AGRICULTURAL REPORT ON
THE MONTANE PLAINS AND WADI RIMA PROJECT
YEMEN ARAB REPUBLIC

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Land Resources Division, Tolworth Tower,
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Agricultural report on the Montane Plains and Wadi Rima Project, Yemen Arab Republic

T J Goldsworthy

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SECTION 1. PREFACE

In 1973 an agreement was reached between the governments of the Yemen Arab Republic (YAR) and Great Britain, that the latter would finance a land resources project for the Montane Plains - Wadi Rima (MPWR) area as part of its technical assistance programme to the YAR. The purpose of the project is to establish the extent to which the soil and water resources of these areas can be safely exploited to enable sustained economic and social development to be achieved.

The British Ministry of Overseas Development asked its Land Resources Division to undertake this project.

The YAR Government in its formal request also asked the British Government to provide "an agricultural expert at an appropriate time to study questions of suitable cultivation and fertility (on the Montane Plains), this study to be an entirely separate project".

Accordingly the MPWR project engaged the services of Mr T J Goldsworthy to advise the project on agricultural matters, and specifically to draw up proposals for the agronomic project mentioned above.

Mr Goldsworthy, previously Assistant Director in the Aden Department of Agriculture, was seconded from the British Ministry of Agriculture, Fisheries and Food, to undertake this work with the following terms of reference:

TERMS OF REFERENCE

Wadi Rima and Montane Plains

1. Assess existing agricultural practices, systems and levels of productivity.

2. Identify the technical constraints on increasing production, both those which apply currently and also those which are likely to prevent the full benefits of additional irrigation from being realised.

3. Present guide lines for improving agriculture in terms of new inputs, practices, products and systems of production.
Montane Plains

4. Define the major agronomic problems limiting production which can be solved only through systematic research.

5. Prepare proposals and indicate UK staff requirements for a research programme over about 5 years, the objectives of which would be to tackle the problems identified in (4) through, inter alia, appropriate agronomic experiments and data collection at farm and field levels.
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INTRODUCTION

The content of this report into agricultural production is limited to the project area which comprises the Montane Plains lying roughly between Ma'bar in the North to Citlab in the South, and the Wadi Rima within the coastal area of the Red Sea plains which are collectively known as the Tihamas. Visits have been made to places outside the project area such as Wadi Dhafer, Wadi Hade, Taiz, Ibb, Wadi Sardud, Wadi Zabid and areas near Sana'a to observe systems and methods of agricultural production in these areas. Supplementary and background information has been obtained from the staff of various organizations such as FAO/UNDP, West German Technical Assistance, US Aid, Tipon Kalmbach Incorporation, the Ministry of Agriculture Yemen Arab Republic and resident permanent members of the MPWR Project. The valuable assistance given by the various members of these organizations is gratefully acknowledged.

The geography, human and livestock populations, topography, soils, temperature ranges, rainfall patterns and elevations of various areas in the Yemen Arab Republic have been described by many previous reporters on agriculture and it is not intended to report further on these aspects. Further information will be more fully and factually described by resident members of the team during the life of the project. However certain factors need to be described briefly for the sake of completeness, to put this report in perspective and because of their effect on agricultural production in the 2 distinct environmental areas of the project.

The altitude of the Montane Plains area is about 2300 metres with temperatures ranging between a minimum of 11°C to a maximum of 31°C during the Summer and from a minimum of -4°C to a maximum of 25°C during the Winter. Wind velocities at Sana'a rise to an average of 9 knots in the afternoons which, combined with low relative humidities, can lead to leaf burn and large evapo-transpiration losses. The Winter temperature ranges cause leaf fall in deciduous fruit crops and a slow down of growth in many vegetable and field crops. Rainfall is about 300 mms per annum, falling mainly in March/April and July/August/September, although precipitation during the past 7 or 8 years has been well below this level.

The Wadi Rima is typically tropical - hot and humid in the Summer with temperatures rising to over 40°C maximum and 25°C minimum and less hot and drier in the Winter with maximum temperatures of 36°C and minimum temperatures down to 17°C. Winds are generally strong particularly in the afternoons averaging 16-17 knots causing sand storms, sand dune movement and damage to leaves of more delicate crops such as bananas. Rainfall tends to be slight, up to 300 mms in favourable years falling in 2 main peaks, the smaller in March/April and the major peak in June/July and
August sometimes extending into September. Rainfall in the hills separating the coastal areas from the central highlands arrives in the Wadi Rima in a series of spate floods of varying frequency, size and duration. These floods are diverted by a series of offtakes built in the Wadi bed and through a system of main and subsidiary canals on to the agricultural area. A perennial stream flows at the foothills of the Wadi and this is used to irrigate the upper areas of the alluvial fan.

The farmers of the Montane Plains and Wadi Rima areas have centuries of experience in the traditional subsistence agriculture of the area and are reasonably skilled in the cultivation requirements of crops on rain-fed and spate-irrigated land. This type of agricultural activity has not changed significantly since the Middle Ages. However they are less skilled and often ignorant of modern agricultural practices associated with supplies of lift irrigation water and the economics of utilization of such irrigation water. Intensive cropping without the application of soil nutrients and over watering causing leaching seem to be a potential danger in bringing about a decline in soil fertility. Varieties of crops which may be suited to rain-fed agriculture are used under irrigated conditions and it is doubtful whether the small extra yields obtained are sufficient to meet the extra costs of supplying lift irrigation water. New varieties and crops, inputs of fertilisers, pesticides, improved husbandry and irrigation techniques have not been subjected to a complete and systematic research programme and subsequent demonstration to the farming communities. No resident efficient extension or advisory service exists which can use modern techniques of visual aids, small and large group activities, use of radio and on-farm demonstrations. Leader and innovator farmers in the community should be identified, encouraged to adopt modern husbandry methods, new crops, crop varieties and modern agricultural inputs which have been proven in the area and then used as demonstrators of improved crop husbandry methods to neighbouring farmers.
ASSESSMENT OF CURRENT AGRICULTURE - WADI RIMA

This assessment of existing agricultural practices, systems and levels of productivity has been made through a series of interviews with farmers, village leaders (agal) and Sheiks in the area and by personal observation of the methods employed during visits to the area.

The agriculture of the Wadi Rima area is very different to that of the Montane Plains due to the differences in climate, rainfall, irrigation methods etc. Crops are limited to those suitable for tropical production except for a short period in winter when a wide range of temperate crops can be grown. The Wadi Rima at a latitude of 14°N lies in a zone of 'short day' crops. Assessments of yields were easier to obtain than in the Montane Plains due to the more standardised system of weights and measures being employed. Wide ranges in yields of the various crops are apparent owing to the amount of rainfall and the frequency and amount of irrigation water given whether this was obtained from the Wadi or from lift irrigation. Each major crop is dealt with separately describing the varieties used, cultivation operations, weed control methods, harvesting, pests and diseases, levels of productivity and irrigation practices.

1. Sorghum (dharra) Sorghum vulgare

Sorghum is one of the two main cereal crops grown in the area, the other being Bulrush Millet. Varieties growing in the Wadi Rima are basically white and reddish grained or glumed as follows:

Baida Gaira: white grained, loose panicle, sown in August and September.
Baida Gariba: white grained, erect close panicle, sown in March and April.
Hamra: red grained, close panicles which bend down or neck, sown at end of September.
Hamra Saifi: red grained, erect panicle, sowing time March and April.
Hamra Shitawi: red grained, erect panicle, sowing time November and December.

These varieties differ in their periods of vegetative growth which vary from 3½ to 4 months for most of the above to under 3 months for Gariba. The cultivation systems for sorghum vary according to whether it is grown on rain-fed land or under irrigation.

On rain-fed land the ground is ploughed by oxen using the local type plough and after rain has fallen the land is ploughed again although occasionally there is only one ploughing. Seed is sown in rows about 30-35 cms apart and spaced 6-10 cms within the rows, 2 or 3 seeds being dropped by hand at a time. Sowing may also be done using a pipe attached to the plough. The seed rate is about 20 kg/ha. No further cultivations are made but thinning of an overcrowded stand and hand weeding
may be performed. When mature the shorter strawed varieties will be harvested by removing the heads of grain whilst a well grown crop will be cut down completely and the heads removed.

Under spate irrigation the land is ploughed 3 times, once before irrigation and twice after. After irrigation there may be a delay of up to 20 days before the second ploughing can be done in order to allow the top soil to dry out. Irrigation is from canal or field to field, each field being surrounded by banks (Zabur) 60 cms to 1½ metres high to retain the water. Seed is sown by hand or pipe, this taking place at the third ploughing. If ploughing has been done by tractor plough the crop is sown at the second ploughing. Spacing is 30 to 60 cms between rows depending on amount of watering received and 6 to 10 cms within rows. 15 to 20 kgs/ha seed is sown depending on spacing. In favourable areas the crop may receive a second lighter watering.

