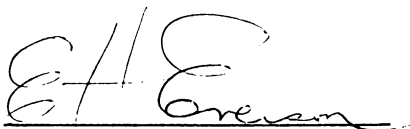




This is to certify that the
thesis entitled
MAJOR FACTORS LIMITING THE YIELD
OF GRAIN SORGHUM IN SOMALIA
presented by
ABDULLAHI NUR ALIO

has been accepted towards fulfillment
of the requirements for
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Major professor

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MAJOR FACTORS LIMITING THE YIELD
OF GRAIN SORGHUM IN SOMALIA

By

Abdullahi Nur Alio

A THESIS

Submitted to
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ABSTRACT

Major Factors Limiting the Yield
of Grain Sorghum in Somalia

By

Abdullahi Nur Alio

Seedbed preparation, fertilizer, insects, weeds, birds and germplasm were examined in two seasons at two different locations. All factors significantly affected the yield.

The traditional system of micro-bunding as a seedbed preparation method gave an increase of 23 to 25 percent more sorghum grain than the macro-bunding system. Planting of sorghum in furrows gave a significant increase of 60 percent in grain yield compared to planting on ridges. Bunding and furrowing systems were thought to reduce the runoff of rainwater.

Nitrogen applications of 80 kg per hectare gave better results than 40 kg and zero levels. The optimum rate of phosphorus application on yield was 40 kg per hectare. Since only two levels of potassium were used, the optimum rate could not be determined in this experiment.

The increase in yield due to insect control ranged from 49 to 86 percent and all treatments were statistically significant at the 5% level.

Yield increases due to weed elimination ranged from 49 to 75 percent. All weeding dates gave yields significantly higher than no weeding.

The grain feeding birds are one of the major factors affecting the yield of grain sorghum. The average yield loss due to Quelea quelea spp. and other birds was estimated to be 41.7 percent even though the field was protected by laborers. No satisfactory method of control was found.

Yield of local red and white dura types of sorghum was very poor. A number of exotic varieties gave significant yield increases.

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Introduction

Agriculture is the backbone of the economy of the Somali Democratic Republic. The cultivatable area of the country is 8,150,000 hectares of which only 700,000 are cropped at least once a year. The total area under sorghum cultivation is about 388,000 hectares, more than 50 percent of the total area under cultivation in Somalia (8). Sorghum in Somalia depends entirely on the fluctuating seasonal rainfall ranging from 200-600mm per annum.

The first season of the year (April-June) is called "GU" whereas the third season (October-December) is called "DER."

The Gu rains are more reliable than Der rains which are more scattered and erratic. The crop is grown mainly in the relatively high rainfall areas in the northwestern highlands and on the plain between the Juba and Shebelle Rivers, but beyond the reach of flood waters. This inter-river area has the highest mean annual rainfall of the country.

Drought resistant, red and white dura sorghum types are grown in this area. They mature in 3-4 months, while a late maturing variety called "ELMIJAMA" is grown in the northwestern area. It matures in 6 months but its yield is higher than the early maturing local varieties in the south. The importance of this crop for the country can be realized from the following facts:

- 1) It is the staple food for the majority of the Somali people.
- 2) It is the main feed for the livestock in the country.
- 3) The area devoted to this crop is more than any other cultivated

crop in the country.

Of the total crop, 301,000 hectares are grown in the inter-river areas at least once a year and 52,000 hectares are grown in the north-western area where the national average grain yield is 300-400 kilograms per hectare. The main reasons for such a low yield may be:

- 1) Low yielding varieties with short and medium maturity ranges in the inter-river areas.

- 2) Late maturing varieties coupled with a low yield potential and lack of moisture in the northwestern area.

- 3) No proper plant protection measures against insects, diseases, birds and weeds.

- 4) Fluctuations of seasonal rainfall coupled with no moisture conservation practices.

At present, there is a major need to improve farming methods because the yield potential of even the local varieties is seldom realized. As sorghum in Somalia is grown entirely with rainfall, the problem is how to improve the production under dryland conditions. Any production improvement program must be based on:

- 1) Identification of varieties with high potential and yield stability and;

- 2) Management practices appropriate to a given environment. The main objectives of these studies were to identify the major factors limiting the grain yield of sorghum in Somalia.



Literature Review:

Seedbed preparation:

The most limiting factors on yield of sorghum is the rainfall. In Somalia, sorghum is grown wherever the soils are suitable and the mean annual rainfall exceeds 300mm. Even where the annual rainfall exceeds 400-500mm, sorghum production by traditional farming methods entails a high risk of periodic crop failure (15). Sorghum cultivation is done by hand except in a few areas of the northwestern region where bullocks are kept for draft purposes. The common seedbed preparation carried out by hand hoeing and hand leveling are inadequate to control runoff of rain water. The traditional hill seeding in which the seed is covered with the planter's foot, as practiced in the southern part of Somalia or broadcasting and covering the seeds by plowing as practiced in the northwest region have resulted in inadequate and uneven plant stands, which cannot be corrected by subsequent management practices. More appropriate techniques than those actually practiced by most local farmers are needed.

The seedbed for sorghum should be plowed deep enough to facilitate water absorption and root penetration (10). Finally, the field must be kept free of weeds. Deep plowing may facilitate more absorption of rain water and lower runoff losses, however, early work at Samaru, Nigeria revealed no significant differences between deep and normal tillage (26). The seedbed preparation practices are determined by the amount and intensity of rainfall, soil type, slope of the land and many other factors (22). Compacting of the soil after planting sorghum in dryland

conditions is found to be useful, as the compaction presumably compresses the soil around the seed making more moisture available and restricting evaporation losses (7).

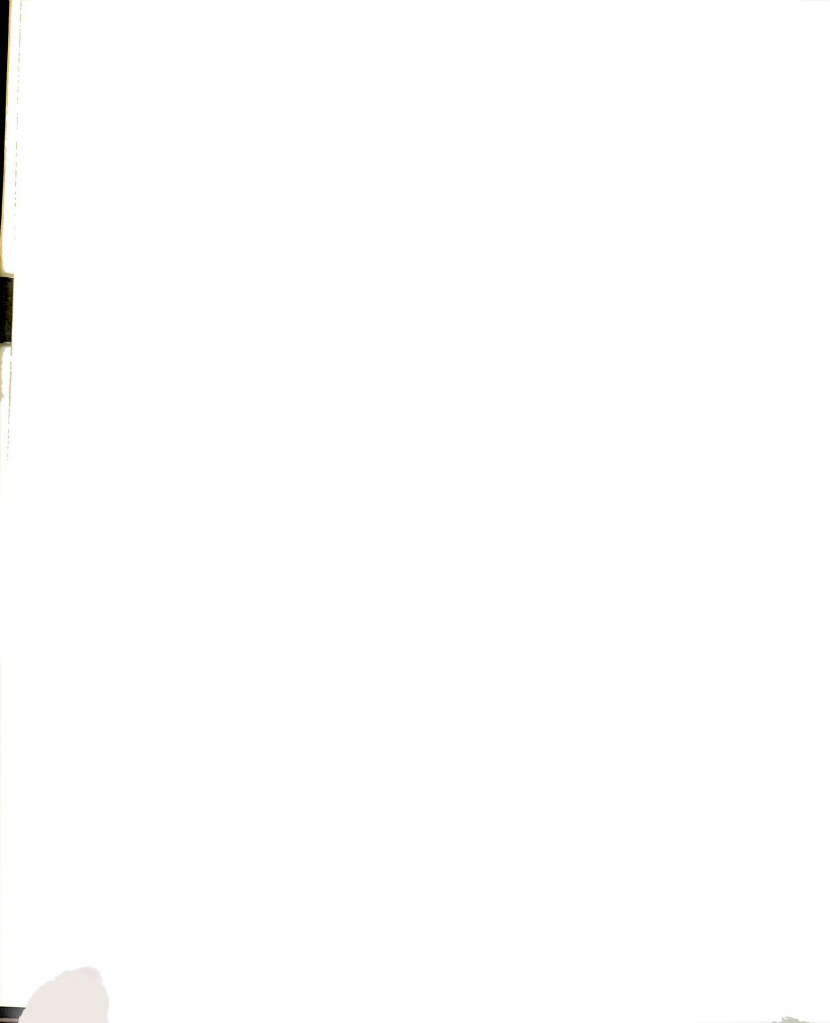
Fertilizer:

Sorghum grows best on soil in good tilth with a relatively high and balanced fertility. Sorghum yield and plant efficiency are both reduced by a low level of fertility and fertility imbalance (3).

Use of chemical fertilizers on crops with a low cash return per unit area, is not traditional in Somalia. The yield potential of local varieties is low, therefore, fertilizer applications are likely to be economical only when the crop is not limited by low yielding varieties coupled with poor cultural practices. Therefore, no chemical fertilizer applications are recommended for the relatively unresponsive local sorghum varieties.

In Upper Volta, 12 kg/ha nitrogen and 30 kg/ha phosphorus gave yield increase ranging from 625 kg to 1,000 kg/ha with some appreciable residual effect the following year (5).

The response of sorghum to fertilizers in dryland production is dependent on the amount of seasonal precipitation. In a year with 572mm of total precipitation, grain yields increased with increasing nitrogen application up to 110 kg/ha (5). However, if the use of fertilizer is excessive, the available moisture in the root zone may be exhausted before the plants come to the reproductive stage, resulting in poor



yields (2). The uptake of nitrogen is very high during rapid vegetative growth preceding heading and grain development. There are differential responses to the time of application of nitrogen fertilizer. In soils where nitrogen does not leach easily, applications up to 80-100 kg/ha at or before planting could be beneficial, whereas in lighter soils, a split application may be better. Varieties also showed a differential response to nitrogen (3). Phosphorus accumulation is high during early vegetative growth, but it is highest in the period of grain formation. Response of sorghum to phosphorus occurs at most of the locations in India, and the optimum limit of application was 40-50 kg/ha (3). Potassium uptake is greatest during vegetative growth preceding heading. Response to K was observed in limited areas in India. In a recent reclaimed area at Hyderabad, there was a significant increase in grain yield of hybrid sorghum (CSH₁) with a dressing of 30 kg/ha over no K dressing (3).

Animal manure:

Animal manure has been found effective in improving the physical and chemical characters of the soil and has resulted in increased yields even under low rainfall conditions, provided the applications are made at the proper time and in moderate doses. In Somalia, use of animal manure is not widespread, though increases on grain yields have been demonstrated. With a dressing of animal manure at a rate of five tons per hectare and using a locally adapted Sudan variety "WADAKAR", the

treated plot with manure produced 2,840 kilograms per hectare while plots receiving no treatment produced only 1,270 kilograms per hectare, an increase of 1,570 kilograms of grain per hectare (1). In Mali, in the framework of a traditional agriculture, use of animal manure gave a yield increase up to 1,400 kilograms per hectare (5). The usual objection or prejudice of the Somali farmers against the use of animal manure to sorghum in dryland is:

a) Their experience of crop failure or drying up of the crop by manuring on account of heavy application in a year of scanty rainfall and;

b) An increase of soil borne insects, such as white grubs and termites, in the treated areas.

Micronutrients:

Minor elements are occasionally deficient in some sorghum production areas. Under some conditions, iron deficiency symptoms occur in calcareous soils. It is corrected in its early stage by foliar sprays with iron compounds. Zinc deficiencies are often noted with irrigation and heavy fertilization with major elements. Soil application and foliar sprays are found to be effective in treating Zn deficiencies. Magnesium deficiencies may occur in some very sandy soils, whereas calcium, and sulphur deficiencies have not been observed in sorghum production areas. Manganese, copper or boron deficiencies may occur but considered economically unimportant (3).

Insects and Diseases

A. Insects:

Numerous insects cause considerable loss to grain sorghum and various control measures have been suggested (3) and can be grouped into:

- a) Preventive agronomic practices
- b) Insecticidal control measures
- c) Use of parasites and predators
- d) Breeding for resistance.

Heavy dependency on insecticides may not be wise, as insects develop resistance to the insecticides. The use of insect resistant varieties provide an ideal way to control damage by insects, because it does not involve recurring expenses, presents no toxicity hazard and minimizes the risk of total failure (3). In some areas where resistance is at a relatively high level, it may be sufficient in itself for control.

Definition and nature of resistance:

A plant resistant to insects possesses heritable qualities which enable it to produce a greater yield of better quality than other plants of the same species when accessible to the same pest population. Resistance of plants is relative and generally must be compared with plants more severely damaged under the same set of conditions (6). Insect resistance in crop plants may be grouped into three major categories (24):

- a) Non-preference: a type of resistance which denotes the presence or absence of plant characters which cause an insect to utilize

it less, than a susceptible plant, for oviposition, food, shelter or a combination of the three.

b) Tolerance: a type of resistance where a plant withstands or recovers from damage in spite of supporting an insect population approximately equal to that damaging a susceptible host.

c) Antibiosis: a type of resistance denoting some adverse effect of the plant on the insect, i.e., reduced reproduction, decreased size, abnormal length of life or increased mortality.

