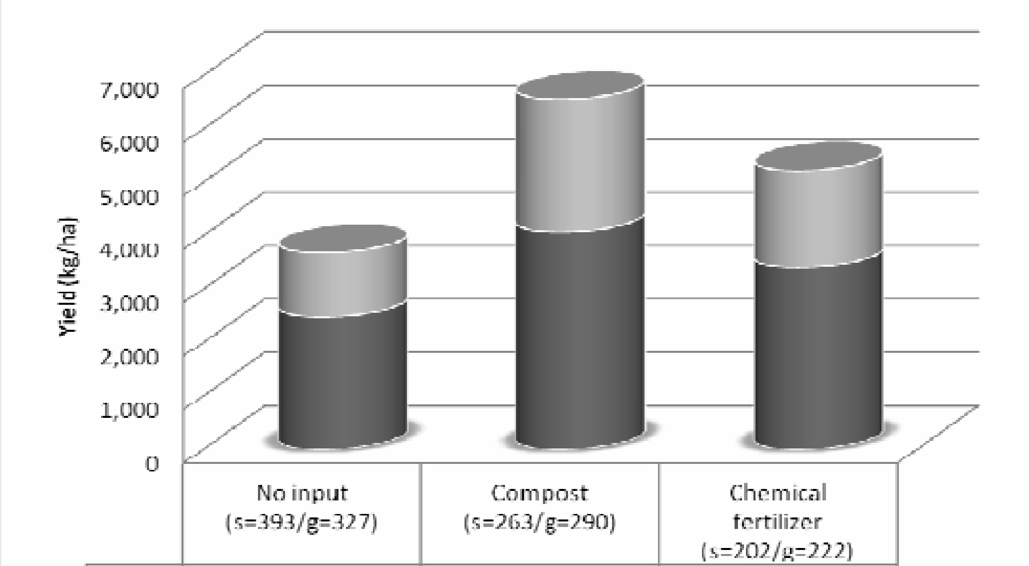
	Crop	Scientific name	Remarks
1	Barley	*Hordeum vulgare*	Many farmers' varieties are grown
2	Durum wheat	*Triticum durum*	The most widely grown wheat
3	Finger millet	*Eleusine coracana*	Not grown as widely as in the past
4	Hanfets	*Hordeum vulgare + Triticum durum*	A mixture of barley and durum wheat grown in areas prone to erratic rainfall and generally poor soils
5	Maize	*Zea mays*	Grown more for the fresh cobs than the grain
6	Millet	*Eleusine coracana*	The same as finger millet – less than 10 observations were recorded under this name
7	Sorghum	*Sorghum bicolor*	Grown more widely in the western lowlands than the highlands
8	Teff	*Eragrostis tef*	Ethiopia's endemic cereal with many varieties
9	Chick pea	*Cicer arietinum*	Not very widely grown – less than 10 observation were recorded
10	Faba bean	*Vicia faba*	The most widely grown pulse, also known as horse bean
11	Field pea	*Pisum sativum*	More often grown mixed with faba bean than by itself
12	Haricot bean	*Phaseolus vulgaris*	A recent introduction by the BoARD – less than 10 observation were recorded
13	Horse bean	*Vicia faba*	The same as faba bean – less than 10 observations were recorded under this name

The data were analysed using the statistical program, STATA. The average grain and straw yields converted from g/plot to kg/ha for each treatment for the nine crops are given in Table 3. The table also gives the number of observations included in the analysis for each crop and treatment. The average grain and straw yields as kg/ha for the seven cereal crops, based on the averages for each crop, are shown in Figure 1.

Table 3: Average yields by treatment in kg/ha for 9 crops in Tigray, 2000-2006 inclusive

	Average Yield (kg/ha)					
Crop type	**Check**		**Compost**		**Fertilizer**	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Barley	1,115	2,478	2,349	4,456	1,861	3,739
	(n=56)	(n=52)	(n=57)	(n=55)	(n=36)	(n=35)
Durum wheat	1,228	2,342	2,494	3,823	1,692	3,413
	(n=73)	(n=67)	(n=61)	(n=57)	(n=48)	(n=45)
Finger millet	1,142	2,242	2,652	4,748	1,848	3,839
	(n=16)	(n=16)	(n=14)	(n=13)	(n=8)	(n=7)
Hanfets	858	2,235	1,341	3,396	1,199	2,237
	(n=31)	(n=31)	(n=31)	(n=31)	(n=29)	(n=29)
Maize	1,760	3,531	3,748	4,957	2,900	3,858
	(n=31)	(n=20)	(n=41)	(n=31)	(n=25)	(n=13)
Sorghum	1,338	2,446	2,497	3,662	2,480	4,433
	(n=14)	(n=13)	(n=11)	(n=10)	(n=5)	(n=5)
Teff	1,151	2,471	2,143	3,801	1,683	3,515
	(n=106)	(n=94)	(n=75	(n=66)	(n=71)	(n=68)
Faba bean	1,378	2,121	2,857	4,158	2,696	3,783
	(n=20)	(n=17)	(n=23)	(n=24)	(n=3)	(n=3)
Field pea	1,527	1,201	1,964	1,625	0	0
	(n=9)	(n=9)	(n=9)	(n=9)		

'hanfets' is a mixture of barley and durum wheat
(n = number of records for each treatment and crop)



	No input (s=393/g=327)	Compost (s=263/g=290)	Chemical fertilizer (s=202/g=222)
Grain	1,200	2,473	1,812
Straw	2,477	4,073	3,404

Figure 1: Average grain and straw yields (kg/ha) for 7 cereal crops, based on the averages for each crop, Tigray, 2000-2006 inclusive
(s=number of observations for straw yield
g=number of observations for grain yield)

The data for the 9 crops were subjected to linear regression analysis by treatment based on the values obtained from fields where compost was applied, chemical fertilizer (DAP and urea) was applied and no input (check) was applied. The null hypothesis used was that the treatments have no impact on the yields. The probability that this null hypothesis could explain the results was found to be less than 0.05. In other words, the confidence limit was found to be above 95 percent. The increase in grain yields in fields where chemical fertilizer was applied was significantly higher (95% confidence limit) than in the fields where no input (check) was applied, and the grain yields in fields where compost was applied were also significantly higher (95% confidence limit) than in the fields where chemical fertilizer was applied. The significance in the differences among the straw yields for each treatment was similar. The differences among treatments in the yields of each of the crops were also similarly significant.

Except for field pea, the compost generally doubled the grain yield when compared to each respective check (Table 3). The difference was significant (95% confidence limit). The application of compost also increased straw yield compared to the check, but not to the same extent as it increased grain yield (Figure 1).

The use of compost also gave higher yields than the use of chemical fertilizer, though differences in the yields from compost and from chemical fertilizer were not as great as the differences between the use of compost and the check. For sorghum and faba bean the yields from the use of compost and chemical fertilizer were similar. But the yield difference for all the other crops was greater with that from the compost treatment being always higher than that from the use of chemical fertilizer.

The proportion, expressed in percentages, of the grain in the total harvested yield (grain + straw) for each of the 9 crops is given in Table 4. For the cereal crops, the percentages of the grain in the harvest are given in Figure 2. The data are only indicative because, as noted earlier, the farmers usually leave long stubble up to 20 cm tall from their cereal crops in the field for domestic animals to graze on. However, for faba bean and field pea all the above ground biomass is harvested. The results show that compost not only increases the overall biomass yield, but also increases the proportion of the grain to straw in the yield. The most striking crop is field pea where the proportion of grain in the total yield exceeded 50% for both the check and the compost treatment, but the field pea ‘check’ was probably grown in fields that had received compost in previous years – see the discussion below. For all the other crops, the proportion of grain in the total harvested yield ranged from 28% for hanfets to 35% for sorghum in check fields, from 28% for hanfets to 43% for maize in fields treated with compost, and from 32% for finger millet and teff to 43% for maize in fields where chemical fertilizer had been applied.

In 1998, when the first set of data were collected from plots in the four original communities, except for maize, the grain yields of the cereals from the fields without any inputs (checks) were all below 1 tonne a hectare: 395-920 kg/ha for barley, 465-750 kg/ha for durum wheat, 760 kg/ha for finger millet, 590-630 kg/ha for hanfets, and 480-790 kg/ha for teff (Annex in Edwards, 2003). In the 7-year data set, only hanfets had an average grain yield below 1 tonne a hectare (858 kg/ha). The average check yields for all the other cereals ranged from 1115 kg/ha for barley to 1760 kg/ha for maize. The 4 original communities had been making and using compost for ten years, and all the others had been using compost for 3-5 years, and the higher average check yields were probably due to the residual effect of the use of compost in previous years.