Inter-row cultivation using oxen drawing the local plough may be carried out when the crop is 60 to 70 cms high or weeding may be done by hand. Harvesting is performed by removing the heads and allowing the stems to rattoon. Some crops may be inter-row cropped at the wider row spacing with cowpeas, lentils and beans.

Under lift or stream (gheil) irrigation, the ploughing and inter-row cultivations are similar to those described for spate irrigation but after sowing small banks and irrigation channels are constructed using a 'draw board'.

This tool comprises a long handle with a board about 60 cms x 15 cms attached to the lower end to form an inverted 'T'. A loop rope is attached to the board. In operation, one labourer holding the handle will dig the board into the soil about 30 cms from the proposed line of the bank and the second labourer draws the board towards him by pulling on the rope. By continued repetitive movements they gradually form a bank around the area of the basin.

Irrigation frequency is 4 to 5 times during the growing period and quantities of water given at each irrigation depend on the acreage of cropping per well or amount and division of water available from the gheil. Many farmers appear to try to irrigate too much land with the result that crops on the perimeter of the irrigated area show poor growth due to water stress.

Weed competition from Cynodon dactylon (Bermuda grass), Nut grass (Cyperus rotundus) and other grasses is usually severe and the practice of simply cutting the foliage often encourages the spread of grass weeds. No attempts are made to remove plants and their roots and many farms are now badly weed infested. The crop may reach 1½ metres high with good irrigation.

Under all systems of irrigation harvesting is done by hand, the harvesters being
paid in kind, usually a basket of ears of grain per day's work. Some crops, depending on season and variety will be cut off at ground level when the heads are ripe and allowed to dry. The stems may be greenish at this stage. The crop is bundled and transported to the threshing area where the heads of grain are cut off and spread out in the sun for one day to dry further. The stalks are stored in a round or cone shaped stack and used for animal fodder and sometimes for thatching. After a few days drying the heads are threshed by flails which are bent poles with a flattish blade at the lower end. The grain is wind winnowed, the grain, chaff and dust being allowed to fall from head height from a basket to the ground. The wind blows the lighter chaff and dust to one side and the grain falls directly below the basket. The grain is brushed clean of chaff and residues by a second person using a broom made usually of palm leaves. After winnowing the grain is allowed to dry when it is taken away for storage.

Some varieties however will be harvested by having the heads of grain cut from the stems. These are taken in baskets to the threshing ground where the threshing and winnowing process described above will be done. The stems will be allowed to ratoon once and often a second time.

Yields vary according to the variety grown, the season and the amount of water the crop has received. On rain-fed land the yield of grain will be negligible on poor sandy soils rising to 400 kgs/ha when rainfall has been better on the fine sandy loams. Under spate irrigation yields of the better varieties such as Qaira can reach 1.5 tonnes/ha but usually averages 900 kgs/ha. On lift and gheel irrigation average yields are assessed at 1.3 to 1.5 tonnes/ha with yields on new land reaching 2.25 tonnes/ha. Some varieties are allowed to ratoon, the yield of grain from the first ratoon (agb) producing only a quarter of the main crop with the grain being inferior in size and quality. Very little or most often no grain is harvested from the second ratoon (thalath) which is cut green, dried and stored for animal fodder.

Plant diseases reported and observed were covered and loose smuts and rust. Main pests reported were the army worm, aphids and birds. Termites were found burrowing in the woody stems of second ratoon crops but did not appear to be troublesome to the main crop. Although boys were employed to scare off birds and many platforms were seen where these boys sat during bird scaring, reports suggest that birds are only a problem when sorghum is grown out of season or as a crop in the Spring.

The most serious problem of sorghum is the witchweed (Striga Sp) 'Udar'. Most fields on the East side of the main road seemed to be affected and near Geruba fields were a purple colour indicating a massive invasion of this weed. Continuous sorghum growing has probably contributed to the increase in the incidence of this weed and a break from sorghum cultivation should be introduced in a long rotation in order to alleviate the problem.
Seed for the following season is retained from the farmers' own harvest stocks. Smitted seed is generally avoided but there will probably be contamination by loose smut. Some farmers with surplus grain for sale will make an attempt to select seed before selling the rest for human consumption, usually selecting for such characters as size, colour and freedom from chipped or cracked grains. This seed is then sold to other farmers.

The rate of ploughing in the Wadi Rima area is much faster than in the Montane Plains. It is estimated that a pair of oxen will plough just over 0.5 ha in 4 hours with approximately a further 2 hours being spent on travelling to and from the site and feeding the oxen during the day. The scraper board is not used to level fields as much as was seen in the Montane Plains, its main purpose being to repair holes in field banks and to construct diversion banks in the canal system.

ii. *Bilrush Millet* (dukhn) *Pennisetum typhoideum*

Millet is the second of the major crops grown in the Wadi Rima. It is cultivated in areas of poorer soil and/or lower water intakes which would not be suitable for the production of sorghum. It is therefore grown more often on rain-fed land or on land which has received a very light irrigation from the Wadi. It is not commonly grown under lift irrigation except in sandy areas.

Two varieties are grown:-

Makkawi: poorly tillering with long compact panicles best sown from mid June to mid August.

Biladi: highly tillering, short compact panicles sown from end May to early August.

Ploughing and sowing operations for irrigated millets are very similar to those already described for sorghum, but there is a difference in cultivation and seed spacing when it is grown under rain-fed conditions.

Land which has had rain will be ploughed twice with the seed being sown at the second ploughing. If rain has been scanty the first ploughing will often be omitted in order to conserve soil moisture. The seed is sown in rows about 1 metre apart and about 10 to 15 seeds are sown in spot sowings about 1 metre apart within the rows. The seed rate is about 12 kg/ha. The whole clump of millet is allowed to grow without thinning except when forage for livestock is in short supply. Lentils, cowpeas, beans and sometimes water melons are sown in the rows between the millet if the farmer thinks there is sufficient soil moisture. Weeding is carried out by hand. With good rainfall millet will grow to 2-2.5 metres tall. When ripe the heads are cut using a sickle. With the Makkawi variety most of the heads ripen at the same time so the whole area can be harvested in one operation. When Biladi is sown, the crop ripens over a
long period depending on the number of tillers produced and several harvestings are required. This variety will also be allowed to ratoon. The beans, lentils and water melons are harvested as they ripen, which is usually slightly later than the millet. The lentil and bean pods are collected by hand and the foliage fed to the livestock. Many pods burst before they are picked and self-seed so that plants may be seen in a field in various stages of growth.

Under lift, spate and gheil irrigation the ploughing operations, sowing methods and spacing will be similar to those already described for sorghum. Seed rate can be up to 25 kg/ha depending on seed spacing. It is very common to see a few rows of sorghum sown around the windward side of a crop of millet as a protection against the millet being blown down or lodged by the winds. The heads of grain are cut off with the sickle and taken to the threshing ground. The variety Makkawi will be harvested at one time but due to later maturing tillers Biladi will need several harvestings and this variety will be allowed to ratoon. Some millet is harvested at the milky stage (Gowsha) for incorporation into milk to form a gruel.

Threshing is done by flails after the heads have been allowed to dry in the sun for 1 or 2 days. Winnowing is by hand as already described for sorghum and the cleaned grain is dried in the sun for 2 or 3 days before being stored. Except when allowed to ratoon, the stalks are cut with the sickle, bundled and stored in a cone or tent shaped stack and used for animal fodder.

Yields vary greatly according to the amount of irrigation or rainfall the crop has received and will vary from very little on marginal rain-fed land to 800 kg/ha for Makkawi and 1.5 tonnes/ha for Biladi. The crop takes about 3 to 3½ months to mature with a further 6 weeks for the ratoon crop. Irrigation frequency on gheil and pump irrigation crops will be 4 or 5 times with about 5 to 7 cms of water being applied each time.

The main diseases are foliage rusts and smuts and the main pests are termites which cause many blind and distorted ears in the ratoon crop as the stalks of millet become more woody. Bird damage is reported to be severe when the crop is grown out of season on gheil or pump irrigation.

iii. **Maize** (Hind, Rumi) Zea mays

Only one local variety is grown which is sown at different times of the year during August, October, November, January and April. It is grown under gheil and pump irrigation.

The land is ploughed 3 times and the seed sown at the third ploughing through a pipe attached to the plough. Sowing distance between the rows is about 40 cms and within the rows varies from 7 to 15 cms. Mixed sowing of sorghum, maize and lentils was observed in November. After sowing, the land is made up
into irrigation basins by the construction of small banks as previously described for sorghum. Seed rate varies from 25 kg to 30 kg per hectare depending on seed spacing. With an overcrowded stand, some thinning takes place and the green stalks are fed to livestock. Weeding is generally done by hand, the most common weeds being Cynodon dactylon and Cyperus rotundus. The crop is watered 7 to 8 times ie about every 12 to 14 days.