Sorghum insects in Somalia:

Study surveys carried out in the main sorghum producing areas have indicated the prevalence of a number of sorghum insects in the country. A brief review of the major insects attacking the crop is given below followed by a summary list of insects attacking the crop in Somalia (17). Starting from the time of seeding, the sorghum crop is vulnerable to many pests in many parts of Africa including Somalia. The planted sorghum seeds are damaged by mole crickets as they begin to swell and germinate. Severe attacks of mole crickets have been observed in the Bonka area in the early Gu and Der rainy seasons. The insects dig where the seed is, damaging it which results in poor crop stands. The fungicide Ceresan, used to treat sorghum seed, did not deter or control the mole cricket.

Sorghum Shootfly (Atherigona varia socata Rond.) is a major insect in most of the sorghum growing countries. Possibly due to the process

of natural selection, some varieties of sorghum incur a relatively small amount of damage by the shootfly. The cause for resistance was a greater content of silica in the cells of the stem of the seedlings of resistant varieties when compared to susceptible varieties (3). A systematic approach for identifying resistant varieties and developing shootfly resistant lines through breeding might be possible due to the availability of a world collection of sorghum.

Shootfly is a serious pest of sorghum during the seedling stage. Limited observation at CARS, Afgoi, indicate that early planting of sorghum, just before the onset of the seasonal rains, permits the seedlings to escape infestation of shootfly while late planted sorghums were seriously attacked (20). Several varieties have been identified as resistant to shootfly. In East Africa, the varieties Namatare and Serena recovered well after damage by the insect (7). Furadan (10G) drilled along with seed at 1.5 kg (A.I.) per hectare gave fair control in the first four weeks after germination. This markedly affected the final grain yield of the local variety (Table 8 and 9). However, further studies on the chemicals, in relation to the cost of production, are needed.

Stem borer (Chilo zonellus = partellus Swin) is the most serious pest of sorghum in Somalia (17). There is no reliable figure on the yield loss it causes. Losses vary with the intensity of infestation and with the growing conditions of the crop. The nature of the larvae is to move from the main stalk, after destroying it, to the tillers or even to

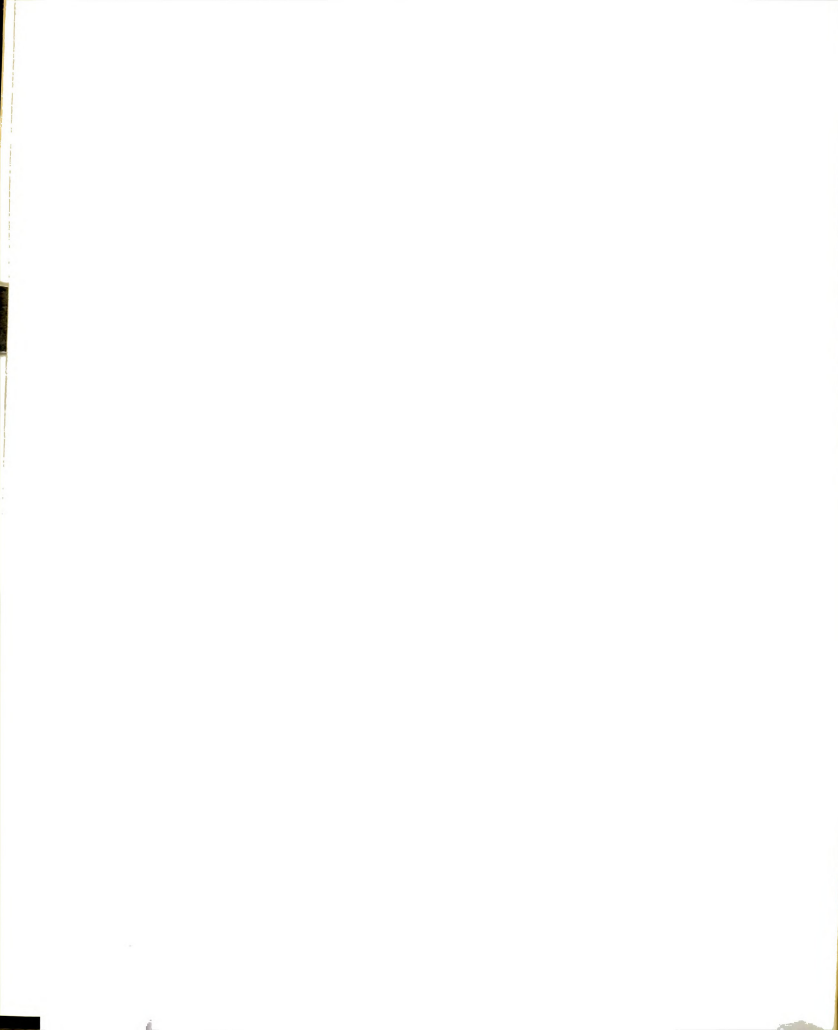
another plant. The losses appear to be higher when there is a shortage of seasonal rainfall since recovery is limited with lack of moisture. To control the borer infestation, strong sanitary measures are recommended. Crop rotation, weed control and the clean up of crop residues might reduce the incidence of borer attack. Chemical control can be effective only when the proper insecticide is applied at the right time. Since the borer can attack the crop during the entire growth period, timely application of insecticides are strongly recommended (16). Resistance to the borers is found in the World Collection of sorghum, but it is not easy to demonstrate, because the female moth exercises choice of food at oviposition. Predators and parasites often contribute to keeping stem borers under control. Parasites attacking the stem borer are found in East Africa (7).

Sorghum midge (Contarinia sorghicola. Cog.). The pest is prevalent in all sorghum growing countries. The adult female fly lays eggs in the flowering heads of the sorghum where the later developed larvae feed on the developing seed for about ten days and then move up to the tip of the spikelets where the pupae develop and emerge as adults (7). The entire head may be eaten by the larvae while it still appears healthy but no grain will develop. On closer examination, shriveled grain and larvae or pupae may be found inside. The pest is found in Somalia causing severe loss in yield of grain. Sorghum planted in the early Gu or Der seasons may escape the attack of the pest. SEVIN, DIAZINON and DIMETHOATE are effective in control of sorghum midges, provided



application is early. Tests, at CARS, Afgoi, using DILEX (DIPTREX) gave excellent control of sorghum midges (20). Millets and other grasses such as Johnsongrass, serve as alternative hosts for the pest, therefore, elimination of wild sorghum and grasses, especially those that bloom before the sorghum may reduce the damage of midges.

Maize leaf aphid (Rhopalosiphum maidis Fitch) is the most prevalent pest infesting the sorghum plant in Somalia, attacking the leaves and panicles. Infestation starts in the whorl of the leaves and later on the heads producing sticky honey dew on which various fungi will be established. Sorghum varieties differ in their susceptibility to aphids. Use of a chemical to control aphids may lead to the destruction of its natural predators such as ladybug (Coccinellidae), however Malathion is often used at 0.8 to 1 liter per hectare to control the aphids (3).



Insects attacking sorghum in Somalia

Sample No.	Common Name	Scientific Name	Nature of damage
1	Sorghum shootfly	Atherigona varia soccata Rond.	Produces dead hearts in young plants
2	Stem borers	Chilo zonllus (swim)	Leaf injury and "dead heart"
3	Midge	Contarinia sorghicola Cog.	Larvae feed on ovaries destroy young develop- ing seeds.
4	Aphid	Rhopalosphum maidis Fitch.	Feeds in the central portion of the whorl causing honey dew.
5	Mole crickets	---	Feeds on germinating seeds.
6	American bolworm	Heliothis armigera Hub.	Caterpillars feed on maturing grains, ser- ious in compact heads.
7	White grubs	Unidentified	Larvae feed on roots.
8	Termites	Unidentified	Feed on roots and make galleries in the stem of living plants.
9	Blue bugs	Calidea Spp.	Feed on the grain as it develops and causes it to shrivel and be distorted.
10	Spider mite	Olygonichus simus Pritch and Baker	Feeds on undersurfaces of leaves causing dark red spots.

Armyworms, cutworms, grasshoppers and hairy caterpillars also damage sorghum.

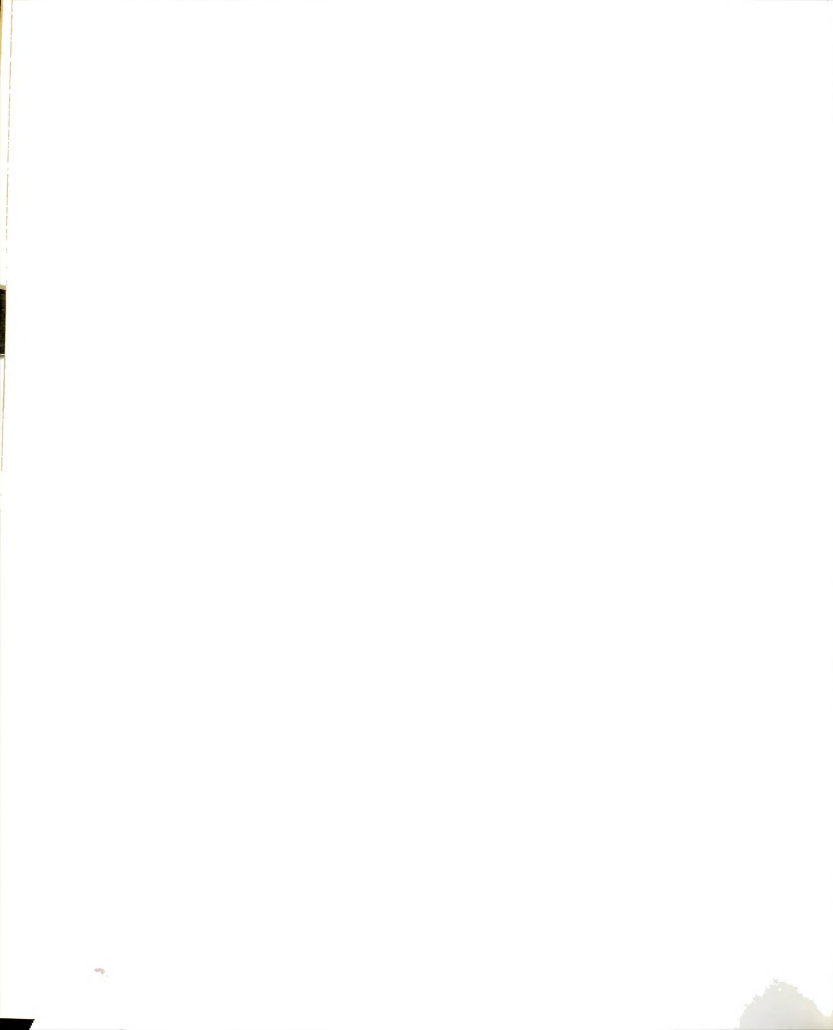


Sorghum Diseases:

Numerous fungi, bacteria, nematodes, and virus diseases affect sorghum. Mercurial compounds often check the seed borne diseases. Beside the use of chemicals, sanitary conditions within the crop always insure minimum infestation of pests and diseases (9). As sorghum in Somalia is grown in areas of limited rainfall, the prevalence of disease is limited. Studies on sorghum diseases in Somalia are limited. However, various localized smut diseases are observed. The loss in grain varies according to the intensity of infection, which, in turn, depends upon the climatic conditions. Accurate information on the extent of grain loss are not available.

Weeds:

The environmental factors where sorghum is planted and grown favor germination and luxuriant growth of weeds. The competition between the weeds and the sorghum is particularly severe in the seedling stage because sorghum seedlings are small and weak and do not compete favorably. The Somali farmer, with limited means, is well aware that after moisture, weeds are the main limiting factor in grain sorghum production. Failure to control weeds on time will reduce the yields. The farmer endeavors to clear the land of weeds prior to planting and to assure weed free initial stands. Thus, by planting at the proper time in a weed free seedbed, the sorghum seedlings have an initial advantage over early weed growth. Weed control can be accomplished either by mechanical methods,



chemical methods or a combination of the two. Mechanical cultivation may be accomplished by hand hoe, rotivatory hoe and with the cultivator. Usually 1-3 shallow cultivations are necessary to control weeds. Deep and too frequent cultivation will seriously damage the sorghum roots and thereby defeat its very purpose (5).

Sorghum is more susceptible to damage by chemical herbicides than is maize or wheat. Successful use of herbicides depends upon the accurate calibration of the sprayer and close following of label instructions regarding rate, methods and time of application (3). Herbicides can be applied as, a) pre-plant; b) pre-emergence; c) post-emergence (4 and 18). Two herbicides, Propazine and Atrazine (Triazine compounds) have given good results in control of weeds in sorghum. Propazine is the most promising herbicide for pre-emergence control of weeds in sorghum. It gives good control with little or no crop injury. Pre-emergence application of Atrazine generally gives good control of weeds but frequently injures the sorghum crop (5). In a sorghum field, it is difficult to control Johnsongrass with a chemical as it belongs to the sorghum group. A combination of chemical and mechanical control may be the best solution. Research on sorghum that is non-irrigated in Nebraska has shown that the most efficient control of weeds and the highest yields were achieved by a combination of weed control methods (5). Better grass and broadleaf weed control was obtained also when Atrazine plus two cultivations were applied on sorghum grown at CARS, Afgoi (20).