Table 4: Total biomass and percentage grain by crop in Tigray, 2000-2006 inclusive

Crop type	% Grain in total biomass yield (kg/ha)					
	Check		Compost		Fertilizer	
	% Grain	Total	% Grain	Total	% Grain	Total
Barley	31	3,593	35	6,805	33	5,600
Durum wheat	34	3,570	39	6,317	33	5,105
Finger millet	34	3,384	36	7,400	32	5,687
Hanfets	28	3,093	28	4,737	35	3,436
Maize	33	5,291	43	8,705	43	6,758
Sorghum	35	3,784	41	6,159	36	6,913
Teff	32	3,622	36	5,944	32	5,198
Faba bean	39	3,499	41	7,015	42	6,479
Field pea	56	2,728	55	3,589	0	0
'hanfets' is a mixture of barley and durum wheat						

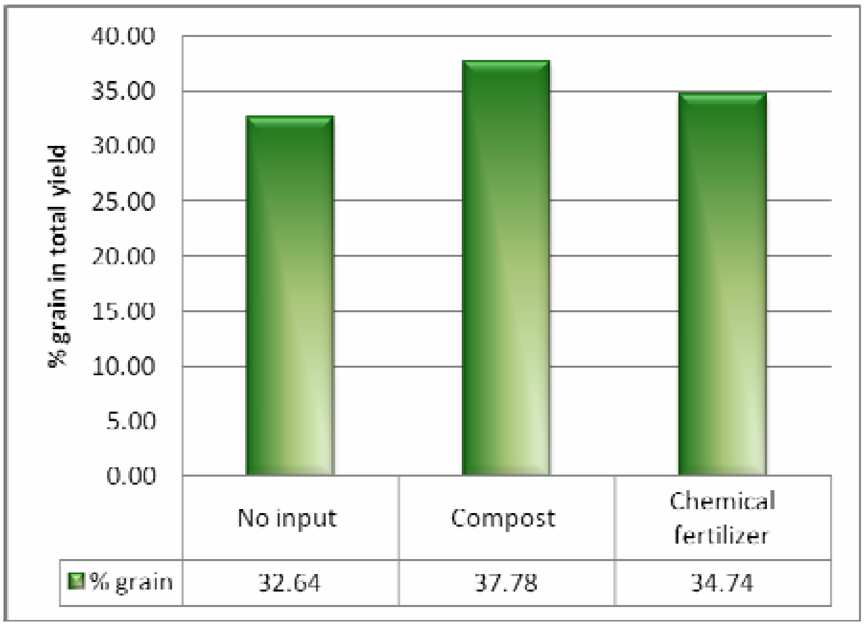


Figure 2: Averages of cereal grain yields/crop/treatment as proportions of their respective grain + straw yields/crop/treatment, averaged over all the 7 cereal grains and expressed as percentages, Tigray, 2000-2006

The impact of compost on restoring soil fertility is well illustrated by data for grain yields of the pulses, faba bean and field pea, shown in Figure 3 for Adi Abo Mossa. The difference between the yields for the check fields and fields that had received compost was very large in 1998, but in 2002 there was hardly any difference – for both crops and both treatments, the grain yields were over 2 tonnes a hectare. This similarity in yields is also seen for field pea in the 7-year data set in Table 3.

The residual effect of compost in maintaining soil fertility for two or more years was soon observed and appreciated by the farmers. They are thus able to rotate the application of compost on their cultivated land and do not have to make enough to apply to all their cultivated land each year.

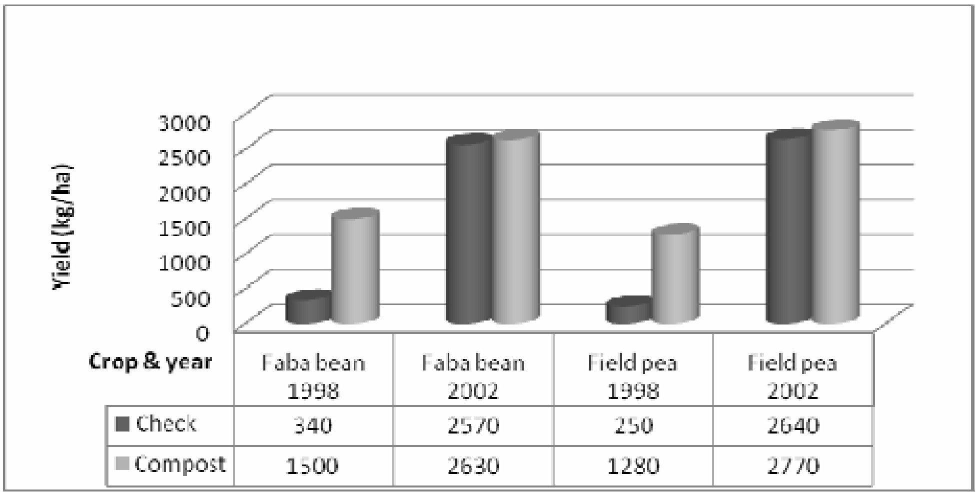


Figure3: Yields (kg/ha) for faba bean and field pea from Adi Abo Mossa, 1998 and 2002

The reduction of difficult weeds, such as Ethiopian wild oats *Avena vaviloviana*, and improved resistance to pests, such as teff shoot fly, has also been noted by the farmers. These impacts from the use of compost, including better resistance to crop diseases, have also been found with farmers practicing organic agriculture in France (Chaboussou, 1985).

One reason that compost has been able to significantly increase yields could be the fact that the farmers are still using their own varieties (also referred to as landraces), which have been selected by them in an organic environment where overall soil fertility is more important than just the amounts of the two major nutrients, N and P, supplied by urea and DAP. Dr Stephen Jones (personal communication) of the Washington State University and his colleagues have been breeding wheat for organic agriculture and they find that varieties that give high yields under organic conditions are different from those that give high yields with chemical fertilizer inputs.

Other reasons that farmers have been ready to adopt making and using compost are that it enables them to avoid the financial risk of taking chemical fertilizer on credit, and that the compost is available when it is needed – chemical fertilizer is sometimes delivered late.

Conclusion

Since 1998, the Bureau of Agriculture and Rural Development of Tigray Region has adopted the making of compost as part of its extension package and by 2007 at least 25% of the farmers are making and using compost. A reflection of the success of this approach is that between 2003 and 2006 grain yield for the Region almost doubled from 714 to 1,354 thousand tonnes (Figure 4). Since 1998, there has also been a steady decrease in the use of chemical fertilizer from 13.7 to 8.2 thousand tonnes (Figure 5).

Making and using compost is also being promoted in other regions of the country, particularly through the "Community-based Participatory Watershed Development" project of the Ministry of Agriculture, and the Land Rehabilitation Project of the Environmental Protection Authority, which has been supported through three successive phases of the Country Cooperation Programme of UNDP.

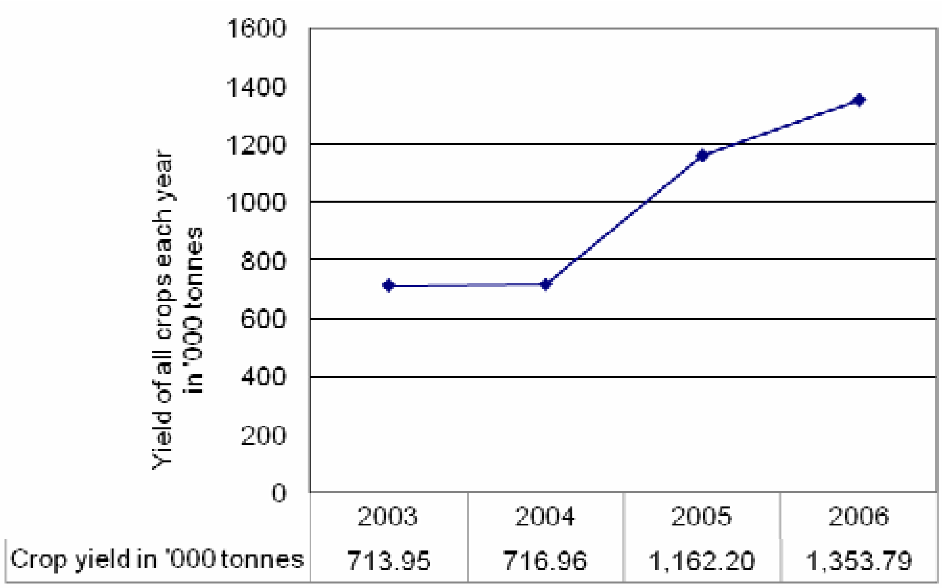


Figure 4: Total recorded crop production in Tigray, 2003-2006

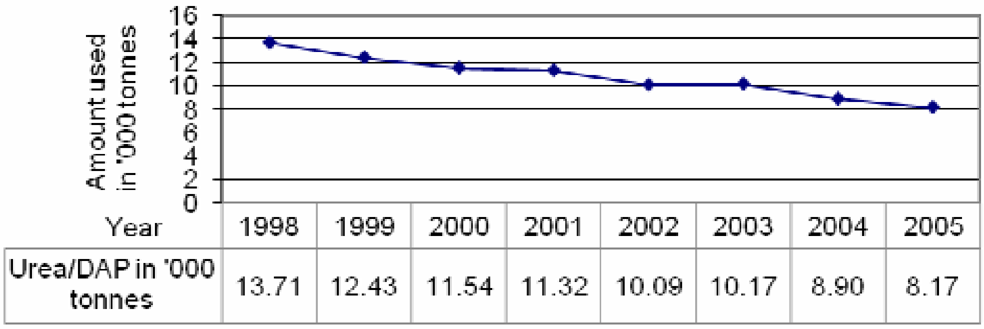


Figure 5: Total use of urea and DAP in Tigray, 1998-2005

There is also a need to involve plant breeders and farmers together in participatory plant breeding in order to explore and develop the potential of the farmers' varieties to give consistent high yields under an organic agriculture system, i.e. where compost is made and used regularly by the farmers.