Maize grows to about 2 metres in height and takes 3 to 3½ months to reach maturity. When ripe the small cobs are collected by hand and taken to the threshing ground. The cobs may be sold whole for roasting or threshed out by flail. Yields are generally in the order of 0.5 to 1 tonne/ha. The stalks are cut by sickle and allowed to dry for a day or two before being bundled and taken away for storage and subsequent feeding to livestock.

Pests and diseases were not considered by farmers to be of importance. The most serious damage is caused by termites when the plant population in severe attacks may be considerably reduced.

iv. Cotton (Gītn) Cossypium barbadense

Cotton is the major cash crop in the Wadi Rima. A report on the cotton growing industry in the Tihamas was prepared by Mr K R M Anthony, General Cotton Adviser, Cotton Research Corporation after a visit to the Yemen Arab Republic from 29 January to 7 February 1973. This report is so complete that very little further information can be added.

All the cotton in Wadi Rima is grown on irrigation from flood water or from wells equipped with submersible type pumps. The variety grown is Acala 1517B.

The land intended to be cropped with cotton is ploughed 4 times with the local plough or once by tractor plough and once by local plough. The final ploughing in each case is made after the land has been irrigated. Under spate irrigation the fields are divided by the construction of large banks often a metre or more high. The water is led to these fields through a system of canals. Field to field irrigation is widely practised when the bank at the lower end of the upper field is broken and water flows into the lower field. When fields are at widely different levels the velocity of water flow when the bank is cut causes deep and wide gully erosion. On pump irrigated lands the fields are sub-divided by small banks enclosing irrigation basins as already described for sorghum.

Seeding is done by a pipe attached to the local plough with one man walking alongside feeding seed down the pipe. In some areas a rigid-tined cultivator is fitted with pipes behind the rear tines and 3 men sit on the implement frame feeding seed down the pipes. Distance between the rows is very close and no cotton was seen growing at row widths greater than 45 cms. Spacing is also
very close within the rows to provide a high plant population because of the damage caused by termites. This spacing from such a heavy seed rate which may be up to 50 kgs/ha produces a very close mass of vegetation resulting in intense plant competition. However where termite attack has been severe the resultant stand of plants can be extremely poor. The crop is sown from July to the end of November and it was common to see cotton being harvested and sown in adjacent fields thus providing excellent conditions for the transfer of pests from one crop to another. Disputes regarding the acreage to be sown to cotton, damage early in the flood season to Wadi off-takes, lack of tractors and the fear of heavy termite attack on early sown cotton are all factors reported to have led to late sowing dates.

Cotton grown under spate irrigation may receive a second lighter watering during the growing season. In areas of permanent gheils the cotton will be watered 3 to 5 times and on pump irrigated areas 5 applications are usually given.

Although farmers reported that they thinned out the cotton no evidence of this was seen. Weeding was done by hand sickle and in areas of pump irrigation weed infestation was severe. No fertilisers are used and much cotton was seen which appeared to be suffering from nitrogen deficiency.

Pests such as leaf jassids (Empoasca lytica) aphids (Aphis gossypii) red bollworm (Diparopsis watersi) and spiny bollworms (Sarios spp) were noted and some damage was seen from the American bollworm (Heliothis armigera) as well as the severe damage caused by termites in both young and mature cotton. Spraying against bollworm damage is being done this year by the German Technical Assistance Team. Due to the protracted sowing period, several visits have to be made to the area to carry out this work resulting in an increased work load.

Picking of the seed cotton is done by hand, the pickers negotiating with the farmers a piece work rate per ma'ad (approximately 1.1 ha). The crop is picked over 3 times and the cotton placed into sacks provided by the Cotton General Company. Much of the cotton seen was contaminated with sand due to the frequent afternoon dust storms. It would appear that the seed cotton grown South of the Wadi Rima and West of the main road is taken to Zabid Ginnery where it is weighed and ginned whilst North of the Wadi Rima it is taken to Ceruba for weighing and onward transport to Hodeidah Ginnery. Farmers receive payment according to the quality of the cotton and this year are receiving YR 17/farsala (11½ kgs) for 1st grade, YR 16/farsala for 2nd grade and YR 15/farsala for 3rd grade cotton.

Advances of money are made to farmers to grow cotton but no clear picture emerged regarding the amount. Some farmers reported receiving about YR 30/ha while others were receiving YR 100/ha. Enquiries from the Manager, Cotton
General Company produced the information that assessors were sent out to farmers and advance payments were made according to the acreage sown, the condition of the crop and the honesty of the farmer and the payment was a variable figure based on these factors.

The best cotton seen was on the pump irrigated land to the West of the road. Some cotton in these areas which had been sown early was over a metre high with a large number (up to 35) bolls set. Yields in this area were estimated to average 450 kgs seed cotton/hectare. Cotton in the spate irrigated areas to the East of the road and around Geruba was poorly grown and yields of seed cotton were estimated at less than 250 kgs/hectare on average.

A visit to the Zabid Ginnery was made. This is placed in an awkward situation within the town and is inaccessible to lorries making the transport of seed cotton into and baled lint and cotton seed out of the ginnery a 'donkey and cart' affair, thus increasing the costs. The ginnery operates from 6 am to 10 pm on 6 days a week practically throughout the year. At the time of the visit 15 single roller gins were working. The press is an old screw type model producing 150 kg bales at the rate of 25 per day making the output from the ginnery less than 4 tonnes lint per day. Some of the seed cotton was heavily contaminated with trash, dirt and sand and this was hand sorted prior to ginning. All the grades 2 and 3 lint were sent to the textile factory in Sana'a and the grade 1 despatched to the Republic of China although a trial shipment was sent to UK last year. A consortium of 5 banks in Yemen provides the finance to the Cotton General Company for the purchase of the seed cotton crop from the farmers in the Tihamas.

After harvesting the cotton stalks are uprooted and burned although cases were seen of last year's cotton stalks producing new vegetation in some fields. Farmers know that they should observe a close season during mid May to end of July, but it is estimated that the later November sown crop will not be harvested until April and uprooting and burning will probably extend well into May so that the close season is obviously not being observed.

v. Sesame (Sim sim or gil gil) Sesamum indicum

Sesame is a cash crop of minor importance compared with cotton. Only one red local variety exists and it is grown under spate, gheil and pump irrigation. Cultivations are the same as for sorghum and seed may be sown in rows 30-40 cms apart and 5-10 cms within the rows, either alone or mixed with sorghum. Sowing broadcast on to the surface and ploughing in is also practised. Inter-row cultivation is seldom performed but some weeding may take place. There are 2 main sowing periods, mid August to mid October and mid November to mid December. The seed rate is about 6-7 kgs/ha.
Under flood irrigation the crop may be given 2 waterings, under gheil irrigation 3-5 waterings and under pump irrigation 5 applications of water.

Pests (apart from termites) and diseases were not common and no serious losses were reported.

Harvesting takes place in about 3 months from sowing when the majority of the pods are ripe. Undue delay of harvesting causes loss of yield due to bursting of the pods. The sesame is cut with the sickle and bundled up for transport to the threshing floor. Here the bundles are stacked to dry. When completely dry they are shaken and the pods burst to release the small seeds. Further threshing takes place by beating the pods which have not burst with flails. The seeds are cleaned by winnowing. Crop yields average 250 kgs/ha except on pump irrigation when yields can average 600 kgs/ha for a good well-grown crop.

The oil is crudely extracted in a 'pestle and mortar' type of press. The 'mortar' is a hollowed-out tree trunk and the 'pestle' is turned around in this by a system of poles and harness attached to a blindfolded camel which walks around in a circle. The oil is collected through a hole made into the bottom of the mortar. The oil is used for cooking and the oilcake which still has a high oil content is fed to livestock. This is the only high protein feed animals receive.

vi. Bananas (Musa)

The bananas grown in the Wadi Rima were imported from the Lahej area of the People's Democratic Republic of Yemen. They are of the Dwarf Cavendish type. The major plantations are to be found in the area around Mishrafa where there is a plentiful supply of gheil water throughout the year.

At establishment the bananas are planted about 4½ x 4½ metres apart. Holes are prepared about 80 cms deep and soil mixed with manure is filled in around the banana sucker. Water is given about twice a month in basins surrounding the plant. The suckers grow to about 3 metres in height and subsidiary suckers are produced around the parent stem. Bananas are produced from the parent stem in about 15 months from planting and ripen in about 18-19 months from planting. After harvesting, the parent stem is cut down and the subsidiary suckers grow to form the next parent stems. It is therefore common to see clumps of bananas with 6-8 plants and a further dozen suckers per site as little attempt is made to remove unnecessary suckers. No fertilisers are given and no mulching is practised.