Birds:

Quelea quelea - Weaver birds and other bird species feed on the developing or mature grains of sorghum. Quelea Spp. are the most destructive birds of small grain crops in many parts of Africa. These birds are grass feeders and grain eaters for most of the year and the main check on their numbers is food supply (7). As the acreage of grain is increasing, the bird population may increase because of the abundant supply of food. Seasonal rainfall affects grass seed production and therefore, the availability of Quelea food. Studies on the factors influencing the choice of diet has shown that sorghum is attractive only in years when the birds are not feeding on wild grasses (26). Studies on bird populations in Somalia have provided preliminary information about the species, their distribution, feeding and breeding colonies (13).

Small numbers of Quelea quelea intermedia (weaver birds) were found throughout the year in some parts of the country, however, the greatest numbers were present in the southern part, from July when the sorghum and other small grain cereals start heading until early October and from January-February for the second season. The common feeding pattern is in the morning and evening. Considerable numbers of Quelea Spp. were also found in the northwest region during the months of August through October, but no breeding colonies were found (13 and 19).

Considerable numbers of Ploceus cuculatus (black-headed weaver) were found throughout the southern part of Somalia. It is one of the most serious grain eating pests in the vicinity of rivers. Breeding appears



to be concentrated in the months following the seasonal rains.

Considerable numbers of Ploceus bojeri (golden palm weaver) were found in Somalia. It breeds over large areas generally following the rains. It damages maize, sorghum and millets.

Euplectes orix (red bishop) is found throughout Somalia, the greatest population being found in the driest regions of the country. It breeds in the later Gu season and eats all types of grains except maize.

Other grain eating species on which there is little information are as follows (13):

- | | |
|---------------------------------|---------------------|
| 1) <u>Ploceus rubiginosus</u> | chestnut weaver |
| 2) <u>Ploceus galbula</u> | ruppel's weaver |
| 3) <u>Ploceus spekeoides</u> | speke's weaver |
| 4) <u>Passer castanopterus</u> | Somali sparrow |
| 5) <u>Passer griseus</u> | grey-headed sparrow |
| 6) <u>Bulbalornis niger</u> | buffalo weaver |
| 7) <u>Amblyospiza albifrons</u> | grosbeak weaver |

Quelea quelea is the most destructive in Africa. Damage caused by Quelea quelea in the Savannah Zones between Senegal and Lake Chad is estimated at 50,000-80,000 tons of grain per annum (26). Bird damage was reported throughout Somalia, when crops are grown, but figures on the percentage of damage were not documented with the exception of the experimental sites (see Tables 15 and 16). The extent of bird damage depends among others on the natural foods. As the natural foods become less abundant the crop attracts large numbers of Quelea. Bird damage



up to 75% in a millet experiment was reported (13).

Scaring birds away by workers on raised platforms with rope slings in their hands is the only practical method of bird control actually used. However, several other methods to reduce bird damage have been devised such as chemical repellents, acoustical units to scare the birds and bird resistant varieties.

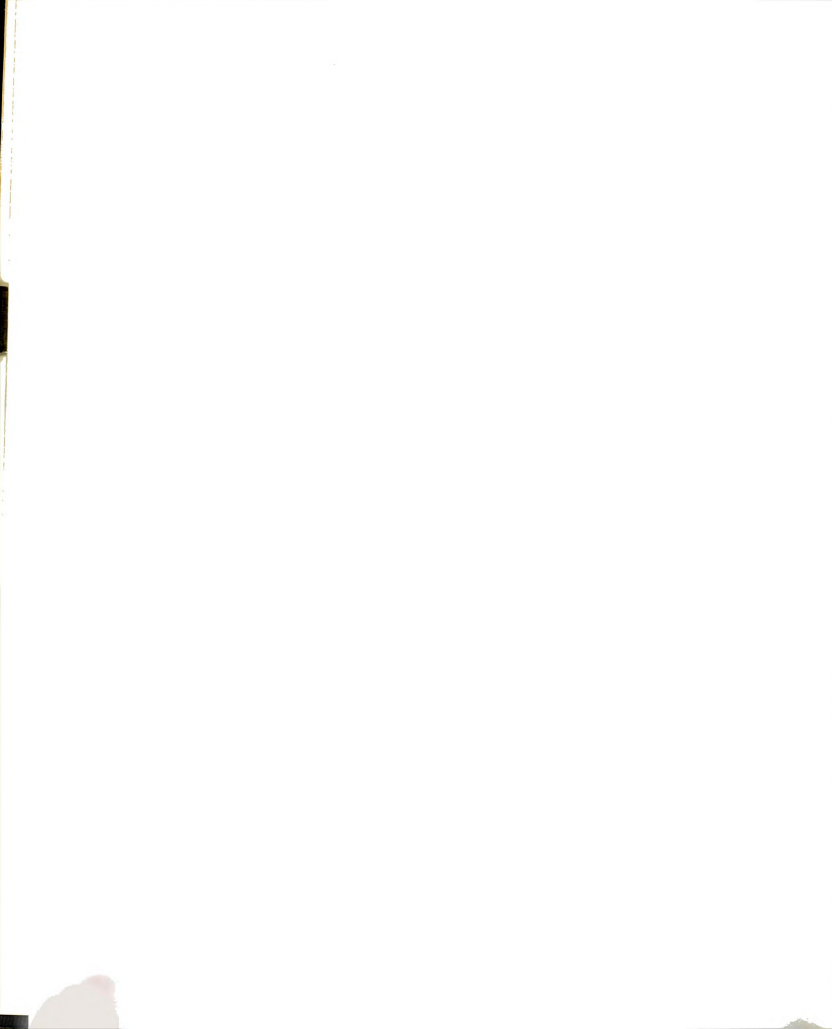
AVITROL (4-Aminopyridin) is used as a repellent to Quelea quelea but sorghum treated with Avitrol at concentrations up to 0.2% is readily accepted by the birds but the dying birds do not repel others from the field (19).

An AV-Alarm sound unit appears to have an effect up to 200m from the unit, but as soon as the birds become accustomed to the noise, the effect may become less (21).

Bird preference (26) is the basis of breeding for bird resistant varieties. The order of preference of birds is given below:

- a) (white corneus) sorghum grain
- b) Grass seeds
- c) Sorghum grain with persistent integuments.

Bird resistance is defined as that mechanism or characteristic of a variety that given a choice of feeding material, birds will not normally deprecate (12). Bird resistance is relative to bird population and other feeding choices and probably many other factors. The primary cause of bird resistance is the presence of tannin in the seed which makes the grain in the milk stage, unpalatable to the birds. Other



plant characters such as long glumes, large awns and loose panicles tend to discourage birds. However, the feeding value of brown seeded sorghum grain is lower than that of red and yellow seeded varieties and their acceptance by the growers is also less because of their bitter taste.

Germplasm:

Sorghum is one of the oldest crops grown in nearly all cultivatable areas of Somalia since time immemorial. As the population increased, the agriculture became more important, several new crops were introduced and large acreages along the two-rivers grew the new crops. Maize became one of the most competent food crops for this area. Maize has replaced sorghum in all irrigated areas of the country due to its easy cultivation, high yield, and fewer problems with grain feeding birds, especially Quelea quelea. The importance of sorghum was not limited as a source of food only but the straw has been considered a main source of feed for the livestock population of the country. The technological advancements in sorghum production that developed in many sorghum producing countries of the world has not yet come to Somalia. One of the major factors limiting this vital crop is the low yield potential of the local varieties. The grain yields of the existing varieties in the southern part of the country are very poor. Those grown in the northwest region mature in six months, which does not fit into the existing rainfall pattern. Therefore, high yielding varieties adaptable to the

agro-climatic conditions should be developed to replace the present local varieties. The high yielding varieties or hybrids can only help to increase yields if management factors are properly carried out.

Local collections, FAO Regional Nurseries, and the World Collection of Sorghum held at the Indian Agricultural Institute-India, can serve as good sources of germplasm for the implementation of sorghum improvement programs. As sorghum is entirely grown without irrigation and the grain is used for human consumption, the choice of the local varieties has never been based on its yield potential (25). The main criteria for the selection was on dependability of the variety under prevailing conditions and the seed color, as the white corneous seeds are preferred by the growers (11).

An initial sorghum yield improvement in Somalia can be achieved by careful selection of local materials which have acquired the resistances and tolerances to the prevailing pests and diseases of the area. This method of improvement has been practiced in many African countries, where the local varieties closely adapted to the local conditions in which some improvements have proved possible by selection (26). In India, the initial sorghum improvement was based on selection within the existing local material. This resulted in varieties of excellent local adaptation with good or very good resistance to local pest and disease complexes (7). Direct introduction of improved exotic varieties may help to increase the yield, especially an introduction from those countries where the growing conditions are similar to that of Somalia.

Careful evaluation is required before any release of new varieties to the growers. Appropriate measures are needed to prevent the entry of pests and diseases with the introduced varieties which may lead to the destruction of even the existing varieties.



Materials and Methods

I. Seedbed preparation:

In this experiment, the effect of two different methods of seedbed preparation on the yield of grain sorghum was considered.

A. The first method widely used by the local farmers in the inter-river region is the bunding method, where the earth is ridged to retain the rainwater in each square plot. According to the size of the bunds this method was subdivided into: 1) Big bunds locally called, "Jibaal" and equals one-sixteenth of a hectare (25m x 25m). 2) Small bunds locally called "Moos" and equals about 1/2500th of a hectare.

The experiment was conducted at the Central Agricultural Research Station (CARS, Afgoi), and Bonka Research Station in Somalia during the Der season 1977 and Gu season 1978 under rainfall conditions. The crop was planted at the onset of the seasonal rains in both seasons, using a common light red early maturing local variety called "Fudfududo" from the Bay Region. Planting was done by hand with spacing of 1m x 40cm, thinned into two plants per hill. The two treatments were replicated three times. No fertilizer was applied, weeds were removed twice during the growth period of the crop using the handhoe. One application of SEVIN 85 was provided to control borers at a rate of 1.7 kg (A.I.) per hectare. Slight bird damage was observed in both locations, however, birds were scared away by laborers using rope slings. An area of 100m² was harvested from each treatment in each replication. The data on grain yield for each location and season was analyzed.

B. The second method of seedbed preparation was deep furrowing. This method was possible where oxen or tractor plow were used. Under this method, seeding was done by hand; 1) in furrows, and; 2) on ridges using the common local variety from the Bay Region. The experiment was conducted at CARS, Afgoi, under rainfall conditions during the Der season, 1977. The crop was planted at the onset of the rains with no fertilizer. During the growing season, the crop was weeded twice and protected against stem borers using SEVIN 85 at a rate of 1.7 kg (A.I.) per hectare. The two treatments were replicated three times. Each plot consisted of 6 rows 10m long with spacing 1m x 40 cm, thinned to two plants per hill. Since two border rows were eliminated, the harvested area was 40m². The data on grain yield was analyzed.

II. Fertilizer

In this experiment, the effect of nitrogen, phosphorus and potassium fertilizer on grain yield of a local sorghum was studied.

0, 40, 80 kg per hectare of nitrogen and phosphorus were applied with 0 and 80 kg per hectare of potassium expressed as K₂O. Normal cultural practices were adopted. The experiment was conducted at CARS, Afgoi, in Der season, 1977, under rainfall conditions. The crop was planted at the first onset of the rain. The local variety from the Bay Region was used.

Design: 3 x 3 x 2, completely randomized block factorial design replicated three times. Plot size was (5m x 6m) = 30 m² for each plot



having 6 row 1m wide and 5m in length with the spacing of 40cm between plants. The plants were thinned to two plants per hill. The area harvested was 4 rows 5m long = 20m^2 . Data on grain yield was collected and analyzed.

III. Insect Control

A. Above ground insects:

Treatments:

- 1) No pesticides.
- 2) Furadan at a rate of 1.5 kg (A.I.) per hectare applied one time at planting with the seed.
- 3) SEVIN 85 at the rate of 1.7 kg/ha post-emergence spray followed by weekly applications.
- 4) DIAZINON at the rate of 1.5 l/ha post-emergence spray followed by weekly applications.
- 5) MALATHION at the rate of 1.7 kg/ha post-emergence spray followed by weekly applications.

Design: Randomized blocks of 5 plots with 6 replications. The plot size was $(4.5\text{m} \times 10\text{m}) = 45\text{m}^2$ with spacing of 75cm x 25cm between rows and between plants.