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STATISTICAL ANALYSIS

Crop Yield data from Tigray, 2000-2006 inclusive

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List of local communities from which crop yield data were taken between 2000 and 2006 inclusive

Zone	Woreda	Tabia	Communities
Southern Tigray	Ofla	Hashenge	Adi Abo Mossa (O)
	Alamata	Lemat Seelam Beqalsei	Adi Abo Golgi (2)
Eastern Tigray	Sa'esi'e Tsada Amba	Sendeda Mai Megelta Agamat	Tsebela (2) Zeban Sas (O) Gu’emse (O)
	Kilte Awla’elo	Mai Weyni	Sherafo (2)
	Atsbi-Wonberta	Hayelom	Gergera (2) Enda Maino (2)
Central Tigray	Tahtai Maichew	Mai Berazio	Adi Nefas (O)
		Akab Se'at	Adi Gua'edad (2)
		Ruba Shewit	Adeke Haftu (4)
		Mai Siye	Mai Tsa'ida (4)
		Kewanit	Hagere Selam (4)
		Adi Guara	Tselielo (4)
		Adi Hutsa	Kenef (2)
	Kolla Tembien	Guroro Miwtsa'e Worki	Shimarwa (2) Adi Reiso (4)
Western Tigray	Tahitay Adyabo	Adi Aw'ala	Adi Aw'ala (2)
Total	9	17	18 +

Key – (O) refers to communities where work started in 1996/7; (2) refers to communities where work started 2002; (4) refers to communities where work started in 2004.

Barley from Tigray, 2000-2006 inclusive

```
log:  F:\ISD\croptype2.log = BARLEY
log type:  text
opened on:  21 May 2007, 14:32:42

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 2
(817 observations deleted)

***data manipulation
tab woreda, gen(district)
1= Ofla, 3= Sa'esi'e Tsada Amba, 4= Kilte Awla'elo, 5= Atsbi-Wonberta,
6= Tahtai Maichew,
     Woreda |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |         28       17.83       17.83
          3 |         63       40.13       57.96
          4 |          6        3.82       61.78
          5 |         18       11.46       73.25
          6 |         42       26.75      100.00
------------+-----------------------------------
      Total |        157      100.00

tab tabia, gen(pa)
          Tabia |      Freq    Percent        Cum.
----------------+-----------------------------------
         Agamat |         27       17.20       17.20
     Akab Se'at |         15        9.55       26.75
       Hashenge |         28       17.83       44.59
        Hayelom |         18       11.46       56.05
         Kewait |          3        1.91       57.96
    Mai Berazio |         12        7.64       65.61
    Mai Megelta |         27       17.20       82.80
      Mai Siye |          12        7.64       90.45
      Mai Weyni |          6        3.82       94.27
        Sendeda |          9        5.73      100.00
----------------+-----------------------------------
          Total |        157      100.00

tab kushet, gen(village)
       Kushet |      Freq    Percent        Cum.
--------------+-----------------------------------
Adi Abo Mussa |         19       12.10       12.10
 Adi Abomossa |          9        5.73       17.83
    Adi Nefas |         12        7.64       25.48
   Enda Maino |          6        3.82       29.30
      Gergera |         12        7.64       36.94
      Gua'eda |         15        9.55       46.50
       Guemse |         27       17.20       63.69
 Hagere Selam |          3        1.91       65.61
  Mai Tsa'eda |         12        7.64       73.25
      Sherafo |          6        3.82       77.07
      Tsebela |          9        5.73       82.80
    Zeban Sas |         18       11.46       94.27
    Ziban Sas |          9        5.73      100.00
--------------+-----------------------------------
        Total |        157      100.00
```

Barley from Tigray, 2000-2006 inclusive

```
tab year, gen(season)

       Year |      Freq    Percent        Cum.
------------+-----------------------------------
          0 |         9       5.73        5.73
          1 |        24      15.29       21.02
          2 |        25      15.92       36.94
          3 |        36      22.93       59.87
          5 |        18      11.46       71.34
          6 |        45      28.66      100.00
------------+-----------------------------------
      Total |       157     100.00

tab crop, gen(croptp)

       Crop |      Freq    Percent        Cum.
------------+-----------------------------------
          2 |       157     100.00      100.00
------------+-----------------------------------
      Total |       157     100.00

tab treatment, gen(treat)

  Treatment |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |        56      35.67       35.67
          2 |        57      36.31       71.97
          3 |        36      22.93       94.90
          4 |         8       5.10      100.00
------------+-----------------------------------
      Total |       157     100.00

gen lnyield= log(avgoutput)

gen lnstraw= log(avgstrawyield)
(11 missing values generated)

*** summarize
sort crop

by crop: sum avgoutput
crop = 2

    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-------------------------------------------------------
   avgoutput |       157     176.434    95.62167      15.33        460
```

Barley from Tigray, 2000-2006 inclusive

```
sort tabia

by tabia: sum  avgoutput

tabia = Agamat
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        27     161.383  81.39279     43.33     366.67

tabia = Akab Se'at
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        15    218.1993  69.41722     86.67        282

tabia = Hashenge
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        28    194.8389  98.53572     23.33        335

tabia = Hayelom

    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        18      209.11  112.4539        55        360

tabia = Kewait
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    386.6667  80.82904       300        460

tabia = Mai Berazio
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        12    154.1392  87.82444     62.67     366.67

tabia = Mai Megelta
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        27    106.9507  57.85374     15.33        227

tabia = Mai Siye
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        12    232.7783  88.71523    116.67        400

tabia = Mai Weyni
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         6      115.61  60.28141     50.33     180.33

tabia = Sendeda
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9    162.8889  59.19131        72        225
```

Barley from Tigray, 2000-2006 inclusive

```
 oneway  avgoutput tabia , tabulate

                |        Summary of avgoutput
          Tabia |        Mean   StdDev      Freq.
---------------+------------------------------------
         Agamat |   161.38296   81.392793          27
     Akab Se'at |   218.19933   69.417219          15
       Hashenge |   194.83893   98.535716          28
        Hayelom |      209.11   112.45388          18
         Kewait |   386.66667   80.829038           3
    Mai Berazio |   154.13917   87.824439          12
    Mai Megelta |   106.95074   57.853745          27
       Mai Siye |   232.77833   88.715228          12
      Mai Weyni |      115.61   60.281408           6
        Sendeda |   162.88889   59.191309           9
---------------+------------------------------------
          Total |   176.43401   95.621671         157

                        Analysis of Variance
    Source              SS         df       MS            F     Prob > F
------------------------------------------------------------------------
Between groups      391842.048      9   43538.0053      6.19     0.0000
 Within groups      1034544.58    147   7037.71826
------------------------------------------------------------------------
    Total           1426386.63    156   9143.50406

Bartlett's test for equal variances:  chi2(9) =  13.7105  Prob>chi2 = 0.133

sort treatment
by treatment: sum avgoutput

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        56    111.5396    72.84147      15.33     348.33

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        57     234.884    90.83193      78.33        460

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        36    186.1072    79.34188      43.33     366.67

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         8    170.7087     50.7254     106.67     238.33
```

Barley from Tigray, 2000-2006 inclusive

```
oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   111.53964   72.841465          56
          2 |   234.88404   90.831931          57
          3 |   186.10722    79.34188          36
          4 |   170.70875     50.7254           8
------------+------------------------------------
      Total |   176.43401   95.621671         157

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      434197.513      3   144732.504     22.32     0.0000
 Within groups      992189.119    153    6484.8962
------------------------------------------------------------------------
    Total           1426386.63    156   9143.50406

Bartlett's test for equal variances:  chi2(3) =   4.9516  Prob>chi2 = 0.175

by treatment : sum avgstrawyield

treatment = 1
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |        52     247.844    169.1174      39.33     968.33

treatment = 2
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |        55    445.6347    217.0447     106.67     950.17

treatment = 3
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |        35    373.8814    194.0573     126.67     920.33

treatment = 4
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |         4       237.5    93.30945     146.67     366.67
```