Unfortunately during the cooler months of the year an unidentified disease attacks the ripening bananas causing vast losses in yields. Secondary rot organisms and insects take over and the bananas deteriorate into an evil
smelling, putrefying mess. Dr M J Watt, the FAO Entomologist at Hodeidah, considers that the original damage is caused by thrips making pinhole wounds allowing entry of secondary fungal and bacterial diseases which spread rapidly. The problem is now so severe that many farmers are uprooting their plantations. Apparently this disease has only developed within the past 3 years being unknown more than 3 years ago. The gross income from bananas has been very high in the past and farmers are feeling the effect of the disastrous loss in yield.

It is strongly recommended that the services of a banana pathologist should be obtained who should visit the area during Autumn 1975 to advise on this problem and on the cultural operations necessary for optimum yields. Until this problem is resolved it is likely that the acreage of bananas will continue to decline at a time when it is possible with the increasing number of pumps in the area to increase the acreage of bananas quite substantially.

vii. Date Palms (Nukhl) Phoenix dactylifera

A large plantation of date palms containing some Damm Palma (Hyphaene thebaica) has been long established around the village of Mijaylis and extending to the sea. This is an area of saline surface soil conditions with large deposits of salt on the surface. Water levels in the wells seen, varies from 60 cms to 4 metres from the surface allowing the use of simple portable close-coupled engine/centrifugal pumps to lift the water from the wells for irrigation.

Most of the date palms in the plantation are very old and there is very little replanting taking place. Many palms had fallen down or had been blown over by the wind and these and other standing old palms were being set on fire in situ. The majority of the palms seen were beyond the stage when they could yield well, bearing only a few leaves at the top of the trunk and obviously close to death. The whole plantation had taken on a scene of neglect and dereliction.

There were a few small areas where replanting of suckers had been carried out. Deep pits are prepared about 8 x 8 metres apart and the suckers, trimmed of most of their fronds and the remainder tied into a bundle, are planted in these holes where they are irrigated regularly. As soon as new growth appears confirming that the sucker has taken fresh roots, the string binding the foliage is cut and new fronds develop. These palms produce fruit in about 6 or 7 years. One male sucker is planted for every 50 to 60 female suckers and pollination of the female inflorescence is carried out by hand either by shaking pollen over the female flower, or less usual, by tying the male flower over the female inflorescence. The dates are ripe and ready for harvesting about 4 months after pollination.

Suckers are produced from the parent stem in 6-12 years and allowed to grow for 4 or 5 years before being removed for transplanting. In the plantation it was
quite common to see 15-20 off-shoots of various ages growing around and exhausted parent stem - an indication of the neglect now evident in the plantation. Irrigation of mature palms according to local sources is given once a year during April but many palms which were seen had recently received irrigation during November. Yields of dates on a good 20 year old palm should be 130 kg per palm, but those seen would not yield more than 25 kg and probably crop only every 2-3 years. There are many varieties of dates grown in the area but no specific information was obtained regarding names.

Whilst the climate of the area is suited for date palm cultivation and palms can thrive on brackish water (provided it is not stagnant) they must also be given a plentiful supply of water. This would not appear to be the situation in this plantation. They are certainly not being given enough water to leach out salts accumulated in the surface soils and this may be the reason for their demise. Any large abstraction of ground water in the upper areas of the Wadi causing a significant lowering of the static water level will lead to an encroachment of water from the sea. In this event there would be little hope for a rehabilitation of this palm plantation. It was difficult to obtain information on the root cause of the neglect of this plantation. Scarcity of labour due to the drift to the towns and neighbouring countries may be the prime reason as only debilitated old men and young boys were seen in the plantation area. Competition from dates imported from Saudi Arabia may also have led to a lowering demand for local dates which appear to be of inferior quality, although this could not be personally determined as no fruit was being borne on the palms at the time of the visit.

The branched doum palm is grown in the same way as already described for the date palm. It is valued for the seeds contained in the oblate nuts.

viii. Other Crops

Tobacco of the local Humoomi variety is grown in the Wadi Rima area but none was seen during the tour. This is grown under pump or gheil irrigation. The acreage grown makes this a very minor crop at this time.

Some pawpaw trees were seen, grown mainly in small clumps near the well head or along irrigation channels. These were not well cultivated, trees being allowed to grow long after their most productive years.

It was reported that over 300 citrus trees, mainly lemons and oranges, had been grown in previous years in the Geruba area but these had been so severely attacked by pests, probably citrus blackfly or Red and Black Scale, that they had been uprooted. Other citrus were seen to the West of the Bodeidah/Aliz road. They had been raised from orange pips and these trees may not be prolific nor produce fruit true to the parent variety in the future. The climate in the Tihamas with strong
winds and frequent sandstorms is not likely to prove favourable for the production of high quality citrus fruit except limes.

Near Mishrefa some well-grown mango trees were seen. The local farmers reported that they yielded well producing good quality fruit. This could not be confirmed.

Some groundnuts were seen at Zabid market which had been grown in the area. They were of good quality with well filled nuts but were subject to damage from termite attacks. The soils and water supply in the Wadi Rima appear suitable for an increase in the acreage of this crop provided that the economics of production, harvesting and marketing are favourable and that the termite problem can be solved.

Water melons are also popular and like lentils, cowpeas and beans are usually grown on rain-fed land inter-cropped with millet.

Some farmers were growing tomatoes. The standards of cultivations were poor and most of the plants seen appeared to be suffering from wilt and virus diseases. Onions are a popular crop and were growing well. Other vegetable crops are of minor importance at the moment but as more pump units are likely to be installed in the near future winter grown vegetable crops could play a more important role in the farm economy provided market outlets exist or could be developed. Peppers were not seen in the area but a few heads of sunflowers were growing near a well on the West side of the road.
TECHNICAL CONSTRAINTS ON INCREASING AGRICULTURAL PRODUCTION, WADI RIMA

Agricultural production in the Wadi Rima area is on a much higher level than that in the Montane Plains due to the better supply of water for irrigation from both floods and wells. There are several constraints currently limiting agricultural production and most of them would be likely to prevent the full benefits of additional irrigation water from being realised. However it is considered that there is a far greater potential in this area for increased output despite the severe climatic conditions.

The following are the technical constraints considered to be major limiting factors to increased production and productivity:

1. Water

In the Wadi Rima area water is available and utilised from 4 sources - rain, perennial Wadi flow (gheil), Wadi floods and ground water from wells. Nothing practical can be done to increase the amount of the first mentioned but the inefficient utilization of the other three sources is a major limiting factor to increasing agricultural production and the expansion of land under crops.

At present the system of water control and distribution of flood water in the Wadi Rima is inefficient and wasteful. Offtakes are constructed in the Wadi bed on both sides to lead into the main feeder canals. These offtakes are constructed of sand and boulder banks which are not strong enough to withstand large flash floods and often get carried away allowing the flood water to flow down the Wadi and spread over the gravel plains and scrub land on the fringes of the cultivated areas resulting in a waste of water. With this type of offtake construction little effective control is achieved on the amount of water entering the main canals and some of these appear to have been perilously near to breaking point in the past.

In order to obtain command of the upper land on the alluvial fan the main canals have their offtakes constructed in the upper reaches of the Wadi and follow closely the line of the main Wadi channel. They are thus exposed to erosion from flood water in the Wadi. The canals are sometimes winding waterways following the contours in an attempt to slow down water velocity in an area of somewhat steep slopes. This has not always been successful and erosion and cutting and lowering of canal beds has placed some land out of control. Distribution and division of water from main to subsidiary canals is achieved by building earth or brushwood deflectors in the bed of the canals and this leads to further erosion when breached. Irrigation is often from field to field which are sometimes at quite large differences in levels. When the bank separating these fields is cut the resulting torrent of water causes severe gully erosion. Fields are not particularly level
causing overwatering and leaching of plant nutrients at lower levels in the fields and underwetering at higher levels.

The priority of water distribution and rights to water may also be a limiting factor.

These constraints limit the amount of good quality land which can be irrigated from each flood. Improvements to water control and distribution from the Wadi itself and improvements to primary and secondary canal layout and alignment would remove most of these constraints in the future provided the local population would cooperate and water rights and disputes could be settled. This would appear to be a matter for the Government to resolve. Land levelling or subdivision of large fields would overcome the problem of gully erosion and uneven irrigation in field to field watering.

Improvements to water control structures in the Wadi would also lead to better utilization of perennial water and could bring into production larger acreages of crops which need frequent irrigation.