Four central rows were harvested to record yield of grain. The experiment was conducted on irrigated land at CARS, Afgoi during the Der 1977 and Gu 1978. The total rainfall for Der 1977 was 327.9mm, so only one irrigation was given at the time of planting. The Gu 1978

trial was given two supplemental irrigations plus the seasonal precipitation of 126mm. The common local variety from the Bay Region was used. The experiment for the Der 1977 was erroneously sprayed once with Malathion when the crop was at the milk stage. Data on grain yield was analyzed.

B. Soil borne insects:

Treatments:

- 1) Check - no soil treatment.
- 2) Soil was treated with Chlordane at the rate of 1 kg/ha plus 1 kg/ha of Systox before planting.

The experiment was conducted at CARS, Afgoi, in Der 1977 under rainfall conditions using the local variety from the Bay Region, planted at the first onset of the rains. Randomized block design of two plots each replicated four times was used. The plot size was $(6m \times 10m) = 60m^2$ with 1m spacing between rows and 40cm between plants thinned to two plants per hill. No fertilizer was applied, spraying with SEVIN 85 once at the rate of 1.7 kg/ha and two hand-weedings were provided. No severe bird damage was noticed due to the surrounding millet crop. Four central rows were harvested for yield and number of plants per plot was recorded at the time of harvest. Data on grain yield and plant population were analyzed.

IV. Weed Control:

Treatment:

- 1) Check - No weeding.
- 2) Weeding one week after germination and whenever required.
- 3) Weeding two weeks after germination and whenever required.
- 4) Weeding three weeks after germination and whenever required.

The trial was conducted under rainfall conditions as well as irrigation at CARS and Bonka. The design used was randomized blocks of four plots each with four replications. Plot size for irrigated plots was $(7.5\text{m} \times 5\text{m}) = 37.5\text{m}^2$ with spacing of 75cm x 25cm between rows and plants.

The plot size for dryland was $(10\text{m} \times 5\text{m}) = 50\text{m}^2$ with spacing of 1m x 40cm between rows and plants.

Four center rows were harvested for Afgoi trial while 8 rows were harvested for Bonka trial to record grain yield. Data on yield were analyzed.

V. Birds damage assessment on sorghum trials:

An attempt was made to estimate the effect of birds on grain yield and the data are analyzed.

In this study, an attempt was made to estimate the percentage loss caused by birds on a protected sorghum field. The sorghum field was divided into 8 blocks and each block was subdivided into 8 plots, and in each 64 plots, 10 sorghum heads were sampled, and the percentage damage to each head examined was visually estimated. The first reading for the 640 heads was carried out on July 22, 1978, when the sorghum was in the soft dough stage. On July 29, 1978, when the sorghum was

near maturity a second reading was made following the above described method of sampling. The data were analyzed.

VI. Germplasm:

A. Selected exotic and local varieties:

Ten entries including three local varieties were tested under rainfall as well as under supplementary irrigation at CARS, Afgoi. All entries were planted in randomized blocks of 10 plots each with three replications. Plot size for the irrigated trial was $(3\text{m} \times 5\text{m}) = 15\text{m}^2$ with spacing of 75cm between rows and 25cm between plants. The plot size for dryland was $(4\text{m} \times 5\text{m}) = 20\text{m}^2$, plants were thinned to two plants per hill for both trials. Two central rows were harvested and data on grain yield were analyzed.

B. FAO Regional Nursery Yield Trials, 1977-78.

Seventeen and fourteen entries from the FAO Cooperative Sorghum Yield Nursery Trials, including a local check were tested under supplementary irrigation as well as under rainfall at Afgoi and Bonka, respectively. All entries were planted in a randomized block design replicated three times. Plot size for the irrigated trial $(3\text{m} \times 3\text{m}) = 9\text{m}^2$ with spacing of 75cm between rows and 25cm between plants. The plot size for dryland was $(4\text{m} \times 3\text{m}) = 12\text{m}^2$. Plants were thinned to two plants per hill for both trials. The first application of fertilizer of 40, 60, and 40 kg/ha of nitrogen, phosphorus and potassium, respectively, was given at the time of planting. The second application of nitrogen at

the rate of 60 kg/ha, was applied when the crop was at flowering stage. One supplementary irrigation was provided for the Der 1977 trials, while two supplementary irrigations were applied for Gu season 1978. Two hand weeding and two spray applications of SEVIN at 1.7 kg per hectare were carried out during the growing season. Two central rows were harvested for yields.

Results and Discussion

A series of experiments was conducted at two locations in Somalia during 1977 and 1978 to determine some of the major factors limiting yield of grain sorghum. Seedbed preparation, fertilizer level, soil moisture, sorghum cultivars, insects, weeds, and birds all were significant factors in limiting yield.

It should be noted in this discussion on experimental results that several experiments had high coefficients of variation. Besides the data presented, three fertilizer experiments were abandoned because of extremely high coefficients of variation. This extreme variation had several root causes.

Only 80 hectares of the 400 hectares of the Afgoi Experimental Station have been developed; i.e., these have been leveled and have irrigation water. These are the fields nearest to the headquarter buildings and have had the greatest use. They are extremely variable because of salinity problems, effects of previous experiments (especially fertilizer), uneven cropping and no regular crop rotation. Other sources of variation are introduced by the labor used to conduct the experiments. Very little sub-professional assistance is available for experimentation. The planting, fertilizing, weeding, treating with pesticides and harvesting was done by unskilled hand laborers. Field operations in general, are marginal, seeding and chemical rates are unevenly applied, and harvest somewhat inaccurate. However, in the experiments reported the trend definitely demonstrates which factors reduce grain sorghum yield.

I. Seedbed preparation:

In this study two systems of seedbed preparation were examined; the bunding and the furrowing systems. The results for bunding are presented in Tables 1, 2, and 3. The results on the bunding system at Afgoi and Bonka in Der 1977 indicate that the micro-bund plots gave an increase of 23 and 25 percent more sorghum grain than the macro-bund plots (Tables 1, 2, and 3).

However, when the data in Table 1 was analyzed this increase was not statistically significant due to the high coefficient of variation. Micro-bunding provided a significantly higher yield than macro-bunding at Bonka in 1977. There was no significant difference in seedbed preparation at Bonka in Der 1978.

Moisture seems to be the most limiting factor for dryland sorghum production. Bunding is practiced by the farmers in most dryland areas of the country to minimize runoff where moisture penetration is slow. The method is laborious but useful where the land is relatively flat and the size of the holding relatively small. This method might not be applicable where the land is quite hilly or rocky.

The furrowing system is possible only where bullocks or tractor plows are used for seedbed preparations. The results of the furrowing system, Table 4, indicate that planting of sorghum in furrows gave a significant increase of 60 percent in grain yield compared to planting on ridges (Table 4).

The initial plant stand in the furrows was better than that on the

ridges. The reason might be shortage of moisture in the surface soil of the ridges due to runoff and rapid evaporation of scanty rainfall.

TABLE 1. Yield of sorghum grain in kg/ha with two methods of seedbed preparation for moisture retention (macro-bund vs micro-bund) Afgoi, Somalia, 1977 Der season

Treatment	Replications			Mean kg/ha
	I	II	III	
1) Macro-bund	224.5	390.0	224.5	280.0
2) Micro-bund	351.0	344.5	337.0	344.0
Mean	287.7	367.3	280.0	311.9

C.V. = 22%

L.S.D. 05 = 110.2

L.S.D. 01 = 143.4

TABLE 2. Yield of sorghum grain in kg/ha with two methods of seedbed preparation for moisture retention (Macro-bunding vs micro-bunding). Bonka, Somalia, 1977 Der season.

Treatment	Replications			Mean kg/ha
	I	II	III	
1) Macro-bunding	309.3	380.0	330.0	339.8
2) Micro-bunding	466.0	429.0	384.5	426.5
Mean	387.6	404.5	357.2	383.1

C.V. = 11.2%

L.S.D. 05 = 70.0

L.S.D. 01 = 91.0

TABLE 3. Yield of sorghum grain in kg/ha with two methods of seedbed preparation for moisture retention (macro-bund vs micro-bund) Bonka, Somalia, 1978 Gu season.

Treatment	Replications			Mean
	I	II	III	
1) Macro-bunding	364.0	437.0	315.5	372.2
2) Micro-bunding	376.4	392.5	405.4	391.4
Mean	370.0	414.75	360.45	381.8

C.V. = 12.5%

L.S.D. 05 = 77.9

L.S.D. 01 = 101.3

TABLE 4. Grain yield of sorghum in kg/ha with planting on ridges vs furrows. Afgoi, Somalia, 1977 Der season.

Treatment	Replications			Mean
	I	II	III	
1) Ridges	241.25	206.25	198.75	215.4
2) Furrows	418.75	231.25	381.25	343.8
Mean	330.00	218.75	290.00	279.6

C.V. = 23%

L.S.D. 05 = 103.4

L.S.D. 01 = 134.4

II. Fertilizer:

In this study, three levels of nitrogen and phosphorus together with two levels of potash were examined. The results of the experiment are presented in Tables 5, 6, and 7.



As sorghum in Somalia is entirely grown where the seasonal rainfall is low and uncertain, the use of chemical fertilizer on sorghum is not traditional. Though the grain yield of the local variety used in this experiment was very poor, the results obtained at Afgoi under rainfall conditions in a newly reclaimed land indicate that nitrogen, phosphorus and potash seemed to be the limiting nutrients in sorghum production. Nitrogen was the most limiting nutrient. The grain from the plots which received the 40 kg/ha and the 80 kg/ha applications of nitrogen (Table 6) was 6% and 33% greater, respectively, than that from the plot which received no nitrogen. The yield differences between the plots receiving 0 and 80 kg/ha of nitrogen was highly significant.

Phosphorus was also found limiting sorghum production as shown in Table 6, the plots with 40 kg/ha of phosphorus outyielded both the plots with 0 and 80 kg/ha and thus seemed to be the optimum rate for sorghum production under the conditions of the study.

Since only two levels of potash were used, the optimum rate for it could not be found. Potassium also seemed to have little effect on sorghum grain production under these conditions (Table 7). Soil analysis for this experiment, has shown a deficiency in all three major elements and a high level of sodium, calcium and magnesium. The pH level of the soil ranged between 7.7 - 8.1.

This experiment was probably not too pertinent since the local sorghum variety used had such a low yield potential. Fertilizer trials should be conducted in cooperation with small farmers in the coming



years, over a wide range of environments. Experiment station locations should be avoided because of the confounding effects of previous research.

Table 5. Yield of non-irrigated grain sorghum in kilograms per hectare with 0, 40, 80 kg/ha of nitrogen and phosphorus together with 0 and 80 kg/ha of potassium. Afgoi, Somalia, 1977 Der season.

Levels of N, P, K in kg/ha				Replications			Mean
No.	N	P	K	I	II	III	
1	0	0	0	232.5	405.0	325.0	320.83
2	0	0	80	427.5	280.0	175.0	294.16
3	0	40	0	285.0	465.0	517.5	422.5
4	0	40	80	515.0	410.0	372.5	432.5
5	0	80	0	297.5	380.0	295.0	324.16
6	0	80	80	405.0	310.0	312.5	342.5
7	40	0	0	175.0	295.0	282.5	250.83
8	40	0	80	550.0	352.5	400.0	434.16
9	40	40	0	587.5	300.0	357.5	415.0
10	40	40	80	557.5	252.5	382.5	397.5
11	40	80	0	327.5	392.5	440.0	386.66
12	40	80	80	332.5	410.0	377.5	373.33
13	80	0	0	490.0	235.0	345.0	356.66
14	80	0	80	455.0	442.5	532.5	476.66
15	80	40	0	595.0	437.5	607.5	546.66
16	80	40	80	532.5	437.5	472.5	480.83
17	80	80	0	500.0	397.5	515.0	470.83
18	80	80	80	557.5	485.0	395.5	479.33
Mean				435.0	372.0	395.0	400.28

C.V. = 22.5%

L.S.D. 05 = 147.0

L.S.D. 01 = 191.1



TABLE 6. Yield of grain sorghum in kg/ha with three levels of phosphorus (0, 40, 80) and three levels of nitrogen (0, 40, 80). Afgoi, Somalia, 1977 Der season.

Level of Nitrogen kg/ha	Level of Phosphorus kg/ha			Mean
	0	40	80	
0	307.5	428.0	333.5	356.3
40	342.5	406.5	380.0	376.3
80	417.0	514.0	491.5	474.1
Mean	355.7	449.5	401.5	402.2

C.V. = 5.6

L.S.D. 05 = 37.0

L.S.D. 01 = 48.1

TABLE 7. Yield of grain sorghum in kg/ha with two levels of potassium (0,80 kg/ha) and three levels of nitrogen (0,40,80 kg/ha). Afgoi, Somalia, 1977 Der season.

Level of Nitrogen kg/ha	Levels of Potassium kg/ha		Mean
	0	80	
0	356.3	355.8	356.3
40	351.0	401.7	376.4
80	468.0	480.0	474.0
Mean	391.7	412.8	402.23

C.V. = 4.6

L.S.D. 05 = 37.1

L.S.D. 01 = 48.2

III. Insect Control:

In this study the effect of insects on yield of grain sorghum and the use of insecticides to control them were examined.