Barley from Tigray, 2000-2006 inclusive

```
oneway avgstrawyield treatment , tabulate

            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   247.84404   169.11738          52
          2 |   445.63473   217.04473          55
          3 |   373.88143    194.0573          35
          4 |       237.5   93.309448           4
------------+------------------------------------
      Total |   352.28528   210.49215         146

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      1115517.59      3   371839.198      9.95     0.0000
 Within groups       5308989.5    142     37387.25
------------------------------------------------------------------------
    Total            6424507.1    145   44306.9455

Bartlett's test for equal variances:  chi2(3) =   5.0859  Prob>chi2 = 0.166



*log, close
exit, clear

end of do-file

log close
       log:  F:\ISD\croptype2.log
  log type:  text
 closed on:  21 May 2007, 14:33:17
```

Faba Bean from Tigray, 2000-2006 inclusive

```
log:  F:\ISD\croptype1.log = FABA BEAN
log type:  text
opened on:  21 May 2007, 14:32:15

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 1
(924 observations deleted)

***data manipulation
tab woreda, gen(district)
```

1= Ofla, 3= Sa'esi'e Tsada Amba, 5= Atsbi-Wonberta, 6= Tahtai Maichew,

Woreda	Freq	Percent	Cum.
1	16	32.00	32.00
3	4	8.00	40.00
5	6	12.00	52.00
6	24	48.00	100.00
Total	50	100.00	

```
tab tabia, gen(pa)
```

Tabia	Freq	Percent	Cum.
Agamat	2	4.00	4.00
Akab Se'at	9	18.00	22.00
Hashenge	16	32.00	54.00
Hayelom	6	12.00	66.00
Kewanit	3	6.00	72.00
Mai Berazio	9	18.00	90.00
Mai Siye	3	6.00	96.00
Sendeda	2	4.00	100.00
Total	50	100.00	

```
tab kushet, gen(village)
```

Kushet	Freq	Percent	Cum.
Adi Abo Mussa	10	20.00	20.00
Adi Abomossa	6	12.00	32.00
Adi Nefas	9	18.00	50.00
Gergera	6	12.00	62.00
Gua'eda	9	18.00	80.00
Guemse	2	4.00	84.00
Hagere Selam	3	6.00	90.00
Mai Tsa'eda	3	6.00	96.00
Tsebela	2	4.00	100.00
Total	50	100.00	

Faba Bean from Tigray, 2000-2006 inclusive

```
tab year, gen(season)

       Year |      Freq     Percent        Cum.
------------+-----------------------------------
          0 |         6       12.00       12.00
          1 |         6       12.00       24.00
          2 |         9       18.00       42.00
          3 |        17       34.00       76.00
          6 |        12       24.00      100.00
------------+-----------------------------------
      Total |        50      100.00

tab treatment, gen(treat)

  Treatment |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |        20       40.00       40.00
          2 |        24       48.00       88.00
          3 |         3        6.00       94.00
          4 |         3        6.00      100.00
------------+-----------------------------------
      Total |        50      100.00

gen lnyield= log(avgoutput)
(1 missing value generated)

gen lnstraw= log(avgstrawyield)
(6 missing values generated)

*** summarize
sort crop

by crop: sum avgoutput

crop = 1

    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        49    216.2965     133.289      22.33     693.33

sort tabia

by tabia: sum  avgoutput

tabia = Agamat
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2      100.83    53.03301      63.33     138.33

tabia = Akab Se'at
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9    259.2222    104.2888      76.67     358.67

tabia = Hashenge
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        16    113.2425    67.56518      22.33     235.37
```

Faba Bean from Tigray, 2000-2006 inclusive

```
tabia = Hayelom
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         6     164.445    52.77526       100        250

tabia = Kewanit
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2     421.665    30.63893       400     443.33

tabia = Mai Berazio
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9      344.85    156.8232    118.33     693.33

tabia = Mai Siye
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    232.2233    15.75213       220        250

tabia = Sendeda
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2     310.835    36.53622       285     336.67

oneway  avgoutput tabia , tabulate

               |        Summary of avgoutput
         Tabia |        Mean   StdDev      Freq.
---------------+------------------------------------
        Agamat |      100.83   53.033009           2
    Akab Se'at |   259.22222    104.2888           9
      Hashenge |    113.2425   67.565176          16
       Hayelom |     164.445   52.775261           6
        Kewait |   421.66499   30.638927           2
   Mai Berazio |      344.85   156.82316           9
      Mai Siye |   232.22333   15.752131           3
       Sendeda |   310.83501   36.536217           2
---------------+------------------------------------
         Total |   216.29653   133.28902          49

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      481024.588      7   68717.7983      7.58     0.0000
 Within groups      371741.592     41   9066.86811
------------------------------------------------------------------------
    Total           852766.181     48   17765.9621

Bartlett's test for equal variances:  chi2(7) =  16.2229  Prob>chi2 = 0.023
```

Faba Bean from Tigray, 2000-2006 inclusive

```
sort treatment
by treatment: sum avgoutput
treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
   avgoutput |        20     137.861     101.118      22.33     336.67

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
   avgoutput |        23    285.7526    128.8638        120     693.33

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
   avgoutput |         3    269.5567    138.4951        110     358.67

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
   avgoutput |         3    153.4433    14.88757     139.33        169

 oneway  avgoutput treatment , tabulate
            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |    137.861   101.11801          20
          2 |  285.75261   128.86381          23
          3 |  269.55667   138.49509           3
          4 |  153.44333   14.887566           3
------------+------------------------------------
      Total |  216.29653   133.28902          49

                        Analysis of Variance
    Source              SS          df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      254359.514      3   84786.5046      6.38     0.0011
 Within groups      598406.667     45   13297.9259
------------------------------------------------------------------------
    Total           852766.181     48   17765.9621

Bartlett's test for equal variances:  chi2(3) =   6.7543  Prob>chi2 = 0.080
```

Faba Bean from Tigray, 2000-2006 inclusive

```
by treatment : sum avgstrawyield
treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        17    212.1182    111.9841      78.33     495.33

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        24    415.8517    224.9212     153.33        850

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         3      378.33     212.191     253.33     623.33

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         0

oneway avgstrawyield treatment , tabulate
            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   212.11823   111.98414          17
          2 |   415.85167   224.92125          24
          3 |      378.33   212.19096           3
------------+------------------------------------
      Total |   334.57818   208.73197          44

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      419211.229      2   209605.614      5.91     0.0056
 Within groups      1454257.23     41   35469.6885
------------------------------------------------------------------------
    Total           1873468.46     43   43569.0339

Bartlett's test for equal variances:  chi2(2) =   7.2857  Prob>chi2 = 0.026
```

Field Pea yields from Tigray, 2000-2006 inclusive

```
log:  F:\ISD\croptype5.log = FIELD PEA
log type:  text
opened on:  21 May 2007, 14:34:28

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 5
(956 observations deleted)

***data manipulation
tab woreda, gen(district)
1= Ofla
     Woreda |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |         18      100.00      100.00
------------+-----------------------------------
      Total |         18      100.00

tab tabia, gen(pa)
          Tabia |      Freq     Percent        Cum.
----------------+-----------------------------------
       Hashenge |         18      100.00      100.00
----------------+-----------------------------------
          Total |         18      100.00

tab kushet, gen(village)
       Kushet |      Freq     Percent        Cum.
--------------+-----------------------------------
Adi Abo Mussa |         12       66.67       66.67
 Adi Abomossa |          6       33.33      100.00
--------------+-----------------------------------
        Total |         18      100.00

tab year, gen(season)
       Year |      Freq     Percent        Cum.
------------+-----------------------------------
          2 |          8       44.44       44.44
          3 |          4       22.22       66.67
          6 |          6       33.33      100.00
------------+-----------------------------------
      Total |         18      100.00

tab crop, gen(croptp)
       Crop |      Freq     Percent        Cum.
------------+-----------------------------------
          5 |         18      100.00      100.00
------------+-----------------------------------
      Total |         18      100.00

tab treatment, gen(treat)
  Treatment |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |          9       50.00       50.00
          2 |          9       50.00      100.00
------------+-----------------------------------
      Total |         18      100.00

gen lnyield= log(avgoutput)

gen lnstraw= log(avgstrawyield)
```

Field Pea yields from Tigray, 2000-2006 inclusive

```
*** summarize
sort crop

by crop: sum avgoutput
crop = 5

    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        18    174.5133     89.3686      51.67     283.33

sort tabia

by tabia: sum  avgoutput

tabia = Hashenge
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        18    174.5133     89.3686      51.67     283.33

oneway  avgoutput tabia , tabulate

               |        Summary of avgoutput
         Tabia |        Mean   StdDev      Freq.
---------------+-----------------------------------
      Hashenge |   174.51333   89.368599          18
---------------+-----------------------------------
         Total |   174.51333   89.368599          18

                        Analysis of Variance
    Source              SS          df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups               0      0             .
 Within groups      135774.691     17   7986.74654
------------------------------------------------------------------------
    Total           135774.691     17   7986.74654
```