Lift irrigation from wells is likely to increase rapidly over the next few years. A close watch needs to be maintained on the static water levels in wells in the area. If the discharge of water via wells becomes greater than the recharge into the underground aquifers this may gradually lead to the encroachment of saline water from the sea into the lower cultivated areas which would then go out of production. The situation which has developed in the Wadi Zabid where the SWL has dropped by 1 metre/annum over the past 5 years and by 1½ metres during 1974 should not be allowed to be repeated in the Wadi Rima area.

Water losses through seepage from unlined irrigation channels are very large and the area of land which can be commanded by each well is reduced accordingly. Observation of water delivered at the well head and water entering the field suggests that in many cases 50% of the water is lost in transmission. Irrigation by the basin system is costly in terms of water use and a change over to furrow irrigation would be more efficient and allow a greater degree of mechanization.

ii. Research and Extension

The standard of cultivation of most crops is very poor. Varieties used are generally low yielding and simple agricultural inputs such as fertilisers, manures and pesticides are seldom used.

Research is needed into new crops (including fodder crops), new varieties of existing crops, times of sowing, crop spacing, water requirements, fertiliser applications and weed control, crop rotations, farm mechanization and harvesting methods. Some of this research work is being carried out at the Qumaisha State Farm near Hodeidah but more intensive work is urgently needed.
When results of research work become available there is no effective extension and advisory service in the area which can impart this knowledge to the farming community. Both these deficiencies are currently limiting factors to increasing agricultural production and will in the future prevent the full benefits of additional or more secure supplies of irrigation water from being realised. Taking one crop as a simple example, the yield of seed cotton is generally very low in the Wadi Rima area. Results of trials carried out at Qumaisha Farm show that yields were treble if not quadruple the average in the Tihamas and this was achieved through earlier sowing, adequate irrigation, pest control and supervised harvesting. If only this knowledge could be imparted to farmers in the Wadi Rima and implemented by them, the effect on crop yields could be startling.

If higher yielding varieties of sorghum and millet could be grown, farmers would need to grow a smaller acreage to satisfy their subsistence requirements. This saving in acreage would release more land for the cultivation of cotton which is the only major cash crop in the area and the only cash crop which has an orderly albeit not super efficient processing and marketing organization. It is not unreasonable to envisage a 5-fold increase in the production of seed cotton from the area provided that the deficiencies in research and extension are rectified and farmers co-operate.

iii. Plant Health and Hygiene

There are some problems which require urgent attention, such as termite control and the control of pests on cotton. Some of the latter could be partly solved by more vigorous health and hygiene regulations such as restricting the time of sowing cotton to August and September and the enforcement of a close season. Without these regulations pests will continue to multiply requiring the use of more expensive and sophisticated chemical control methods.

iv. Credit Facilities

A large increase in the number of wells dug and equipped with engines and submersible pumps can be expected provided credit facilities are available to reasonably skilled farmers. Some form of credit will also be needed in the future for the purchase of seeds, fertilizers, pesticides and machines, otherwise the rate of increased agricultural production will be slowed down and the full potential benefits of additional irrigation water will take longer to be realized.

v. Land Tenure

The complex nature of the problem of land tenure and landlord/tenant relationships needs to be thoroughly investigated. On the North bank of the Wadi Rima information was volunteered that on good land the farmer receives one third of the produce and the landlord (which includes the Government on State owned land) receives two thirds with all costs of production being shared equally between both parties. On poorer
and the tenant farmer and landlord share the output and production costs equally. Other areas of the Wadi Rima may have different agreements. Agroeconomic studies should reveal whether these arrangements provide sufficient incentive for tenant-farmers to provide their share of increased inputs in order to achieve a proportionally smaller share of the resulting increased production.

vi. Labour and Mechanization

Very farmers particularly those on pump irrigated areas stated that labourers were increasingly difficult and more costly to hire because of the attractions of more lucrative employment in the towns or in neighbouring countries. If this is a general complaint in the area it will naturally follow that more mechanization of farm tasks will be required particularly ploughing and harvesting operations. Very few farmers are able to purchase farm equipment such as tractors and ploughs and there is only a very limited hire service available for the majority of farmers. Indeed, the lack of tractor power was given as one reason why cotton sowing was delayed this year. Very tractors are fitted with unsuitable ploughs and operated by semi-skilled drivers. The resulting standard of work is poor and achieved at a high operating cost.

No simple machinery is available to assist with the threshing and winnowing operations which are performed mainly by hand. The locally made oil presses are slow and inefficient.

All these factors are currently limiting agricultural production. If additional irrigation water becomes available and more land is brought into agricultural production the situation is likely to be exacerbated in the future.

vii. Feeder Roads

The lack of feeder roads makes access very slow and difficult and increases the cost of transporting agricultural materials into and out of the area.

viii. Wind Breaks

Strong winds and dust storms are a common feature in the Wadi Rima as elsewhere in the Tihama. Wind damage to delicate crops and sand dune movement make production on the Western side of the project area very difficult. Very few wind breaks have been planted and no vegetative fixing of sand dunes attempted. Grazing by sheep and goats on the fringes of the existing agricultural area may remove what vegetation survives in the dune area making the situation worse.

ix. The condition of all classes of livestock, but particularly sheep and goats is reported to have improved this year as a result of the good rains. Cattle especially ploughing oxen are still undernourished and their work rate is very slow as has already been mentioned. Improved nutrition particularly in the protein content of
the diet of young cattle is required to at least give them a chance of growing into larger and stronger adult cattle. Strangely no lucerne is grown in the area which could be a valuable addition to the diet. It is considered that lucerne of the right variety would grow well on pump and sheel irrigated farms either as pure stands or inter-cropped with bananas and other tree crops. Apart from supplying a higher quality forage crop the nitrogen fixing role of lucerne would be beneficial to succeeding crops.

1. Processing and Marketing

Apart from cotton the lack of processing and marketing facilities limit the variety of crops which could be grown. Virginia-type tobacco, groundnuts and sunflower are just three examples of crops which could be grown in the area if processing facilities and market outlets exist. The Marketing Consultant is reporting separately on this problem.
GUIDELINES FOR IMPROVING AGRICULTURAL PRODUCTION - WADI RIMA

There are many ways in which agricultural production can be improved but it should be remembered that the Yemeni farmer will always give priority to growing food crops to satisfy his own subsistence requirements. This means that the production of cereal grain crops will continue to be the most important feature of the farming pattern in the Wadi Rima. The Yemen is a net importer of cereals and any increase in cereal production surplus to the farmers' own requirements will serve as a valuable import saver in the economy of the country. The value of the cereal straw crops in terms of animal food should also be considered.

Only when these subsistence requirements have been met will the Yemeni farmer turn to cash cropping and it is in this main field of activity that export earning or import saving crops can be exploited.

This section will therefore deal with the introduction of inputs such as improved varieties of existing crops, fertilisers, pesticides and cultural practices as well as suggestions for the introduction of new crops. The technical constraints described in the preceding section should also be borne in mind.

i. Improved Varieties of Existing Crops

Cereals

The main cereal crops in the Wadi Rima are sorghum and millet. Even under favourable water application rates and improved crop husbandry methods it is believed that the existing varieties do not possess the yield potential to achieve economic returns from increased agricultural inputs such as fertilisers, manures and pesticides. The sorghum specialist working with FAO/UNDP is currently engaged in conducting trials with improved sorghum varieties and is nearing the stage when he will be able to recommend the use of 5 or 6 varieties from the 5000 or so varieties with which he commenced the screening programme.

These improved varieties will not be able to express their yield potential unless such factors as adequate irrigation, fertiliser application, pest and weed control are also prescribed to the farming community. It is hoped that the FAO personnel at Hodsdiah when recommending new varieties will also issue instructions on the optimum amounts and frequency of irrigation, amounts of fertilisers required and weed control measures and that the seeds issued will be dressed against smut and other seed borne diseases. Care should be taken to ensure that mixing with local varieties is avoided as far as possible.

Seed selection within local varieties may also reveal more promising strains although it is appreciated that this is a long term proposition.
Sesame

The local variety yields very poorly and improved imported varieties should be tested as with the sorghum varieties to assess their suitability under local conditions.

ii. Introduction of new crops

Testing of crops new to farmers in the Wadi Hima should be carried out to determine their suitability under local conditions. Crops such as Virginia tobacco, sunflower, pineapple, soya bean (winter production), castor oil, lucerne, berseem (Trifolium alexandrinum) and linseed may prove suitable provided that problems of processing and marketing of most of these crops can be solved. The testing of various fodder grasses and legumes such as Dolichos lab lab to determine their suitability as grazing crops under rain-fed conditions to provide grazing for livestock should not be overlooked. Some of these crops such as lucerne, berseem and pineapple may thrive under shade or partial shade conditions provided by bananas, date palms and possibly castor oil.

iii. Extension of existing crops

Increased acreages could be devoted to crops which are at present only grown on small areas. These are bananas (provided the disease problem can be overcome), limes, (production of lime juice), groundnuts (for nuts and oil production), mango, pawpaw (pappaine production?), tomatoes, onions, peppers and other vegetable crops.

iv. Improved crop husbandry

The standard of husbandry of many crops is generally poor more particularly on the cotton crop. Demonstration units could be established to show farmers improved cultivation techniques, methods and rates of water application, seed spacing and optimum plant populations, optimum times of sowing, efficient weed control by hand and by cultivations, pest and disease control, manure and fertiliser application and harvesting methods. Banana culture could be vastly improved and old pawpaw trees replaced.