The results obtained at Afgoi in the Der season 1977 (Table 8) indicate that all applied insectides were effective in controlling

insects. The increase in grain yield of the treated over the non-treated plots range from 49% to 86% and was statistically significant at the 5% level. The difference in the effect of various insecticides were not significant. There was evidence that Diazinon was better than the other three insecticides. Although the prevalence of stem borers was high, due to favorable weather, Furadan gave good control in the first four weeks after germination. When this experiment was repeated at CARS-Afgoi, in the Gu season 1978 (Table 9), the yield increase due to insecticides ranged from 154% to 213% and the treatment effects were statistically significant. The average performance of Diazinon was better than the other three insecticides. Because of the shortage of seasonal rainfall in Gu 1978, insect prevalence was lower than in normal seasons. A high population of birds caused heavy losses of sorghum grain in the experiment. The main difficulty experienced in this situation was that some members of the bird crews were less efficient in scaring birds than others. The resultant variation in grain yield with the same treatment was very high as shown by the coefficient of variation (Table 8 and 9).

The treatment of soil to control soil borne insects had a highly significant effect on plant stand and yield of sorghum (Tables 10 and 11), at Afgoi in the 1977 Der season. Increases of 11% in plant stand and 81% grain yield were recorded. The residual effect of the insecticides on the soil was not determined (Table 10 and 11).



TABLE 8. Yield of irrigated grain sorghum in kg/ha when sprayed weekly with SEVIN 85, Diazinon, Malathion and a single pre-planting application of Furadan to control above ground insects. Afgoi Somalia, 1977 Der season.

Treatments	Replications						Mean
	I	II	III	IV	V	VI	
1. No pesticide	298.0	339.6	243.1	269.7	263.1	281.4	282.5
2. Furadan	516.2	544.5	654.4	349.7	339.7	278.1	447.1
3. SEVIN 85	489.5	929.1	587.8	333.0	268.05	269.73	479.5
4. Diazinon	639.4	865.8	541.1	386.3	457.9	261.4	525.3
5. Malathion	521.2	439.6	531.1	233.1	338.3	458.3	420.3
Mean	492.8	623.7	511.5	314.4	333.3	309.7	430.9

C.V. = 28%

L.S.D. 05 = 141.17

L.S.D. 01 = 183.

TABLE 9. Yield of irrigated grain sorghum in kg/ha when sprayed weekly with SEVIN 85, Diazinon, Malathion and a single application of Furadan to control above ground insects. Afgoi, Somalia, 1978 Gu season.

Treatment	I	II	III	IV	V	VI	Mean
1. No pesticide	123.67	262.00	433.33	201.33	478.33	166.67	277.56
2. Furadan	34.00	1454.33	1719.00	106.67	406.67	546.67	711.22
3. SEVIN 85	564.00	1386.67	1222.00	619.33	218.00	423.33	738.88
4. Diazinon	871.00	800.00	1235.33	1034.33	606.67	661.00	868.06
5. Malathion	692.67	1525.67	1057.33	181.67	167.00	772.00	732.72
Mean	417.07	1085.73	1133.4	428.67	375.33	513.93	665.68

C.V. = 51.1

L.S.D. 05 = 392

L.S.D. 01 = 510

TABLE 10. Population of dryland sorghum in plants/plot at maturity with soil application of Chlordane plus Systax to control soil borne insects. Afgoi, Somalia, 1977 Der season.

Treatment	Replications				Mean
	I	II	III	IV	
Chlordane + Systox treated soil	183	168	172	147	167.5
Non-treated soil	141	137	129	132	134.75
Mean	162	152.5	150.5	139.5	151.12

C.V. = 6%

L.S.D. 05 = 13.0

L.S.D. 01 = 16.9

TABLE 11. Yield of dryland grain sorghum in kg/ha with soil application of Chlordane plus Systax to control soil borne insects. Afgoi Somalia, 1977 Der season.

Treatments	Replications				Mean
	I	II	III	IV	
Chordane + Systox treated soil	841.25	518.75	617.5	731.25	677.19
Non-treated soil	436.25	491.25	365.00	202.5	373.75
Mean	638.00	505.00	491.25		525.46

C.V. = 29%

L.S.D. 05 = 215.9

L.S.D. 01 = 280.6



IV. Weed Control:

In this study, the effect of weeds and time of weeding on grain yield of sorghum were examined. The results of the experiments on irrigated plots as well as rainfall plots are presented in Tables 12, 13 and 14.

The results (Table 12) obtained at CARS-Afgoi in the 1977 Der season under irrigated conditions show the importance of weed control. All treatments gave yield of grain sorghum substantially more than the control or check plots, weeds having reduced the yield drastically. Yield increase due to weed elimination ranged from 49% to 75%. Since the competition between the weeds and the seedlings of sorghum is particularly severe in the seedling stage, the critical time of first weeding was also examined. All weeding dates gave yields significantly higher than the no weeding plots. As weeding was done by hand-hoeing, the result might indicate that weeding after the first week of germination by unskilled farm laborers unable to distinguish between sorghum and Johnsongrass seedlings, a common weed in maize and sorghum fields of Afgoi area, may have caused damage to the roots of the small and weak sorghum plants. The reduction in yields due to a delay of weeding until the fourth week is most probably due to the competition between weeds and sorghum plants for water and nutrients. However, treatments were statistically significant at the 5% level.

The same experiment was conducted at Afgoi under rainfall conditions in the 1977 Der season. Yield increases due to weeding ranged between

41% and 86%, and all were statistically significant at the 5% level (Table 13). Weeding after the second and third weeks of germination resulted in higher yields than weeding after the first week of germination. Because rain water does not carry weed seeds as does irrigation water, the infestation of weeds was less in this experiment than in the previous one and, therefore, the resultant reduction in yields due to weed competition for moisture was less.

When the same experiment was repeated at Bonka in the 1978 Gu season under rainfall conditions, the results in Table 14 show yield increases of 134% to 226%, due to the removal of weeds. Weeding after the first and second weeks of germination was more productive than weeding after the third week of germination. The seasonal rainfall was less than 100mm and, therefore, moisture conservation by proper and early weeding was the most limiting factor for higher yields.

In conclusion, the results of the three weeding experiments show the importance of early weed control for grain sorghum production. Experiences in other countries have shown that there is no absolute substitute for hand-weeding and mechanical interculturing in controlling weeds such as Johnson grass. In the sorghum field, it is difficult to control Johnson grass with chemicals as it also belongs to the sorghum group. However, proper time of hand-weeding for large scale sorghum production will become impractical as more farm laborers are absorbed by other sectors of the national development. Therefore, testing of herbicides, especially under rainfall, should be considered in the



sorghum research program, particularly those of pre-emergence herbicides.

TABLE 12. Yield of irrigated grain sorghum in kg/ha with three different times of initial hand-weeding vs no-weeding. Afgoi, Somalia, 1977 Der season.

Treatment	Replications				Mean
	I	II	III	IV	
No-weeding	223.0	259.7	208.1	201.0	223.0
Weeded one week after germination and there- after when needed	286.4	351.3	341.3	429.6	353.0
Weeded two weeks after germination and there- after when needed	421.2	243.0	351.3	547.8	391.0
Weeded three weeks after germination and there- after when needed	387.9	296.4	304.7	338.0	332.0
Mean	329.67	287.63	301.37	379.2	

C.V. = 22%

L.S.D. 05 = 102.2

L.S.D. 01 = 132.9

TABLE 13. Yield of non-irrigated grain sorghum in kg/ha with three different times of initial hand-weeding vs no-weeding. Afgoi, Somalia, 1977 Gu season.

Treatment	Replications				Mean
	I	II	III	IV	
No-weeding	155.5	153.75	188.75	191.25	172.3
Weeded one week after germination and there-after when needed	221.25	326.25	228.75	195.00	242.8
Weeded two weeks after germination and there-after when needed	346.25	338.75	392.5	203.75	320.3
Weeded three weeks after germination and there-after when needed	345.0	412.5	226.25	295.0	319.7
Mean	267.0	307.8	259.1	221.25	263.75

C.V. = 2.3%

L.S.D. 05 = 87.5

L.S.D. 01 = 113.7

TABLE 14. Yield of dryland grain sorghum in kg/ha with three different times of initial weeding vs no-weeding. Bonka, Somalia, 1978 Bu season.

Treatments	Replications				Mean
	I	II	III	IV	
No-weeding	225.00	172.5	141.25	243.75	195.6
Weeded one week after germination and there-after when needed	731.25	646.25	871.25	655.0	725.9
Weeded two weeks after germination and there-after when needed	473.75	802.51	706.25	565.0	636.98
Weeded three weeks after germination and there-after when needed	467.5	515.0	410.0	441.2	458.43
Mean	474.40	534.10	532.19	476.25	504.2

C.V. = 20%

L.S.D. 05 = 145.9

L.S.D. 01 = 189.6

V. Estimation of bird damage percentage:

In this study, damage by birds was examined during the Gu season 1978 at Afgoi, the data being presented in Tables 15 and 16. In spite of scaring or chasing the birds from the sorghum plots, the percentage of loss was high (Tables 15 and 16).

From the second week of July onward, the daily grain damage caused by mixed flock of Quelea quelea and Ploceous species increased. Attack on the grain was heavier in the morning before the bird-crew



assumed their duties and in the evening just before sunset. The first notes were made on July 22, 1978 when the sorghum grain was at the soft dough stage. Ten sorghum heads were sampled in each of eight replications at each of eight sampling sites in a half hectare field and the damage percentage to each head was visually estimated. Of the 640 heads examined, 435 heads received some damage by birds for an average yield loss of 21.7% for the entire field (Table 15). When the second reading was carried out a week later on July 29, 1978 (Table 16), when the grain was near maturity, the average grain yield loss was 41.7% for the entire field. The main reasons for this damage were: a) the sorghum crop was grown under irrigation and no other small cereal grains were grown around except two hectare of rice which was completely destroyed by the birds; b) the shortage of seasonal rainfall had caused a shortage of grass seeds which are the main feed for Quelea quelea; c) the preference of birds to this small seeded crop. Maize, unlike sorghum, has its grain covered by a husk and protected from Quelea quelea birds but not from big birds like ploceous. The results of this investigation and other research reports on bird damage indicated that the grain feeding birds are one of the major factors affecting the yields of grain sorghum and other small grain cereals in the country. Several methods including cultivation of bird resistant varieties of sorghum were suggested to control the birds but no method has been found that is satisfactory.

TABLE 15. Grain loss in percentage due to bird damage present on July 22, 1978 when irrigated grain sorghum was in the soft dough stage - 10 heads were sampled at each sampling point in each replication. Afgoi, Somalia, 1978 Gu season.

Sampling Sites in Field									
Reps	1	2	3	4	5	6	7	8	loss/rep
1	18.0	22.0	61.0	31.5	38.0	83.5	37.5	34.0	40.69
2	22.5	15.5	6.0	24.5	12.0	48.5	25.0	16.0	21.25
3	22.0	8.5	7.0	5.5	14.5	6.0	24.0	37.5	15.63
4	33.5	48.0	23.0	4.5	10.5	0.2	19.0	44.5	22.9
5	49.0	28.5	8.5	4.5	1.5	5.0	8.0	4.0	13.63
6	1.5	12.5	24.5	7.5	9.0	3.0	1.5	3.0	7.81
7	45.5	5.5	21.0	17.0	4.5	14.5	7.0	12.0	15.88
8	35.0	36.5	5.5	34.0	0.5	24.5	64.0	90.5	36.31
Mean	28.38	22.13	19.56	16.13	11.31	23.15	23.25	30.19	21.76

TABLE 16. Grain loss in percentage due to bird damage present on July 29, 1978 when irrigated grain sorghum was near maturity- 10 heads were sampled at each sampling point in each replication. Afgoi, Somalia, 1978 Gu season.