Field Pea yields from Tigray, 2000-2006 inclusive

```
sort treatment

by treatment: sum avgoutput

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
   avgoutput |         9    152.6556     103.147      51.67        270

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
   avgoutput |         9    196.3711    72.50912        100     283.33

 oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   152.65555   103.14697           9
          2 |   196.37111   72.509123           9
------------+------------------------------------
      Total |   174.51333   89.368599          18

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups       8599.7252      1    8599.7252      1.08     0.3137
 Within groups      127174.966     16   7948.43537
------------------------------------------------------------------------
    Total           135774.691     17   7986.74654

Bartlett's test for equal variances:  chi2(1) =   0.9165  Prob>chi2 = 0.338
```

```
by treatment : sum avgstrawyield

treatment = 1

    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         9    120.1089    39.75567      67.33        165

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         9    162.4744     20.1911     136.67     203.97

oneway avgstrawyield treatment , tabulate
            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev       Freq.
------------+------------------------------------
          1 |   120.10889    39.75567           9
          2 |   162.47444   20.191095           9
------------+------------------------------------
      Total |   141.29167   37.559623          18

                        Analysis of Variance
    Source              SS         df       MS            F     Prob > F
------------------------------------------------------------------------
Between groups      8076.78105      1   8076.78105      8.12     0.0116
 Within groups       15905.549     16    994.09681
------------------------------------------------------------------------
    Total             23982.33     17   1410.72529

Bartlett's test for equal variances:  chi2(1) =   3.2202  Prob>chi2 = 0.073


*log, close
exit, clear

end of do-file

log close
       log:  F:\ISD\croptype5.log
  log type:  text
 closed on:  21 May 2007, 14:34:53
```

Finger Millet yields, Tigray, 2000-2006 inclusive

```
log:  F:\ISD\croptype10.log = FINGER MILLET in 4 weredas
log type:  text
opened on:  21 May 2007, 14:37:08

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 10
(935 observations deleted)

***data manipulation
tab woreda, gen(district)
3= Sa'esi'e Tsada Amba, 4= Kilte Awla'elo, 6= Tahtai Maichew,
7= Kolla Tembien
     Woreda |      Freq    Percent        Cum.
------------+-----------------------------------
          3 |         1       2.56        2.56
          4 |         2       5.13        7.69
          6 |        26      66.67       74.36
          7 |        10      25.64      100.00
------------+-----------------------------------
      Total |        39     100.00

tab tabia, gen(pa)

          Tabia |      Freq    Percent        Cum.
----------------+-----------------------------------
     Akab Se'at |         3       7.69        7.69
         Guroro |        10      25.64       33.33
         Kewanit |         3       7.69       41.03
    Mai Berazio |         8      20.51       61.54
       Mai Siye |         9      23.08       84.62
      Mai Weyni |         2       5.13       89.74
   Ruuba Shewit |         3       7.69       97.44
        Sendeda |         1       2.56      100.00
----------------+-----------------------------------
          Total |        39     100.00

tab kushet, gen(village)
       Kushet |      Freq    Percent        Cum.
--------------+-----------------------------------
  Adeke Haftu |         3       7.69        7.69
    Adi Nefas |         8      20.51       28.21
      Gua'eda |         3       7.69       35.90
 Hagere Selam |         3       7.69       43.59
  Mai Tsa'eda |         9      23.08       66.67
      Sherafo |         2       5.13       71.79
     Shimarwa |        10      25.64       97.44
      Tsebela |         1       2.56      100.00
--------------+-----------------------------------
        Total |        39     100.00

tab year, gen(season)
       Year |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |         6      15.38       15.38
          2 |        11      28.21       43.59
          3 |         6      15.38       58.97
          4 |         7      17.95       76.92
          6 |         9      23.08      100.00
------------+-----------------------------------
      Total |        39     100.00
```

Finger Millet yields, Tigray, 2000-2006 inclusive

```
tab crop, gen(croptp)

       Crop |      Freq    Percent        Cum.
------------+-----------------------------------
         10 |         39      100.00      100.00
------------+-----------------------------------
      Total |         39      100.00

tab treatment, gen(treat)
  Treatment |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |         16       41.03       41.03
          2 |         14       35.90       76.92
          3 |          8       20.51       97.44
          4 |          1        2.56      100.00
------------+-----------------------------------
      Total |         39      100.00

gen lnyield= log(avgoutput)

gen lnstraw= log(avgstrawyield)
(2 missing values generated)

*** summarize
sort crop

by crop: sum avgoutput

crop = 10

    Variable |       Obs        Mean    StdDev       Min        Max
-------------+------------------------------------------------------
   avgoutput |        39    184.6667     108.991      41.67        410

sort tabia
by tabia: sum  avgoutput

tabia = Akab Se'at
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+------------------------------------------------------
   avgoutput |         3      131.11    75.74296         50        200

tabia = Guroro
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+------------------------------------------------------
   avgoutput |        10     115.266    77.08301      43.33     313.33

tabia = Kewanit
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+------------------------------------------------------
   avgoutput |         3      368.89    45.50161        320        410

tabia = Mai Berazio
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+------------------------------------------------------
   avgoutput |         8    149.2925    104.1013      41.67        335

tabia = Mai Siye
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+------------------------------------------------------
   avgoutput |         9    272.9633    79.15257     173.33        400
```

Finger Millet yields, Tigray, 2000-2006 inclusive

```
tabia = Mai Weyni
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2      170.83  19.09188     157.33     184.33

tabia = Ruuba Shewit
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    116.6667  35.11885         80        150

tabia = Sendeda
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         1      206.67               206.67     206.67

 oneway  avgoutput tabia , tabulate

               |        Summary of avgoutput
         Tabia |        Mean   StdDev      Freq.
---------------+-----------------------------------
    Akab Se'at |      131.11   75.742962          3
        Guroro |     115.266   77.083013         10
       Kewanit |      368.89   45.501609          3
   Mai Berazio |    149.2925   104.10131          8
      Mai Siye |   272.96333    79.15257          9
     Mai Weyni |      170.83   19.091883          2
  Ruuba Shewit |   116.66667   35.118846          3
       Sendeda |      206.67           0          1
---------------+-----------------------------------
         Total |   184.66667   108.99098         39

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      253500.608      7   36214.3726      5.67     0.0003
 Within groups      197902.677     31   6383.95733
------------------------------------------------------------------------
    Total           451403.286     38   11879.0338

Bartlett's test for equal variances:  chi2(6) =   4.9294  Prob>chi2 = 0.553

note: Bartlett's test performed on cells with positive variance:
      1 single-observation cells not used
```

Finger Millet yields, Tigray, 2000-2006 inclusive

```
sort treatment

by treatment: sum avgoutput
treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |        16    114.1875  70.45059    41.67        250

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |        14    265.1671  108.0024   103.67        410

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |         8    184.7913  88.73184   100.67        350

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |         1      184.33            184.33     184.33

 oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |    114.1875   70.450591         16
          2 |   265.16714   108.00242         14
          3 |   184.79125   88.731842          8
          4 |      184.33           0          1
------------+------------------------------------
      Total |   184.66667   108.99098         39

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups       170201.82      3   56733.9399      7.06     0.0008
 Within groups      281201.466     35    8034.3276
------------------------------------------------------------------------
    Total           451403.286     38   11879.0338

Bartlett's test for equal variances:  chi2(2) =   2.4159  Prob>chi2 = 0.299

note: Bartlett's test performed on cells with positive variance:
      1 single-observation cells not used
```

Finger Millet yields, Tigray, 2000-2006 inclusive

```
by treatment : sum avgstrawyield

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |        16    224.1663    190.6374      77.33        650

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |        13      474.82    254.9083     131.67     793.33

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |         7    383.9057    231.3505      86.67        700

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
avgstrawyi~d |         1      249.33              249.33     249.33

oneway avgstrawyield treatment , tabulate

            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   224.16625   190.63741          16
          2 |      474.82   254.90828          13
          3 |   383.90571   231.35045           7
          4 |      249.33           0           1
------------+------------------------------------
      Total |   343.13486   242.57534          37

                        Analysis of Variance
    Source              SS         df       MS            F     Prob > F
------------------------------------------------------------------------
Between groups       472324.36      3   157441.453      3.16     0.0376
 Within groups      1646016.31     33   49879.2822
------------------------------------------------------------------------
    Total           2118340.67     36   58842.7964

Bartlett's test for equal variances:  chi2(2) =   1.1003  Prob>chi2 = 0.577

note: Bartlett's test performed on cells with positive variance:
      1 single-observation cells not used

*log, close
exit, clear

end of do-file

log close
       log:  F:\ISD\croptype10.log
  log type:  text
 closed on:  21 May 2007, 14:37:33
```