Again taking the cotton crop as an example it is believed that farmers in the area either over or under water the crop due to faulty field design leading to variations in depth of water applied. Row spacing is too close and seed spacing within rows is too heavy giving high density plant populations and intense plant competition. No thinning takes place even when termite attack has not been severe. No fertilisers are applied and plant growth is often stunted. Although trials have shown that August and September sowings give the best yields farmers are still sowing cotton late into November and early December. This provides ideal conditions for the transference of pests from an early to a late sown crop. Farmers in the main rely on outside help for pest control. Their weed control is faulty as only the top
growth of weeds is removed. This often leads to a greater infestation of weeds especially Nut Grass and Couch. A close season when no cotton remains in the ground from mid-May to the end of July is not strictly observed and the possibility of pest carry over from one season to the next is a real danger.

Fertilisers

Due to large increases in costs, the use of artificial fertilisers has largely been discontinued. Provided that other husbandry factors especially water demand are satisfied it is believed that an economic response to fertilisers can still be achieved although this will have to be demonstrated by field trials.

Rotations

No real crop rotation is practised in the Wadi Rima. As a result of continued monoculture soil fertility is declining, yields decreasing and plant pests and diseases multiplying. A typical example is the sorghum crop where continuous cropping has led to a large build-up of witchweed (Striga). There is no leguminous crop in the rotation which by nitrogen fixation could build up fertility for the succeeding crop.

Pest and weed control

As has already been mentioned the use of rotations and improved cultivations and weeding techniques could substantially reduce weed populations. Observance of optimum sowing dates and close season could reduce pests substantially but chemical pest control would still be required. Widely spread sowing dates make control more difficult in terms of spray schedules and effectiveness and increases costs.

Irrigation

The water requirements for the crops in the area have not been determined with any degree of precision. This situation should be rectified on spate, gheil and pump irrigation systems. It is considered that some crops such as bananas are over irrigated whilst some cotton crops on pump irrigation appear to be under moisture stress. Quantities of water applied to fields from flood irrigation appear to be very variable and control of the irrigation system appears to be minimal because of poor design and construction of the distribution network.

Power

Any improvement in agricultural production creates an increased demand for labour and animal and mechanized draft power. The shortage of labour and the low rate of work of animal power is already creating a demand for increased mechanical power. Suitable machines and implements have to be made available for cultivations and for threshing operations to speed up the rate of work. Pump and engine breakdowns are common particularly when the equipment is 3-4 years old due to lack of simple maintenance. Operators should be trained in the maintenance of their equipment.
The size and power of existing machines do not appear to match the job in hand. The problems of large tractor size and over large ploughs have already been mentioned but engine/pump combinations are also often poorly matched and it is quite common to see engines throttled back because at their rated speeds the pumps soon empty the wells.

A machinery hire service using suitable implements should be made available to farmers and properly trained mechanics stationed in the area to deal with mechanical breakdowns.

v. Research and Extension

Due to the lack of research data currently available it is not possible to produce a blueprint for optimum crop husbandry methods for farmers in the Wadi Rima. More research work needs to be urgently carried out on a wider range of crops and it is recommended that the FAO/UNDP staff at Hodeidah should be strengthened in order to give priority to this work.

Having obtained the basic data more extension and advisory workers are needed in the field to disseminate this information to farmers through modern extension methods.

Summarising this section, it is considered that the following may serve as guidelines for improving agricultural production in the Wadi Rima area:

1. Introduction of improved crop varieties.
2. Testing of new crops.
3. Increasing the acreage of several existing crops.
4. Improved crop husbandry including better cultivation methods, times of sowing, planting distances, use of fertilisers, establishment of crop rotations, improved pest and weed control, more efficient irrigation and improved mechanization.
5. Provision of a machinery hire service and trained mechanics.
6. Intensification of the research programme.
7. Establishment of an extension/advisory service resident in the area.
ASESSMENT OF CURRENT AGRICULTURE - MONTANE PLAINS

This assessment of current agricultural practices, systems and levels of productivity was made through a series of interviews with farmers in the area and by personal observation. Most of the crops had been harvested at the time of the visit so field assessments of yields and pest and disease levels were made from those crops left unharvested and from interviews. Average assessments of yields were difficult to obtain due to the multiplicity of different measurements of bushel weights and land areas used throughout the area. It was also very evident that farmers had only a vague recollection of yields in physical terms, preferring to quote financial returns as comparisons between the major crops. It would be beneficial to introduce a metric system of weights and measures throughout the area.

Each major crop is dealt with separately detailing the cultivation, sowing, other cultural operations during the growing period, harvesting and a description of the major pests and diseases is given as far as it is possible to identify these from the descriptions received.

1. Barley (Shai'r) - Hordeum vulgare

Most of the 2-rowed barley on the Montane Plains is cultivated on rain-fed land (agar). With a variable rainfall which seldom exceeds 300 mm during the growing period of the crop, production depends on this factor of adequate soil moisture and determines the vegetative growth and yield of the crop grain and straw.

Soon after the previous crop has been cleared, the field is ploughed. Depth of ploughing with the local plough varies with the hardness of the soil but seldom exceeds 15 cms and the ploughing does not invert the soil. Tractors are also used which are hydraulically mounted with 1 or 2 furrow non-reversible ploughs which do invert the soil. Most of the tractors seen were of an unnecessarily high horsepower for the task in hand and fitted with 35 cms or 40 cms single-furrowed ploughs which penetrate to a depth of 30-35 cms very often bringing up sub soil and sometimes small gravel. As weeds during this dry period after harvest are not a major problem it is difficult to see the need for this depth of ploughing. Farmers reported that they liked to have a tractor plough cultivate the land one year in five as it brought to the surface more fertile soil. The only possible advantage in this deep ploughing would be to eliminate Bermuda grass (Cynodon dactylon) called "Wabl", when ploughing to 25 cms could bring up the rhizomes for exposure to the drying out and killing action of the sun and wind.

After ploughing the clods are broken up and the land levelled by cattle pulling a log or flat board (Mahar) over the surface. It is also believed that this helps to conserve soil moisture.
The second ploughing is made after rain and seed is sown at the time of the third ploughing. If a tractor plough has been used the second ploughing with the local plough is omitted. The local plough is drawn by a pair of oxen or by a single camel. Speed of ploughing depends on the hardness of the soil and particularly on the strength of the bullocks being used. These appeared to be in a weak and undernourished condition, if not actually stunted in growth, and ploughing is a very slow operation.

The time of sowing varies depending on time of rainfall, but is usually during the period end May/June/July. Furrows are opened by the final ploughing about 15-20 cms apart and the sower throws seed by hand into the bottom of the furrow, seed spacing in the rows being variable, but averaging about 1½-2cms apart. The sower walks about 1 metre behind and slightly to one side of the ploughman. The seed is contained in a leather bag made of goatskin slung over his shoulder, the bag resting against his left hip. The seed is taken out of the bag with the right hand and appears to be thrown from the palm of the hand along the forefinger in an arc of seed which lands in the bottom of the furrow about half a metre in front of him, seed being taken from the bag and thrown at each step. The seed is covered either by the sower dragging his foot along the furrow or by the passage of the plough in the next furrow, the latter method being the most common for barley. The seed rate is about 120 kgs/ha.

Varieties of seed used were described as follows:-

Bagalah, Bagur, Jorah, Ziragi aswad and Biladi.

Bagur was identified as being suitable for Winter sowing, usually in January. Any of these varieties could be called 'Biladi' and some of them could be the same genotype with different names being used in different areas.

Generally no fertilisers are applied to the field although animal manure or the residues (ash) from dried manure used as fuel are applied when available. No pest control is attempted and no seed dressings are used. On rain-fed crops no further cultivations are performed before harvest. Growth of the crop seems to depend solely on the amount of rainfall the land had received. Crops were seen which had developed to only 15 cms in height with no ears of grain or very small ears containing a few shrivelled grains. On land which had received a higher rainfall crops had grown to 50 cms high with longer ears of well developed and matured grain. The crop reaches maturity in about 4 months.