Reps	1	2	3	4	5	6	7	8	loss/rep
1	90.5	65.5	22.5	7.0	17.5	15.5	16.0	33.8	33.54
2	49.5	27.0	54.5	55.0	54.0	13.8	15.0	17.0	35.73
3	86.5	45.0	27.5	56.0	58.5	52.0	69.0	85.0	59.93
4	70.0	72.5	84.0	90.0	79.5	80.5	95.0	91.5	82.88
5	35.5	23.0	24.0	19.0	21.5	44.5	40.0	31.0	29.81
6	27.0	13.0	8.5	21.5	17.5	42.0	10.0	18.5	19.75
7	13.0	25.0	43.0	24.5	12.5	24.0	17.5	22.8	22.79
8	57.0	54.5	17.0	36.0	57.0	61.0	41.5	71.5	49.44
Mean	53.63	40.69	35.13	38.63	39.75	41.66	38.0	46.39	41.72

VI. Germplasm:

In this study, a number of exotic entries were grown under rainfall or irrigated conditions in two different locations to study their



performance under Somali agro-climatic condition. The data are presented in Tables 17, 18, 19, 20 and 21. Results obtained under two locations in 1977 showed that most of the exotic entries grown under irrigated as well as under rainfall conditions, were considerably superior to the common local varieties red and white dura type sorghum (entries 1 and 2 in Tables 17 and 18) from the Bay Region. Dabar, Tub 7, Tub 22 and white dwarf milo from Sudan, Giza 3 from Egypt 7502 and D. G. Pearl from Pakistan, seem to be promising as far as their yield potential is concerned. A locally adapted variety called Falax (entry 3 in Tables 17 and 18), which was a mixture of white martin types with semi-compact heads, gave a reasonably good yield under both conditions. However, the quality and taste of its grain was not acceptable to the growers and the buyers. The martin types are susceptible to shoot fly and do not store well. Varieties like Korkhatib from the Sudan and Sarokartho from Pakistan have shown great susceptibility to various unidentified diseases at Afgoi. The grain yield of these two varieties was markedly reduced due to the diseases.

TABLE 17. Grain yield of irrigated sorghum in kg/ha of seven exotic cultivars selected for their previous high yielding performance vs three common local varieties. Afgoi, Somalia, 1977 Der season.

Variety	Country	Replications			Mean
		I	II	III	
1-White pearl	Somalia	253.00	219.95	199.95	224.3
2-Light red	Somalia	386.57	473.22	459.88	439.89
3-Falax	Somalia	1219.69	833.125	986.42	1013.08
4-R90	Germany	1092.05	1392.97	1706.24	1397.08
5-DABAR	Sudan	2852.62	2246.105	2925.00	2674.57
6-SAROKARTHO	Pakistan	133.30	66.67	66.67	88.88
7-TUB 7	Sudan	2079.48	1892.85	1892.86	1955.06
8-KORKHATIB	Sudan	133.3	146.63	166.625	148.85
9-954063	USA	2286.095	2532.7	2012.83	2277.21
10-954206	USA	2532.7	2312.755	2246.105	2363.85
Mean		1297.005	1211.697	1266.258	1258.77

C.V. = 15.9%

L.S.D. 05 = 326.1

L.S.D. 01 = 423.9



TABLE 18. Grain yield of non-irrigated sorghum in kg/ha of seven exotic cultivars selected for their previous high yielding performance vs three common local varieties. Afgoi, Somalia 1977 Der season.

Variety	Country	Replications			Mean
		I	II	III	
1-White pearl	Somalia	190.00	130.00	210.00	176.66
2-Light red	Somalia	270.00	325.00	295.00	296.66
3-Falax	Somalia	570.00	520.00	490.00	526.66
4-R90	Germany	570.00	650.00	530.00	583.33
5-DABAR	Sudan	490.00	415.00	400.00	435.00
6-SAROKARTHO	Pakistan	100.00	120.00	225.00	148.00
7-TUB 7	Sudan	350.00	360.00	355.00	355.33
8-KARKHATIB	Sudan	50.00	130.00	35.00	71.66
9-954063	USA	260.00	210.00	265.00	245.00
10-954206	USA	375.00	440.00	370.00	395.00
Mean		322.50	330.00	317.50	323.33

C.V. = 14%

L.S.D. 05 = 75.7

L.S.D. 01 = 98.5



TABLE 19. Yield of irrigated grain in kg/ha of 17 sorghum entries including a local check variety from the FAO Regional Sorghum Yield Trial Nursery. Afgoi, Somalia, 1977 Der season.

Variety	Country	Replications			Mean
		I	II	III	
1-GIZA 3	Egypt	1155.55	633.33	1866.66	1218.51
2-GIZA 15	Egypt	55.55	0.00	33.33	29.62
3-GIZA 114	Egypt	588.88	0.00	0.00	196.29
4-R90	Germany	1033.33	688.88	1044.44	922.21
5-SSI	Pakistan	1365.66	622.22	226.66	738.18
6-SSII	Pakistan	1699.99	799.99	933.33	1144.43
7-7502	Pakistan	633.33	433.33	155.55	407.40
8-SAROKARTHO	Pakistan	299.99	255.55	255.55	270.33
9-D.G. Pearl	Pakistan	1033.33	1333.33	1699.99	1355.55
10-DABAR	Sudan	1728.88	2288.88	1511.11	1842.95
11-GADAM ELHAMAN	Sudan	659.99	735.55	611.11	668.88
12-KORKHATIB	Sudan	444.44	399.99	599.99	481.47
13-TUB 7	Sudan	1033.33	1199.99	1477.77	1237.00
14-TUB 22	Sudan	1411.11	1722.22	1588.88	1574.00
15-White Dwarf					
Milo	Sudan	408.88	684.44	211.11	434.81
16-AKS 618	USA	1344.44	1877.77	1333.33	1518.00
17-Fudfududo	Somalia	988.00	1033.33	1055.55	1025.62
Mean		934.5	871.11	859.08	888.00

C.V. = 36.3

L.S.D. 05 = 525.3

L.S.D. 01 = 682.9

TABLE 20. Yield of grain in kg/ha of 17 sorghum entries including a local check variety from the FAO Regional Sorghum Yield Trial Nursery under rainfall conditions. Bonka, Somalia, 1977 Der season.

Variety	Country	Replications			Mean
		I	II	III	
1-GIZA 3	Egypt	1211.11	1222.22	1215.55	1216.29
2-GIZA 15	Egypt	744.44	855.55	655.55	751.84
3-GIZA 114	Egypt	1055.55	722.22	888.88	888.88
4-R90	Germany	1822.22	1433.33	1626.66	1627.40
5-SSI	Pakistan	2000.00	1400.00	1700.00	1700.00
6-SSII	Pakistan	588.88	488.88	388.88	488.88
7-7502	Pakistan	1511.11	1733.33	1622.22	1622.22
8-SAROKARTHO	Pakistan	822.22	800.00	811.11	811.11
9-D.G. Pearl	Pakistan	1777.77	1377.77	2400.00	1851.84
10-DABAR	Sudan	1344.44	1388.88	1222.22	1318.51
11-GADAM ELHAMAN	Sudan	460.00	444.44	477.77	460.73
12-KORKHATIB	Sudan	700.00	500.00	400.00	533.33
13-TUB 7	Sudan	777.77	688.88	866.66	777.77
14-TUB 22	Sudan	666.66	660.00	655.55	660.73
15-White Dwarf					
Milo	Sudan	800.00	600.00	777.77	725.92
16-AKS 618	USA	1333.33	566.66	948.88	949.62
17-Fudfududo	Somalia	600.00	455.55	311.11	455.55
Mean		1071.50	902.21	998.16	990.62

C.V. = 18.7%

L.S.D. 05 = 302.7

L.S.D. 01 = 393.5



TABLE 21. Yield of grain in kg/ha of 14 sorghum entries including a local check variety from the FAO Regional Sorghum Yield Trial Nursery under irrigated conditions. Afgoi, Somalia, 1978 Gu season.

Variety	Country	Replications			Mean
		I	II	III	
1-D.G. Pearl	Pakistan	1244.44	1188.88	1111.11	1181.88
2-SSI	Pakistan	1226.66	611.11	591.11	809.63
3-SSII	Pakistan	888.69	277.77	733.33	633.33
4-7502	Pakistan	1037.77	1177.77	833.33	1016.29
5-GIZA 3	Egypt	2300.00	1933.33	611.11	1614.81
6-GIZA 15	Egypt	844.44	1455.55	766.66	1022.22
7-GIZA 114	Egypt	1644.44	1422.22	955.55	1340.74
8-White Dwarf					
Milo	Sudan	1655.55	1533.33	1244.44	1477.77
9-TUB 22	Sudan	2933.33	1722.22	3088.88	2581.48
10-TUB 2	Sudan	1277.77	757.77	1400.00	1145.18
11-Gadamel Haman	Sudan	628.89	1500.00	1177.77	1102.22
12-DABAR 1/1/1/1/	Sudan	1200.00	2033.33	777.77	1337.03
13-KARKTIB	Sudan	1211.11	1211.11	533.33	1218.52
14-Fudfududo	Somalia	1288.89	1022.22	1122.22	1144.44
Mean		1384.44	1324.76	1067.62	1258.94

C.V. = 36.4%

L.S.D. 05 = 749.7

L.S.D. 01 = 974.6

VII. Summary and Conclusion:

Grain sorghum is the main food and feed crop in Somalia, occupying the largest part of the cultivated area of the country. It is entirely a rainfall crop, grown wherever the soils are suitable and the annual seasonal rainfall exceeds 300mm. Drought resistant red and white dura sorghum types, with a maturity range of 3-4 months are grown in the

southern part, while the late maturing types are grown in the northwest region of the country. The grain yield of the existing local varieties are very poor and the technological advancements in sorghum production that have developed in many sorghum producing countries of the world have not been adopted by Somalia. Sorghum research in Somalia is still in an infant stage. The FAO-MUCIA-Somalia project is strengthening agricultural research in Somalia and has emphasized the importance of this crop for the country and initiated this research to study the major factors limiting the grain yield of this crop.

All experiments point to the dominant role of moisture in limiting yield. Furthermore, research results of two seasons in two different locations have clearly demonstrated the need for varietal change, use of fertilizers, especially nitrogen and proper plant protection measures. Exotic varieties were considerably superior to the common local varieties often increasing yield by over 300% under dryland conditions. Use of 80 kg of N per hectare increased the yield by 33% over the control. Weeds have reduced the yield drastically by competing with the sorghum seedlings for water. Yield increase due to weed elimination ranged from 50% to 80% and a similar amount of yield increase also was realized by insect control. Birds especially Quelea quelea frequently devastate a sorghum field. The grain loss due to birds was estimated at 41% and no appropriate methods of controlling them has been found.

As sorghum research in the country is in its infancy, plant introduction could be an immediate help to enhance the yield of sorghum,



practiced with due care to prevent eventual introduction of new diseases and pests. Sudan selections like white dwarf milo, TUB 7, TUB 22, DABAR and GIZA 3 from Egypt may have immediate applicability in the main sorghum producing areas of the country. Use of fertilizers especially nitrogen should be considered once a high yielding variety is identified. Birds, weeds and insects cause considerable losses, therefore, good management practices and resistant varieties could reduce the losses. Several other factors which were not included in this study, such as use of treated seed, planting date, plant population and crop rotation should be included in the sorghum research program, especially, for the new introductions.



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APPENDIX



APPENDIX

TABLE 1. Variance analysis of the yield of sorghum grain with two methods of seedbed preparation for moisture retention (macro-bunding vs micro-bunding) in a randomized block design with three replications. All data in kilograms per hectare. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	1	6,240.37	6,240.37	1.37
Block:	2	9,234.33	4,617.00	1.01
Error:	2	9,123.99	4,561.99	
Total:	5	24,598.70		

TABLE 2. Analysis of variance of the yield of sorghum grain with two methods of seedbed preparation for moisture retention (macro-bunding vs micro-bunding) in a randomized block design with three replications. All data in kilograms per hectare. Bonka, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	1	11,284.00	11,284.00	6.13
Block:	2	2,293.70	1,146.87	0.62
Error:	2	3,679.06	1,839.54	
Total:	5	17,256.83		

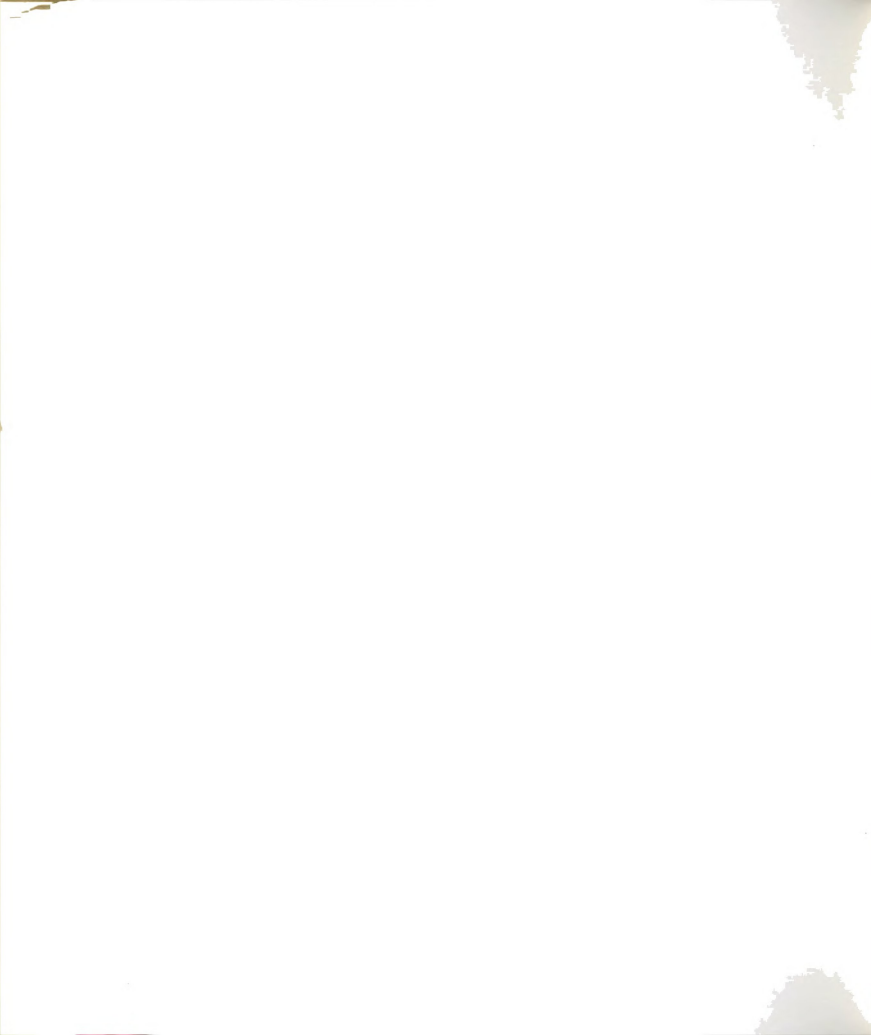
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TABLE 3. Analysis of variance of the yield of sorghum grain with two methods of seedbed preparation for moisture retention (macro-bunding vs micro-bunding) in a randomized block design with three replications. All data in kilograms per hectare. Bonka, Somalia, 1978 Gu season