Hanfets (mixed barley + durum wheat) yields, Tigray, 2000-2006

```
log:  F:\ISD\croptype9.log = HANFETS (mixed barley + durum wheat)
log type:  text
opened on:  21 May 2007, 14:36:44

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 9
(865 observations deleted)

***data manipulation
tab woreda, gen(district)
3= Sa'esi'e Tsada Amba, 4= Kilte Awla'elo
     Woreda |      Freq     Percent        Cum.
------------+-----------------------------------
          3 |         94       86.24       86.24
          4 |         15       13.76      100.00
------------+-----------------------------------
      Total |        109      100.00

tab tabia, gen(pa)
          Tabia |      Freq     Percent        Cum.
----------------+-----------------------------------
         Agamat |         42       38.53       38.53
    Mai Megelta |         34       31.19       69.72
      Mai Weyni |         15       13.76       83.49
        Sendeda |         18       16.51      100.00
----------------+-----------------------------------
          Total |        109      100.00

tab kushet, gen(village)
       Kushet |      Freq     Percent        Cum.
--------------+-----------------------------------
       Guemse |         42       38.53       38.53
      Sherafo |         15       13.76       52.29
      Tsebela |         18       16.51       68.81
    Zeban Sas |         34       31.19      100.00
--------------+-----------------------------------
        Total |        109      100.00

tab year, gen(season)
       Year |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |         29       26.61       26.61
          3 |         47       43.12       69.72
          5 |         33       30.28      100.00
------------+-----------------------------------
      Total |        109      100.00

tab crop, gen(croptp)
       Crop |      Freq     Percent        Cum.
------------+-----------------------------------
          9 |        109      100.00      100.00
------------+-----------------------------------
      Total |        109      100.00
```

Hanfets (mixed barley + durum wheat) yields, Tigray, 2000-2006

```
tab treatment, gen(treat)
  Treatment |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |        31       28.44       28.44
          2 |        31       28.44       56.88
          3 |        29       26.61       83.49
          4 |        18       16.51      100.00
------------+-----------------------------------
      Total |       109      100.00

gen lnyield= log(avgoutput)

gen lnstraw= log(avgstrawyield)

*** summarize
sort crop

by crop: sum avgoutput

crop = 9

    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |       109    117.5201    59.03074      41.67      446.67
```

Hanfets (mixed barley + durum wheat) yields, Tigray, 2000-2006

```
sort tabia
by tabia: sum  avgoutput

tabia = Agamat
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        42    127.0638  71.45711     56.67     446.67

tabia = Mai Megelta
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        34    117.3526  58.40002     43.33     343.33

tabia = Mai Weyni
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        15     105.422  40.89201     60.33        210

tabia = Sendeda
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        18    105.6494  36.35769     41.67     183.33

 oneway  avgoutput tabia , tabulate
              |        Summary of avgoutput
        Tabia |        Mean   StdDev      Freq.
--------------+------------------------------------
       Agamat |   127.06381  71.457113          42
  Mai Megelta |   117.35265  58.400016          34
    Mai Weyni |     105.422   40.89201          15
      Sendeda |   105.64944  36.357689          18
--------------+------------------------------------
        Total |   117.52009  59.030744         109

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      8558.29922      3   2852.76641      0.81     0.4887
 Within groups      367781.598    105   3502.68189
------------------------------------------------------------------------
    Total           376339.898    108   3484.62868

Bartlett's test for equal variances:  chi2(3) =  12.1080  Prob>chi2 = 0.007
```

Hanfets (mixed barley + durum wheat) yields, Tigray, 2000-2006

```
sort treatment

by treatment: sum avgoutput

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
   avgoutput |        31    85.82839    28.39505      41.67     183.33

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
   avgoutput |        31    134.1184    45.19285      63.33        295

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
   avgoutput |        29    119.8734    70.60672      43.33     446.67

treatment = 4

    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------------
   avgoutput |        18    139.7228    77.68008      46.67     343.33

 oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   85.828387    28.39505          31
          2 |   134.11839   45.192852          31
          3 |   119.87345   70.606715          29
          4 |   139.72278   77.680081          18
------------+------------------------------------
      Total |   117.52009   59.030744         109

                        Analysis of Variance
    Source              SS         df       MS            F     Prob > F
------------------------------------------------------------------------
Between groups      48709.7715      3   16236.5905      5.20     0.0022
 Within groups      327630.126    105   3120.28692
------------------------------------------------------------------------
    Total           376339.898    108   3484.62868

Bartlett's test for equal variances:  chi2(3) =  28.4995  Prob>chi2 = 0.000
```

Hanfets (mixed barley + durum wheat) yields, Tigray, 2000-2006

```
by treatment : sum avgstrawyield

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        31    223.5381     103.122         80        525

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        31     339.569    206.5231        115        950

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        29    223.7362    93.90081         65     403.33

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        18    233.7411     80.1293        110        420

oneway avgstrawyield treatment , tabulate

            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   223.53807   103.12199          31
          2 |   339.56903   206.52308          31
          3 |   223.73621   93.900812          29
          4 |   233.74111   80.129301          18
------------+------------------------------------
      Total |   258.27532   144.09108         109

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      287705.927      3   95901.9758      5.15     0.0023
 Within groups      1954615.87    105   18615.3892
------------------------------------------------------------------------
    Total           2242321.79    108   20762.2388

Bartlett's test for equal variances:  chi2(3) =  30.4315  Prob>chi2 = 0.000


*log, close
exit, clear

end of do-file

log close
       log:  F:\ISD\croptype9.log
  log type:  text
 closed on:  21 May 2007, 14:36:49
```

Maize yields, Tigray, 2000-2006 inclusive

```
log:  F:\ISD\croptype7.log = MAIZE
log type:  text
opened on:  21 May 2007, 14:35:46

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 7
(871 observations deleted)

***data manipulation
tab woreda, gen(district)
1= Ofla, 6= Tahtai Maichew, 7= Kolla Tembien, 9= Tahitay Adyabo
     Woreda |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |         26       25.24       25.24
          6 |         43       41.75       66.99
          7 |         30       29.13       96.12
          9 |          4        3.88      100.00
------------+-----------------------------------
      Total |        103      100.00

tab tabia, gen(pa)

          Tabia |      Freq     Percent        Cum.
----------------+-----------------------------------
     Adi Awa'la |          4        3.88        3.88
      Adi Hutsa |         14       13.59       17.48
     Akab Se'at |          3        2.91       20.39
         Guroro |         25       24.27       44.66
       Hashenge |         26       25.24       69.90
        Kewanit |          3        2.91       72.82
    Mai Berazio |         11       10.68       83.50
       Mai Siye |         12       11.65       95.15
  Miwts'e Worki |          3        2.91       98.06
 Miwtsa'e Worqi |          2        1.94      100.00
----------------+-----------------------------------
          Total |        103      100.00

tab kushet, gen(village)

       Kushet |      Freq     Percent        Cum.
--------------+-----------------------------------
Adi Abo Mussa |         26       25.24       25.24
   Adi Awa'la |          4        3.88       29.13
    Adi Nefas |         11       10.68       39.81
    Adi Reiso |          5        4.85       44.66
      Gua'eda |          3        2.91       47.57
 Hagere Selam |          3        2.91       50.49
        Kenef |         14       13.59       64.08
  Mai Tsa'eda |         12       11.65       75.73
     Shimarwa |         25       24.27      100.00
--------------+-----------------------------------
        Total |        103      100.00

tab year, gen(season)

       Year |      Freq     Percent        Cum.
------------+-----------------------------------
          0 |         18       17.48       17.48
          1 |         19       18.45       35.92
          2 |         27       26.21       62.14
```

```
           3 |         13       12.62       74.76
           5 |          6        5.83       80.58
           6 |         20       19.42      100.00
------------+-----------------------------------
      Total |        103      100.00

tab crop, gen(croptp)

       Crop |      Freq    Percent        Cum.
------------+-----------------------------------
          7 |        103      100.00      100.00
------------+-----------------------------------
      Total |        103      100.00

tab treatment, gen(treat)

  Treatment |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |         31       30.10       30.10
          2 |         41       39.81       69.90
          3 |         25       24.27       94.17
          5 |          6        5.83      100.00
------------+-----------------------------------
      Total |        103      100.00

gen lnyield= log(avgoutput)

gen lnstraw= log(avgstrawyield)
(39 missing values generated)

*** summarize
sort crop

by crop: sum avgoutput

crop = 7

    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-------------------------------------------------------
   avgoutput |       103    298.8899    182.9281         40         925
```

Maize yields, Tigray, 2000-2006 inclusive

```
sort tabia

by tabia: sum  avgoutput

tabia = Adi Awa'la
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         4    365.1675    375.8541         70        900

tabia = Adi Hutsa
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        14    374.3571    266.3785         66        925

tabia = Akab Se'at
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3      127.11    67.07023         68        200

tabia = Guroro
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        25    222.1468    88.59363      56.67     331.67

tabia = Hashenge
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        26    363.2054    153.3969      64.33     518.33

tabia = Kewanit
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    285.5567    37.46891     253.33     326.67

tabia = Mai Berazio
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        11    327.7882    252.6206         40     656.67

tabia = Mai Siye
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        12      281.11    81.59083     173.33     433.33

tabia = Miwts'e Worki
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    192.7767     92.2742         95     278.33

tabia = Miwtsa'e Worqi
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2      145.83    123.7437      58.33     233.33
```