Harvesting takes place when the grain is fully ripe and the crop is cut by hand, the harvesters (Surab or Haadin) using a short curved saw-toothed knife, "Sharim", to cut the straw close to the ground. They are paid in kind at the rate of an armful of the cut crop per day's work. The barley is bundled up and carried to the threshing ground (mijran) where the bundles are opened up and spread over the floor to dry. The straw is turned daily for 3-4 days to ensure complete dryness by which time it
is quite brittle and the grain can be easily separated from the ears. Usually the grain is threshed by a pair of oxen drawing a large stone (majar) around the heaped straw on the threshing floor. Threshing can be by flail (Mahrlyah) if sufficient labourers are available. The straw is rearranged in a heap periodically using a 3-pronged steel or wooden fork. The threshing may take 1 or 1½ days. The threshed straw which by this time is in short lengths is separated by hand from the grain and chaff.

The next process is winnowing (ifqaluh). The grain and chaff is collected in a shallow basket and tipped from a height of about 1½ m to the ground. The wind blows the chaff and dust to one side and the grain drops in a heap directly under the basket. A woman with a bamboo type broom made of twigs or palm leaves brushes away unthreshed ears and other debris which collect on the surface of the grain. This winnowing operation may be repeated a second time. The grain is spread out on the threshing ground in the sun for a day or two to ensure complete dryness before being taken away for storage. The straw is bundled up or filled into sacks and used for animal fodder. After threshing is over goats, sheep and cattle are allowed to wander over the threshing ground picking up chaff and small pieces of straw.

Yields are very variable depending on the amount of rainfall the crop has received. Some growing crops observed would not even return the amount of seed sown. On average and provided that the crop had received adequate moisture yields were reported to be about 0.5 tons/ha.

Diseases observed were mainly foliar and smut diseases. Leaf blotches, very similar to Rhynchosporium, various leaf streaks and unidentified rusts were seen in most crops. In some fields ears of grain were noted which were infected with both covered and loose smut. Smutted crops were stored and harvested separately and this seed was not used for the subsequent crop. An insect pest called "Jidami" was reported to attack the main stem at or below ground level causing collapse of the plant, but none was seen and no identification could be made from the description given. No serious losses were reported by farmers by these pests and diseases.

Weeds on rain-fed land were not a problem, but Cynodon dactylon (Bermuda grass) called "Wahil" and nut grass (Cyperus rotundus) "Mishr" were troublesome on irrigated areas.

Farmers generally saved their own seed for sowing in the following year. Occasionally they would purchase seed from another farmer whose crop they had admired but seldom were purchases of seed made from other sources eg merchants.

The pattern of crop production in lift irrigation from wells closely follows that for rain-fed land except that the land is irrigated once before sowing and 3 times during the growing period, although some farmers reported a total irrigation frequency of 5 or 7 times. Basins seemed to be filled with about 5-8 cms of water.
each time. In some cases basins were disproportionately large in relation to the amount of water being used leading to over-irrigation at the entry point of the water into the field and under-irrigation at the furthest point.

Yields from irrigated barley are higher than for rain-fed, and it is estimated that an average of 1.5 t/ha may be obtained. Artificial fertilisers mainly sulphate of Ammonia (26% N) have been used by some farmers in the past on irrigated crops but due to the sudden increase in prices less are now being used and in some cases no fertilisers are applied.

II. Wheat (Triticum vulgare)

The cultivation of the ground, sowing, seed spacing and harvesting operations follow closely the pattern already described for barley. Varieties of local origin are available to suit Winter or Summer sowing with a long or short growing season. Varieties identified are:

Arabi or Biladi - This variety is sown on both rain-fed and well irrigated land and has a short grain.

Maisari - This is grown on pump irrigated land and has a longer grain than Arabi.

Kanadi - This is reported to be an American wheat, so named after the late President Kennedy.

Australi - This is a wheat imported, as the name implies, from Australia but no varietal name could be discovered for it.

Samra

Amqab - This is a blackish coloured variety.

Sunduqa

Hamara

Again, various areas have their own names for varieties and it is possible that different areas will give their own name to the same variety.

Sowing takes place during 2 main periods, December/January and June/July, although one farmer was sowing Australian wheat under irrigation early in November. Seed rates are similar to those of barley ie 120-140 kgs/ha. Irrigation frequency was the same as for barley the imported varieties such as Australi and Kanadi with a growing period of 4 months and Samra with 4½ months growing period being irrigated up to 6 times and the local varieties with a growing period of 3½ months being irrigated up to 4 times. These frequencies are reduced if there is a good rainfall. As with barley animal manure or ash is incorporated into the soil when available and particularly under irrigated conditions. Artificial fertilisers have been used in the past. Yields vary from very little under poor rain-fed land to 1.6 tons/ha under better rainfall and 2-2½ tons/ha under irrigation, particularly when wheat is the first straw crop taken after lucerne in the rotation. The local varieties are
reported to yield better than the imported varieties. Brown and loose smut, rust
and other foliar diseases were noticed but did not appear to cause much concern
in the farmers. Seed for the following year was retained from the farmers' own
crop and only changed when they saw neighbours with better crops. Imported
varieties are sometimes purchased from merchants. Some contamination of wheat
yields with Wild Cats was noticed and this has probably been introduced through
imported varieties.

iii. *Sorghum* (Durra) — *Sorghum vulgare*

Ploughing and presowing cultivations are the same as those already described for
barley. For rain-fed land, spacing between the rows depends on how much rain the
soil has received. The more rain the greater the distance between rows so it is
common to see a great variety of spacings from 15-50 cms.

The amount of rainfall also controls the variety chosen. Seeds may be sown
through a pipe (gisebannah) attached to the plough or by hand. Seeds are generally
sown at a spacing within the row of 8-10 cms, giving a seed rate of 25-40 kgs/ha.
Lentils (ades) or cowpeas (dijr) may also be sown between the rows. The main
sowing period is May/June and the growing period is between 4½ to 5 months
depending on the variety.

Varieties of sorghum described are:

Hamra   — Large heads with red coloured grain.
Baida   — " " " white " "
Duhairri — Smaller heads with red " "
Gedar   — Heads smaller than duhairri, grain red.
Guradi  — Very small heads with red grain.
Sufra   — Large heads with yellow/orange coloured grain.

Sufra is usually grown under higher rainfall conditions such as near Ibb, or on
terraces, or under well irrigation. All the other varieties are grown on rain-fed
land but Hamra, Baida and Cedar are preferred for well irrigation.

Some inter-row cultivation and weeding may be done and thinning of an over-crowded
stand is also practised when necessary.

Manuring with animal manures or ash is given to this crop in preference to wheat
and barley, but artificial fertilisers are rarely used except by some farmers under
irrigation.

The crop grown under lift irrigation is watered 3 or 4 times when it may grow to
2½-3 metres. Growth under rain-fed conditions depends obviously on the amount of
soil moisture and some crops were seen growing to only 70 cms with small shrivelled
heads of poor quality grain. The growing period of the crop is 4½-5 months except
for Sufra which takes 6-7 months to reach maturity.
when the crop matures and is of good vegetative growth the leaves are stripped off the stem and are stored for animal fodder. This usually leaves a ring of red in the area of the stem which had been clamped by the leaf sheaths.

A few days later the heads of grain which have by this time bent over like a crook are cut off and taken to the threshing ground where they are spread out to dry for several days. When labourers are available the grain is threshed by flails and is separated from the chaff and stalk ends by wind winnowing. The grain is then left in a heap for several more days to ensure that it is thoroughly dry before being taken away for storage. Yields vary considerably according to variety and soil moisture availability and can be from nil for poor rain-fed land to 1.8-2.5 tons/ha for a good crop under well irrigation. The average yield under reasonable rain-fed conditions is about 900 kg/ha.

The stalks remaining in the field are cut with the sickle, bundled and stored in the open in conical shaped stacks. These are then fed to livestock either alone or entwined with lucerne.

Smut was again the most important disease noted with leaf blotches, discolorations and rust also being common. No insect pest was reported as being of consequence, although the Army Worm and stem borer (Sesaria cernew) were described as sometimes attacking sorghum.

Seed is selected for sowing the following year from the farmer's own crops and occasionally seed is purchased from other farmers and merchants.

iv. Maize (Rumi) - Zea mays

This crop is mainly grown under irrigated conditions on the Montane Plains - no maize was seen growing on rain-fed conditions and only one local variety, Thalati, was described. Ploughing and presowing cultivations are the same as for other cereals but distance between the rows can vary from 60 to 80 cms with a distance of 20-25 cms within the rows. Seed is sown 2-4 together and the weaker plants thinned out. This spacing requires a seed rate of 10-12 kgs/ha. The crop is irrigated 4 or 5 times during the 5 months growing period and reaches a height of approximately 2-2½ metres. Artificial fertilisers are not generally applied but animal manure or ash is given when available. The plants are earthed up by ploughing between the rows or by hand hoeing when they are about 60 cms high.