Source of Variation	Degrees of Freedom	Sum of Squares	Mean square (Variance)	F Value
Treatment:	1	556.80	556.80	0.2
Block:	2	3,352.17	1,676.08	
Error:	2	4,551.12		
Total:	5	8,460.19		

TABLE 4. Analysis of variance of the yield of sorghum grain with two methods of seedbed preparation for moisture retention (sowing on ridges vs in furrows) in a randomized block design with three replications. All data in kilograms per hectare. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean square (Variance)	F value
Treatment:	1	24,704.16	24,706.16	6.16
Block:	2	12,702.08	6,351.04	1.58
Error:	2	8,014.58	4,007.29	
Total:	5	45,420.83		



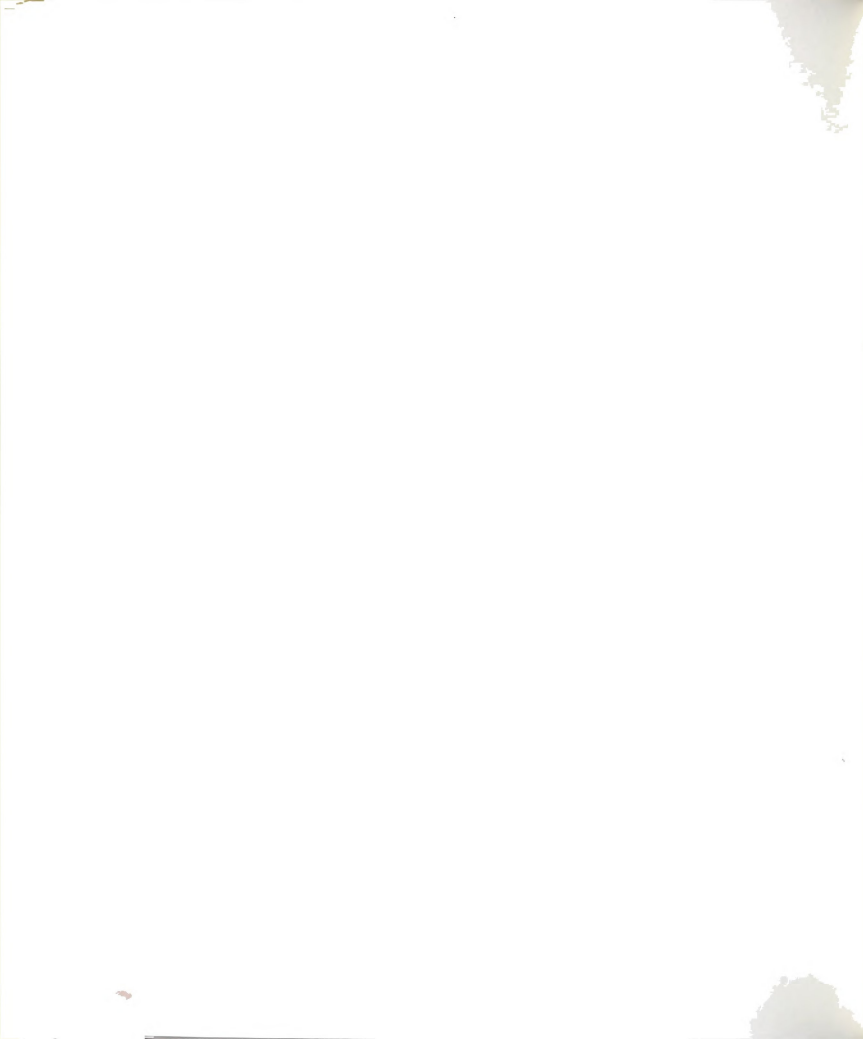
APPENDIX

TABLE 5. Analysis of variance of the yield of sorghum grain with 0, 40, 80 kg/per hectare of nitrogen and phosphorus together with 0 and 80 kg/per hectare of potassium in a randomized block design with three replications. All data in kilogram per hectare. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares (Variance)	F value
Treatments:	17	299,208.13	17,600.47	
Replications:	2	36,611.81	18,305.90	2.17*
Error:	34	275,558.35	8,104.65	
Total:	53	611,378.30		

TABLE 6. Analysis of variance of the yield of sorghum grain with 0, 40 and 80 kg/per hectare of nitrogen and phosphorus in a randomized block design with three replications. All data in kg/per hectare. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
N:	2	23,856.05	11,928.02	23.19*
P:	2	13,208.72	6,604.36	
NP:	4	2,056.77	514.19	
Total:	8	39,121.55		



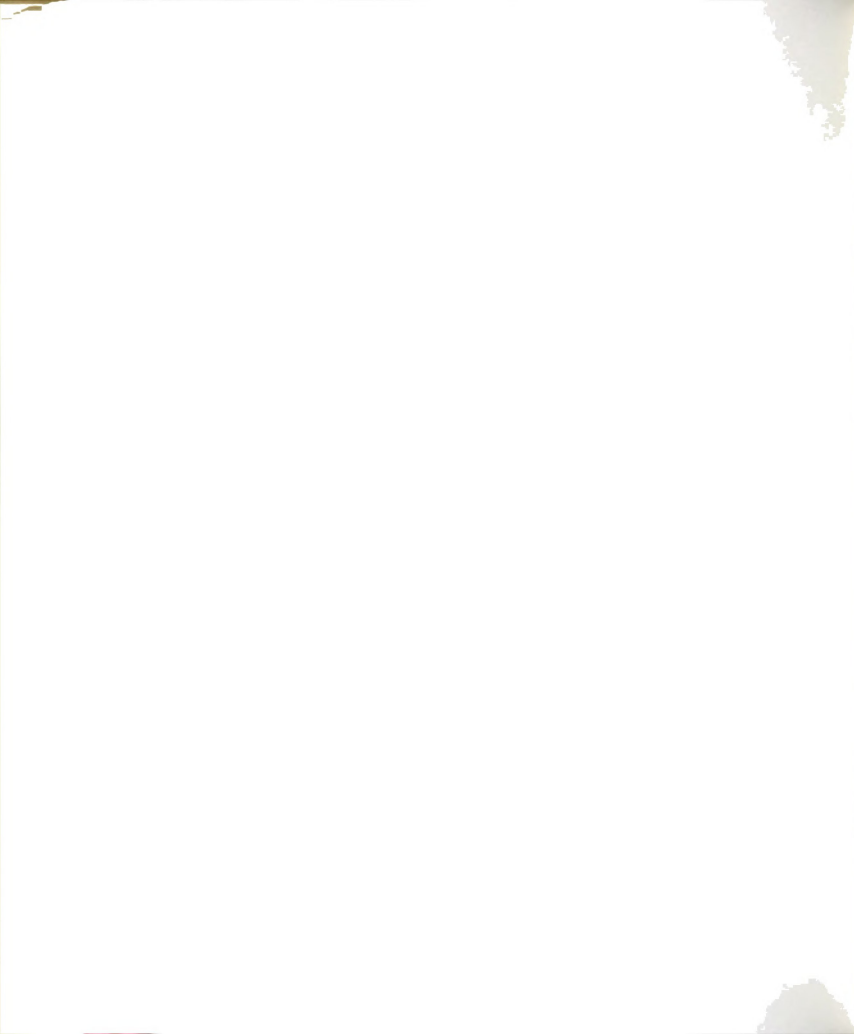
APPENDIX

TABLE 7. Analysis of variance of the yield of sorghum grain with three levels of nitrogen (0,40,80) and two levels of potassium (0,80). All data in kg/per hectare. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
N:	2	15,851.36	7,925.68	23.05**
K:	1	669.92	669.92	1.94
NK:	2	687.56	343.78	
Total:	5	17,208.85		

TABLE 8. Analysis of variance of yield of grain sorghum in kg/ha weekly sprayed sorghum with SEVIN, Diazinon, Malathion and one time application of Furadan at planting with seeds to compete above ground insects vs control, under irrigated conditions, in a randomized block design with six replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	4	202,096.29	50,524.07	3.38*
Block:	5	426,343.18	85,268.64	5.71**
Error:	20	298,963.45	14,948.17	
Total:	29	928,402.93		



APPENDIX

TABLE 9. Analysis of variance of yield of grain sorghum in kg/ha weekly sprayed sorghum with SEVIN, Diazinon, Malathion and one time application of Furadan at planting with seeds to compete above ground insects vs. control, under irrigated conditions. Afgoi, Somalia, 1978 Gu season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	4	1,221,150.70	305,287.67	2.64
Block:	5	3,011,138.70	602,227.80	2.39
Error:	20	2,315,389.72	115,769.48	
Total:	29	6,547,679.14		

TABLE 10. Analysis of variance of the final plant population per plot of treated soil with chlordane plus systax against soil borne insects vs non-treated soil in a randomized block design with four replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	1	2,145.13	2,145.13	25.3**
Block:	3	511.38	170.46	2.01
Error:	3	254.37	84.79	
Total:	7	2,910.88		



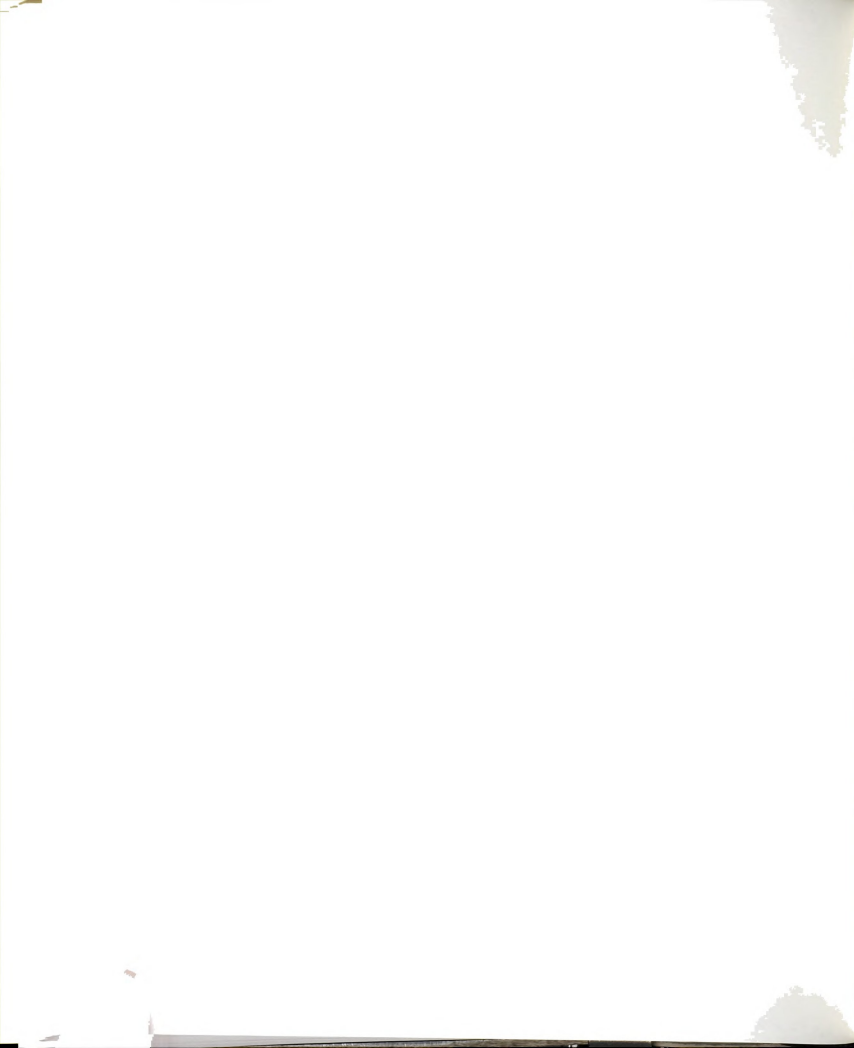
APPENDIX

TABLE 11. Analysis of variance of yield of grain sorghum in kg/ha of treated soil with chlordane plus systax against soil borne insects vs non-treated soil, under rainfall conditions, in a randomized block design with four replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares (Variance)	F value
Treatment:	1	184,148.63	184,148.63	7.9
Block:	3	35,711.525	11,903.841	
Error:	3	69,908.387	23,302.795	
Total:	7	289,768.55		