Maize yields, Tigray, 2000-2006 inclusive

```
oneway  avgoutput tabia , tabulate

               |        Summary of avgoutput
         Tabia |        Mean   StdDev      Freq.
---------------+------------------------------------
    Adi Awa'la |    365.1675   375.85407          4
     Adi Hutsa |   374.35714   266.37846         14
    Akab Se'at |      127.11   67.070234          3
        Guroro |    222.1468   88.593632         25
      Hashenge |   363.20539   153.39689         26
       Kewanit |   285.55668   37.468906          3
   Mai Berazio |   327.78818   252.62057         11
      Mai Siye |      281.11   81.590828         12
 Miwts'e Worki |   192.77666   92.274203          3
Miwtsa'e Worqi |      145.83   123.74369          2
---------------+------------------------------------
         Total |    298.8899   182.92806        103

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      534764.025      9   59418.225      1.92     0.0584
 Within groups      2878428.67     93   30950.8459
------------------------------------------------------------------------
    Total            3413192.7    102   33462.6735

Bartlett's test for equal variances:  chi2(9) =  42.4499  Prob>chi2 = 0.000

sort treatment

by treatment: sum avgoutput

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |        31    176.0003    134.2113         40        495

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |        41    374.8293    198.7412     108.33        925

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |        25     290.066    134.7862         66        490

treatment = 5
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+------------------------------------------------------
   avgoutput |         6    451.6667    45.36124        390     518.33
```

Maize yields, Tigray, 2000-2006 inclusive

```
oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   176.00032   134.21127          31
          2 |   374.82927    198.7412          41
          3 |     290.066   134.78616          25
          5 |   451.66667   45.361244           6
------------+------------------------------------
      Total |    298.8899   182.92806         103

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      846586.572      3   282195.524     10.88     0.0000
 Within groups      2566606.13     99   25925.3144
------------------------------------------------------------------------
    Total            3413192.7    102   33462.6735

Bartlett's test for equal variances:  chi2(3) =  14.8087  Prob>chi2 = 0.002

by treatment : sum avgstrawyield

 treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        20      353.15    325.8464         20        950

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        31    495.6887    319.1038      41.67     956.67

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        13    385.7685    319.2424         30     833.33

treatment = 5
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         0

oneway avgstrawyield treatment , tabulate
            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |      353.15   325.84638          20
          2 |   495.68871   319.10383          31
          3 |   385.76846   319.24243          13
------------+------------------------------------
      Total |   428.81781   322.99137          64
                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      277227.778      2   138613.889      1.34     0.2686
 Within groups      6295147.86     61   103199.145
------------------------------------------------------------------------
    Total           6572375.64     63   104323.423
Bartlett's test for equal variances:  chi2(2) =   0.0111  Prob>chi2 = 0.994
```

```
log:  F:\ISD\croptype11.log = SORGHUM
log type:  text
opened on:  21 May 2007, 14:37:37

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 11
(943 observations deleted)

***data manipulation
tab woreda, gen(district)
6= Tahtai Maichew, 7= Kolla Tembien, 9= Tahitay Adyabo
     Woreda |      Freq    Percent        Cum.
------------+-----------------------------------
          6 |        12      38.71       38.71
          7 |        15      48.39       87.10
          9 |         4      12.90      100.00
------------+-----------------------------------
      Total |        31     100.00

tab tabia, gen(pa)
          Tabia |      Freq    Percent        Cum.
----------------+-----------------------------------
     Adi Awa'la |         4      12.90       12.90
         Guroro |        11      35.48       48.39
       Mai Siye |         9      29.03       77.42
  Miwts'e Worki |         2       6.45       83.87
 Miwtsa'e Worqi |         2       6.45       90.32
   Ruuba Shewit |         3       9.68      100.00
----------------+-----------------------------------
          Total |        31     100.00

tab kushet, gen(village)
       Kushet |      Freq    Percent        Cum.
--------------+-----------------------------------
  Adeke Haftu |         3       9.68        9.68
   Adi Awa'la |         4      12.90       22.58
    Adi Reiso |         4      12.90       35.48
  Mai Tsa'eda |         9      29.03       64.52
     Shimarwa |        11      35.48      100.00
--------------+-----------------------------------
        Total |        31     100.00

tab year, gen(season)
       Year |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |         2       6.45        6.45
          2 |         5      16.13       22.58
          4 |         3       9.68       32.26
          5 |         7      22.58       54.84
          6 |        14      45.16      100.00
------------+-----------------------------------
      Total |        31     100.00

tab crop, gen(croptp)

       Crop |      Freq    Percent        Cum.
------------+-----------------------------------
         11 |        31     100.00      100.00
------------+-----------------------------------
      Total |        31     100.00
```

```
tab treatment, gen(treat)

  Treatment |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |        14       45.16       45.16
          2 |        11       35.48       80.65
          3 |         5       16.13       96.77
          4 |         1        3.23      100.00
------------+-----------------------------------
      Total |        31      100.00

gen lnyield= log(avgoutput)

gen lnstraw= log(avgstrawyield)
(3 missing values generated)

*** summarize
sort crop

by crop: sum avgoutput

crop = 11

    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        31    196.1397  104.9406        50        450

sort tabia

by tabia: sum  avgoutput

tabia = Adi Awa'la
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         4    224.6675  158.3025     81.67        450

tabia = Guroro
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        11    142.4236  50.71491     68.33        220

tabia = Mai Siye
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9    306.6678  62.36114    216.67     416.67

tabia = Miwts'e Worki
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2      135.83  81.31728     78.33     193.33

tabia = Miwtsa'e Worqi
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2     101.665  73.06534        50     153.33

tabia = Ruuba Shewit
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    126.6667   30.5505       100        160
```

```
 oneway  avgoutput tabia , tabulate

               |        Summary of avgoutput
         Tabia |        Mean   StdDev      Freq.
---------------+------------------------------------
    Adi Awa'la |    224.6675    158.3025          4
        Guroro |   142.42364   50.714908         11
      Mai Siye |   306.66778   62.361138          9
 Miwts'e Worki |      135.83    81.31728          2
Miwtsa'e Worqi |     101.665   73.065345          2
  Ruuba Shewit |   126.66667   30.550505          3
---------------+------------------------------------
         Total |   196.13968   104.94063         31

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      184547.985      5   36909.5969      6.33     0.0006
 Within groups      145828.067     25   5833.12269
------------------------------------------------------------------------
    Total           330376.052     30   11012.5351

Bartlett's test for equal variances:  chi2(5) =   8.8970  Prob>chi2 = 0.113

sort treatment

by treatment: sum avgoutput

treatment = 1
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        14      133.81   77.63623         50     306.67

treatment = 2
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        11    249.7264   108.2778     153.33        450

treatment = 3
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         5         248   93.25473        155     356.67

treatment = 4
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         1         220                  220        220
```

```
 oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |      133.81   77.636229          14
          2 |   249.72636   108.27779          11
          3 |         248    93.25473           5
          4 |         220           0           1
------------+------------------------------------
      Total |   196.13968   104.94063          31

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      99993.4815      3   33331.1605      3.91     0.0194
 Within groups      230382.571     27    8532.6878
------------------------------------------------------------------------
    Total           330376.052     30   11012.5351

Bartlett's test for equal variances:  chi2(2) =   1.1880  Prob>chi2 = 0.552

note: Bartlett's test performed on cells with positive variance:
      1 single-observation cells not used
```

```
by treatment : sum avgstrawyield

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        13    244.6154   272.3619     16.67     723.33

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |        10     366.166   371.9415     38.33     916.67

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         5     443.332   368.6295     38.33        750

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
avgstrawyi~d |         0

oneway avgstrawyield treatment , tabulate

            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev       Freq.
------------+------------------------------------
          1 |   244.61539   272.36191          13
          2 |     366.166   371.94147          10
          3 |     443.332   368.62948           5
------------+------------------------------------
      Total |   323.51143   324.87522          28

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      170898.584      2   85449.2918      0.80     0.4616
 Within groups      2678787.03     25   107151.481
------------------------------------------------------------------------
    Total           2849685.61     27   105543.912

Bartlett's test for equal variances:  chi2(2) =   1.0898  Prob>chi2 = 0.580

*log, close
exit, clear

end of do-file

log close
       log:  F:\ISD\croptype11.log
  log type:  text
 closed on:  21 May 2007, 14:37:46
```

```
log:  F:\ISD\croptype4.log = TEFF
log type:  text
opened on:  21 May 2007, 14:34:01

use "F:\ISD\yieldlatest.dta", clear

drop if crop ~= 4
(716 observations deleted)

***data manipulation
tab woreda, gen(district)
1= Ofla,  2= Alamata, 3= Sa'esi'e Tsada Amba, 4= Kilte Awla'elo,
5= Atsbi-Wonberta, 6= Tahtai Maichew, 7= Kolla Tembien
     Woreda |      Freq     Percent        Cum.
------------+-----------------------------------
          1 |         9        3.49        3.49
          2 |        13        5.04        8.53
          3 |         6        2.33       10.85
          4 |        20        7.75       18.60
          5 |        77       29.84       48.45
          6 |       101       39.15       87.60
          7 |        32       12.40      100.00
------------+-----------------------------------
      Total |       258      100.00

tab tabia, gen(pa)
          Tabia |      Freq     Percent        Cum.
----------------+-----------------------------------
      Adi Guara |        18        6.98        6.98
      Adi Hutsa |        15        5.81       12.79
         Agamat |         3        1.16       13.95
     Akab Se'at |        23        8.91       22.87
         Guroro |        27       10.47       33.33
       Hashenge |         9        3.49       36.82
        Hayelom |        77       29.84       66.67
         Kewanit |         9        3.49       70.16
          Lemat |         4        1.55       71.71
    Mai Berazio |        15        5.81       77.52
    Mai Megelta |         3        1.16       78.68
      Mai Siye |        18        6.98       85.66
      Mai Weyni |        20        7.75       93.41
  Miwts'e Worki |         2        0.78       94.19
 Miwtsa'e Worqi |         3        1.16       95.35
   Ruuba Shewit |         3        1.16       96.51
Seelam Beqalsei |         9        3.49      100.00
----------------+-----------------------------------
          Total |       258      100.00

tab kushet, gen(village)
        Kushet |      Freq     Percent        Cum.
--------------+-----------------------------------
   Adeke Haftu |         3        1.20        1.20
Adi Abo Golgi |         4        1.61        2.81
 Adi Abomossa |         9        3.61        6.43
     Adi Nefas |        15        6.02       12.45
     Adi Reiso |         5        2.01       14.46
    Enda Maino |        61       24.50       38.96
       Gergera |        16        6.43       45.38
       Gua'eda |        23        9.24       54.62
        Guemse |         3        1.20       55.82
  Hagere Selam |         9        3.61       59.44
```

```
        Kenef |         15        6.02       65.46
  Mai Tsa'eda |         18        7.23       72.69
      Sherafo |         20        8.03       80.72
     Shimarwa |         27       10.84       91.57
     Tseleilo |         18        7.23       98.80
    Zeban Sas |          3        1.20      100.00
--------------+-----------------------------------
        Total |        249      100.00

tab year, gen(season)
       Year |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |         62       24.03       24.03
          2 |         60       23.26       47.29
          3 |         84       32.56       79.84
          4 |          8        3.10       82.95
          5 |          9        3.49       86.43
          6 |         35       13.57      100.00
------------+-----------------------------------
      Total |        258      100.00

tab crop, gen(croptp)
       Crop |      Freq    Percent        Cum.
------------+-----------------------------------
          4 |        258      100.00      100.00
------------+-----------------------------------
      Total |        258      100.00

tab treatment, gen(treat)

  Treatment |      Freq    Percent        Cum.
------------+-----------------------------------
          1 |        106       41.09       41.09
          2 |         76       29.46       70.54
          3 |         71       27.52       98.06
          4 |          5        1.94      100.00
------------+-----------------------------------
      Total |        258      100.00

gen lnyield= log(avgoutput)
(1 missing value generated)

gen lnstraw= log(avgstrawyield)
(25 missing values generated)

*** summarize
sort crop

by crop: sum avgoutput

crop = 4
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |       257    158.3746    115.7467      21.67        709
```

```
sort tabia

by tabia: sum  avgoutput

tabia = Adi Guara
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        18    158.1472    111.4096     33.33     316.67

tabia = Adi Hutsa
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        15    114.3107    53.33275     49.33        226

tabia = Agamat
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    204.4433    50.03717    153.33     253.33

tabia = Akab Se'at
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        23      149.84    63.86118        39     291.67

tabia = Guroro
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        27    93.13556    55.36513        25        310

tabia = Hashenge
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9    110.9356    39.69044     48.23     154.83

tabia = Hayelom
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        77    179.4077    113.1829     26.67     516.67

tabia = Kewanit
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9    358.8878    158.6676    153.33        570

tabia = Lemat
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         4          92    17.51664     69.33     110.67

tabia = Mai Berazio
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        15    125.8893    74.12848     52.67     333.33

tabia = Mai Megelta
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    44.44333     21.1002     21.67      63.33
```

```
tabia = Mai Siye
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        18    216.2967    100.1237       110     463.33

tabia = Mai Weyni
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |        19    183.0263    209.2898        50        709

tabia = Miwts'e Worki
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         2         105     11.7804     96.67     113.33

tabia = Miwtsa'e Worqi
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    79.44333    44.00817     31.67     118.33

tabia = Ruuba Shewit
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         3    123.3333    25.16611       100        150

tabia = Seelam Beqalsei
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+-----------------------------------------------------
   avgoutput |         9         105    31.00268     68.33     163.33

 oneway  avgoutput tabia , tabulate
              |        Summary of avgoutput
        Tabia |        Mean   StdDev      Freq.
--------------+------------------------------------
   Adi Guara |   158.14722   111.40958          18
   Adi Hutsa |   114.31067   53.332747          15
      Agamat |   204.44333   50.037171           3
 Akab Se'at |      149.84   63.861178          23
      Guroro |   93.135556   55.365132          27
    Hashenge |   110.93556   39.690438           9
     Hayelom |   179.40766   113.18293          77
     Kewanit |   358.88778   158.66761           9
       Lemat |          92   17.516636           4
 Mai Berazio |   125.88933   74.128478          15
 Mai Megelta |   44.443335   21.100203           3
    Mai Siye |   216.29667   100.12369          18
   Mai Weyni |   183.02632    209.2898          19
Miwts'e Worki |         105   11.780402           2
Miwtsa'e Worqi |   79.443335   44.008165           3
 Ruuba Shewit |   123.33333   25.166115           3
Seelam Beqalse |         105   31.002684           9
--------------+------------------------------------
        Total |   158.37455   115.74672         257
                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      766291.252     16   47893.2033      4.32     0.0000
 Within groups      2663418.56    240   11097.5774
------------------------------------------------------------------------
    Total           3429709.82    256    13397.304
```

```
Bartlett's test for equal variances:  chi2(16) = 102.2199  Prob>chi2 = 0.000
sort treatment

by treatment: sum avgoutput

treatment = 1
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |       106    115.0934  91.90847     21.67        659

treatment = 2
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        75    214.2995   132.384        60        709

treatment = 3
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |        71    168.3131  105.9491     38.33     421.67

treatment = 4
    Variable |       Obs        Mean    StdDev       Min        Max
-------------+-----------------------------------------------------
   avgoutput |         5      95.934  10.75041     84.67     110.67

 oneway  avgoutput treatment , tabulate

            |        Summary of avgoutput
  Treatment |        Mean   StdDev       Freq.
------------+------------------------------------
          1 |    115.0934   91.908466         106
          2 |   214.29947   132.38396          75
          3 |    168.3131    105.9491          71
          4 |      95.934   10.750406           5
------------+------------------------------------
      Total |   158.37455   115.74672         257

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      459642.223      3   153214.074     13.05     0.0000
 Within groups      2970067.59    253   11739.3976
------------------------------------------------------------------------
    Total           3429709.82    256    13397.304

Bartlett's test for equal variances:  chi2(3) =  25.7140  Prob>chi2 = 0.000
```

```
by treatment : sum avgstrawyield

treatment = 1
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
avgstrawyi~d |        94    247.0791    151.6292       9.67     783.33

treatment = 2
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
avgstrawyi~d |        66    380.0892    239.4352      11.67        970

treatment = 3
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
avgstrawyi~d |        68    351.4813    208.8497         15     816.67

treatment = 4
    Variable |       Obs        Mean    StdDev      Min        Max
-------------+---------------------------------------------------------
avgstrawyi~d |         5       284.8    45.56489     230.67        346

oneway avgstrawyield treatment , tabulate

            |      Summary of avgstrawyield
  Treatment |        Mean   StdDev      Freq.
------------+------------------------------------
          1 |   247.07915   151.62924         94
          2 |   380.08924   239.43523         66
          3 |   351.48132   208.84972         68
          4 |       284.8   45.564892          5
------------+------------------------------------
      Total |   316.03459   203.45506        233

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      808072.081      3    269357.36      7.01     0.0002
 Within groups      8795327.02    229   38407.5416
------------------------------------------------------------------------
    Total            9603399.1    232   41393.9616

Bartlett's test for equal variances:  chi2(3) =  24.0657  Prob>chi2 = 0.000


*log, close
exit, clear

end of do-file

log close
       log:  F:\ISD\croptype4.log
  log type:  text
 closed on:  21 May 2007, 14:34:06
```