TABLE 12. Analysis of variance of the yield of grain sorghum with three different time of first hand-weeding, under irrigated conditions, in a randomized block design with four replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares (Variance)	F value
Treatment:	3	63,113.87	20,704.62	3.96*
Block:	3	19,619.72	6,539.91	1.26
Error:	9	47,024.63	5,224.96	
Total:	15	128,758.22		



APPENDIX

TABLE 13. Analysis of variance of the yield of grain sorghum with three different time of first hand-weeding under rainfall conditions. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	3	60,510.045	20,170.015	5.27*
Block:	3	15,121.140	5,040.380	1.32
Error:	9	34,450.921	3,827.880	
Total:	15	110,082.10		

TABLE 14. Analysis of variance of the yield of grain sorghum with three different times of first hand-weeding vs no-weeding in a randomized block design with four replications. Bonka, Somalia, 1978 Gu season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	3	656,331.64	218,777.21	20.56**
Block:	3	13,383.20	4,461.07	0.32
Error:	9	95,756.64	10,639.63	
Total:	15	765,471.48		

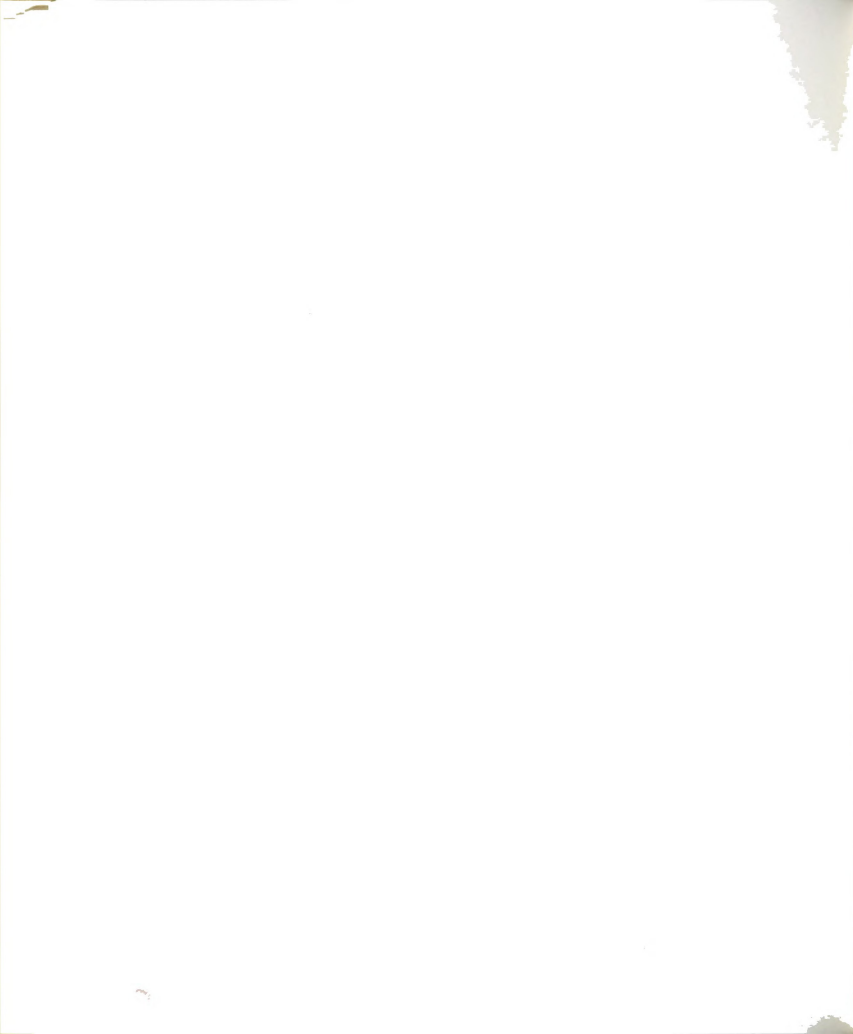
APPENDIX

TABLE 15. Analysis of variance of sorghum grain yield loss percentage due to birds, when irrigated sorghum was at soft dough stage in a randomized block design with eight replications. Afgoi, Somalia, 1978 Gu season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Replications:	7	7,236.54	1,033.79	3.35*
Points:	7	2,118.39	302.63	0.98
Error:	49	15,102.90	308.22	
Total:	63	24,457.83		

TABLE 16. Analysis of variance of sorghum grain yield loss percentage due to birds, when irrigated sorghum was at near maturity in a randomized block design with eight replications. Afgoi, Somalia, 1978 Gu season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Replications:	7	25,367.79	3,623.97	12.53**
Points:	7	1,883.00	269.00	
Error:	49	14,167.52	289.13	0.93
Total:	63	41,418.31		



APPENDIX

TABLE 17. Analysis of variance of irrigated grain yield in kg/ha of seven exotic sorghum entries selected for their previous high yielding performance vs yield of three common local sorghum varieties, in a randomized block design with three replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Variety:	9	27,505,537.27	3,056,170.80	76.62**
Block:	2	37,234.91	18,617.45	
Error:	18	717,945.64	39,885.86	
Total:	29	28,260,717.82		

TABLE 18. Analysis of variance of non-irrigated grain yield in kg/ha of seven exotic sorghum entries selected for their previous high yielding performance vs yield of three common local sorghum varieties in a randomized block design with three replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	9	749,616.66	83,290.74	38.68**
Block:	2	791.67	395.84	
Error:	18	38,758.35	2,153.24	
Total:	29	789,166.68		



APPENDIX

TABLE 19. Analysis of variance of the yield of irrigated grain in kg/ha of 17 sorghum entries including a local check variety from the FAO Regional Sorghum Yield Nursery in a randomized complete block design with three replications. Afgoi, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	16	13,753,434.65	859,589.66	8.3**
Block:	2	59,467.07	29,733.53	
Error:	32	3,312,117.69	103,503.67	
Total:	50	17,334,313.00		

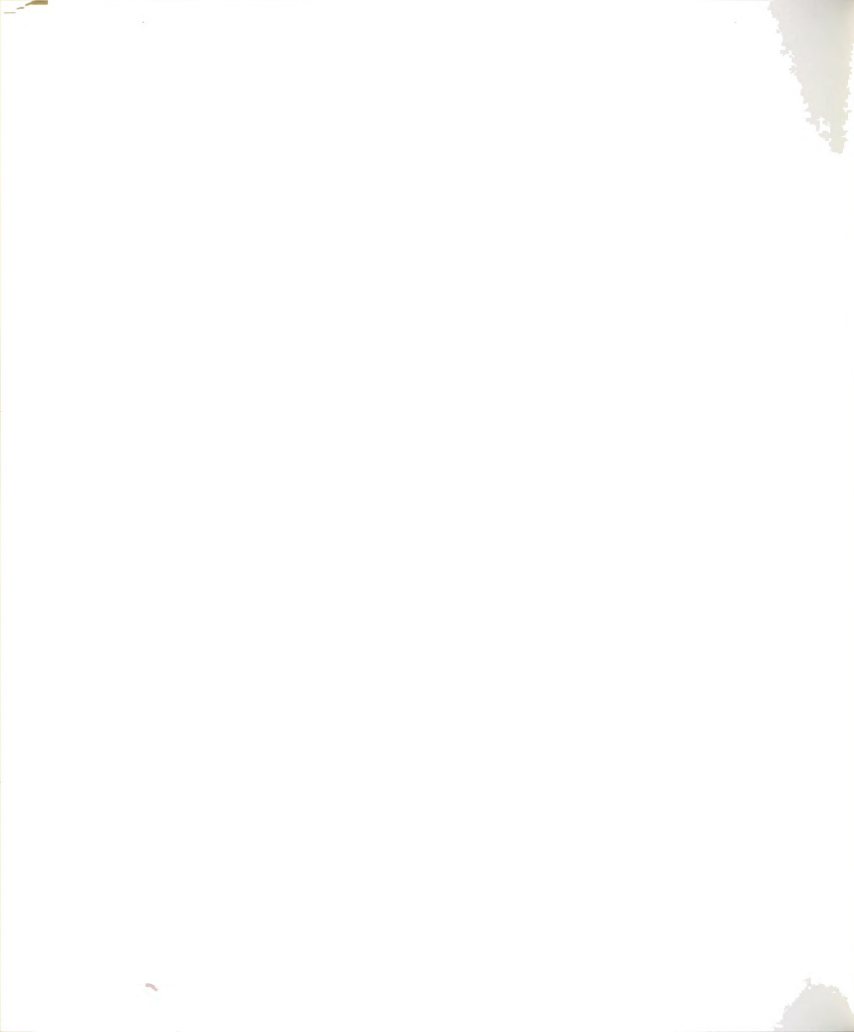
TABLE 20. Analysis of variance of the yield of non-irrigated grain in kg/ha of 17 sorghum entries including a local check variety from the FAO Regional Sorghum Yield Trial Nursery in a randomized complete block design with three replications. Bonka, Somalia, 1977 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	16	10,683,514.00	667,719.62	19.43**
Block:	2	245,028.00	122,514.00	3.5*
Error:	32	1,099,575.00	34,361.71	
Total:	50	1,202,811.70		

APPENDIX

TABLE 21. Analysis of variance of the yield of irrigated grain in kg/ha of 14 sorghum entries including a local check variety from the FAO Regional Sorghum Yield Trial Nursery, in a randomized complete block design with three replications. Afgoi, Somalia, 1978 Der season.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance)	F value
Treatment:	13	8,108,580.76	623,736.98	2.95*
Block:	2	793,629.96	396,814.98	
Error:	26	5,479,646.22	210,755.62	
Total:	41	14,381,856.95		



APPENDIX

TABLE 22. Annual mean precipitation and temperature, 17 observation centers in Somalia-Ministry of Agriculture, Somalia (not published).

STATIONS	PERIOD	MEAN ANNUAL PRECIPITATION IN MM AND TEMPERATURE IN °C
Galcaio	1954-75	152 mm
	1954-75	27 °C
Hobbio	1954-75	207 mm
	1954-72	26.5°C
Elbur	1953-73	155 mm
	1953-65	27 °C
Belet-Weyne	1954-75	262 mm
	1959-75	28 °C
Bulo Burti	1954-61	352 mm
	1954-62	28 °C
Huddur	1954-61	323 mm
	1954-61	25.8°C
Lugh ganane	1954-66	394 mm
	1954-63	29 °C
Baydoa	1954-74	543 mm*
	1959-73	26 °C
Bur Hacaba	1954-62	425 mm*
	1954-62	28 °C
Balad	1954-63	557 mm*
	1954-63	26 °C
Afgoi	1954-75	524 mm*
	1954-75	27 °C
Bardere	1954-72	395 mm
	1954-65	28 °C
Afimndo	1954-61	550 mm*
	1954-61	°C
Jilib	1954-62	455 mm*
	1954-62	°C



APPENDIX

TABLE 22. continued

STATIONS	PERIOD	MEAN ANNUAL PRECIPITATION IN MM AND TEMPERATURE IN °C
Borama	_____ _____	544 mm* ____ °C
Hargesa	_____ _____	430 mm* ____ °C
Borao	_____ _____	191 mm ____ °C

* Area receiving 400mm rainfall or more per annum.



APPENDIX

TABLE 23. Total area under cultivation in the various regions of the country (8).

REGIONS	AREA UNDER FARMING HA	AREA UNDER SORGHUM HA	%
Northwest	60,000	52,000	86.66
Togdher	18,000	16,000	88.88
Sanag	13,000	11,000	84.62
Nugai	2,000	1,500	75.00
Bari	2,000	1,500	75.00
Mudug	2,000	1,500	75.00
Galgudud	5,000	3,500	70.00
Hiran	54,000	46,000	85.19
Middle Shabelle	61,000	8,000	13.14*
Lower Shabelle	171,000	30,000	17.53*
Bakol	28,000	25,000	80.29
Bay	142,000	134,000	94.37
Gedo	52,000	30,000	57.69
Lower Juba	90,000	28,000	31.11
Total	700,000	388,000	55.43

* Agriculture in this area depends on irrigation, maize and other cash crops are grown.



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