The cobs are stripped off by hand and spread out to dry in the sun. Farmers may sell them as whole cobs or may thresh out the seeds. The cobs are generally small and each plant produces 1-3 cobs.

The stems are cut and stored for animal fodder but farmers report that their feed value is less than that of sorghum. This is not an extensively cultivated crop in the Montane Plains area due to the paucity of water supplies.
Potatoes (Solanum tuberosum)

Potatoes are regarded as a high value cash crop in the Montane Plains and are grown under lift irrigation. There are 2 main sowing periods Jan/Feb and June/July and one local variety, "Zaledi", is cultivated although some farmers have obtained imported seed which, whatever their source, is usually called "Musri".

Ploughing with the local plough is carried out 4-5 times, the soil being penetrated deeper each time to a final depth of about 15 cms. If ploughing is done by tractor this is followed once only by the local plough. Manure and ash are applied between ploughings. Artificial fertilisers have been used in recent years but high costs have reduced their usage.

The final ploughing opens furrows about 60 cms apart and the tubers are planted in the bottom of the furrow about 35 cms apart depending on seed size. The tubers are covered over by hand hoe to form a small mound of earth at each planting site. Seed about 3 cms to 4.5 cms in size is used for preference for planting but when there is not sufficient seed of this size range available larger tubers are cut in half or even cut several times as long as one eye remains on the cut pieces. This practice leads to apical dominance, the production of a small number of stems and a small number of large, sometimes very large, tubers by harvest time. No deliberate chitting policy is carried out but tubers may have a few mins of sprouts by planting time. Seed rate is about 2 ton/ha.

Three to four applications of irrigation water are given and the potatoes are earthed up by hoe after each application. At the same time weeds are hoed out. The most troublesome weed is Bermuda grass (Cynodon dactylon) "Wahl" and this hoeing seldom succeeds in eliminating it. Some fields have become so badly infested that they are left fallow for one year in an attempt to reduce the infestation but without much success. A deep ploughing at a depth of 30 cms to bring up the rhizomes to the drying and killing action of the sun would have a far greater effect in controlling this weed.

The crop is ready for harvesting in about 4½ months from planting but the tubers may be left in the soil for a longer period until the farmers are ready to lift them for sale. The crop is harvested using a narrow tined hoe and this results in some damage to tubers. Yields varied from 8 tons/ha on a poor crop to 18 tons/ha on a good crop. Farmers reported that they would get an average of 9 tubers for each one planted.

Seed for the following crop is saved from the farmers' own supplies and this practice may continue for 4-5 years until they realize that yields are falling when they will buy in fresh seed. The value of rotational cropping is appreciated and most farmers understand that consecutive cropping with potatoes leads to a drastic
drop in yield in the second year. They allow at least a one year break from potatoes and prefer a break of 4 years if they have sufficient land to allow them to do so. No fresh foliage was seen but descriptions of aphide "assal" present in the crop and some stunted dead foliage suggests the presence of virus disease. Potato blight was described and potato tubers were attacked by the Army Worm (Spodoptera sp) locally called "Qishr" and wireworms. Potatoes seen were free from skin diseases such as scab and warts and presented quite an attractive commodity.

iv. Lucerne (Medicago saliva) - Gudd

Lucerne is the only crop which is grown solely for forage for livestock in the Montane Plains. Three varieties were identified by farmers:

- **Behadi**: This is grown principally under rain-fed conditions and has a prostrate habit of growth.
- **Kowli**: Grown on irrigated land and it has an upright habit of growth. It is also described as being suitable for rain-fed land.
- **Raymani**: Grown only on irrigated land. It has an upright habit of growth.

Cultivations for both rain-fed and irrigated lucerne are similar. The fields are ploughed 3-4 times and levelled with a scraper board which leaves a good tilth. Under rain-fed conditions the seed is broadcast at 15-20 kgs/ha and the seed is hoed or harrowed in. Cutting frequency and yields vary with the amount of rain the soil receives but 6 cuts can be taken under normal soil moisture conditions. Yields fall rapidly during the Winter due to cold weather and moisture stress. This lucerne is allowed to crop for 3 years before being ploughed in.

Farmers were unable to give any reliable assessment of yields, but personal observation would suggest that yields are low particularly by the third year.

Under irrigated conditions small earth banks (adil) about 20 cms high are constructed using a scraper board (mihaar) to form irrigation basins. After the first irrigation seed is broadcast at about 20 kgs/ha and hoed or harrowed into the tilth. Seed is usually sown during January but the sowing period can be extended up to May. No fertilisers are used. After about 12 weeks the first cut is taken the lucerne being cut close to the crown. During the summer cuts can be taken every month, the lucerne being at the early flowering stage and about 35 cms high. During the Winter cuts are taken at 40 day intervals but yields are very much lower than in the Summer as growth is checked by the cold weather. Thinning of the crop by frost kill is not uncommon. Irrigation frequency is about every 15-18 days during the Summer and every 30 days during the Winter. The crop occupies the ground for 5 years before being ploughed in.

The only pest noticed was a fly which was present in large numbers in the crop. This could be the alfalfa weevil.
proved impossible to estimate the yield of lucerne under irrigated conditions as farmers' recollections of the amount cut during the year proved to be too vague for any meaningful assessment to be made.

Seed is expensive at 350 Riyals/Qadah which is approximately equivalent to £1 per kg. Seed is taken in the final year of the crop when it is allowed to grow to maturity and the seed threshed out by hand.

Farmers appreciate the increased fertility that lucerne produces in the soil and stated that yields in the crop following lucerne were much enhanced.

Several whole plants were dug up in various fields in the Plains and an examination of the roots showed no nodulation. Descriptions and drawings of lucerne roots with nodules were shown to farmers but they did not know of the existence of these nodules and had never seen them. Nodulation decreases during the Winter and it has been reported by research workers in Saudi Arabia that the absence of nodules in lucerne over 6 months old is not uncommon. It has been suggested that blue-green soil algae could provide nitrogen for lucerne grown under Arabian conditions. The final paragraph of a report by Mr J Barley commenting on the analyses of soil samples taken in 1971 by Mr M Brunt states that lucerne does not nodulate in soils with a pH of 8+. It is suggested that examination of newly sown lucerne roots be made in March/April next year to confirm the presence or absence of nodules. If no nodules are present the seed should be inoculated.

vii. Vegetables

A large variety of vegetables is grown in the Montane Plains under well irrigation. Crops are mainly grown in small basins which are flooded periodically. This often leads to soil contamination and deterioration and rotting of tomatoes lying in the water and mud.

The most common vegetables grown are tomatoes, onions, leeks, carrots, green and red peppers, garlic, radish, beans and lentils. Other vegetables such as cabbage, cauliflower, lettuce, beetroot, peas etc are not grown because they are not liked by the local population and there is only a very limited market in Sana'a for expatriates which is already satisfied by farmers nearer the city. Any increase in production in the Plains would have a depressing effect on prices obtained by all farmers and the probability that much of the crop would remain unsold. The climate in the Plains could support a wide variety of horticultural crops provided a suitable market outlet could be found which would provide an economic return.

viii. Fruit

The production of most fruit except grapes is small in the Montane Plains but the environment appears to be suitable for a wide range of deciduous fruit crops. Small mixed orchards containing peach, plum, apricot, apple, pear and almond trees and
Some pomegranate were seen but most trees were neglected and the husbandry techniques were not understood. Irrigation frequency in one orchard was only twice per annum, the first at flowering, the second at fruit expansion and the third during the Autumn. Fruit was always described as being of good quality but inspection of locally grown fruit in the markets did not support this. The origin of these trees was reported to be from Kenya, Ethiopia, Egypt and Lebanon. Indiscriminate importation of uncertified plant material could lead in the future to the risk of the introduction of virus and disease problems into the country.

ix. Rotations

Under rain-fed conditions no rotation was practised, all the main crops grown being cereal crops which without fertiliser application exhaust the soils of plant nutrients. The only break from cereals was a small acreage of lucerne.

Irrigation lift irrigation a loose form of rotation was practised based on lucerne. This was grown for 5 years and was followed in subsequent years by wheat, barley, potatoes, dhura, barley and lucerne again. However many farmers practised no formal rotation.
CURRENT TECHNICAL CONSTRAINTS ON INCREASING AGRICULTURAL PRODUCTION

The following are the major technical constraints to increasing agricultural production which currently apply in the Montane Plains area of the project. These constraints have been identified through interviews and personal observations.

1. Water Supplies

Lack of water both as rainfall and from ground water sources is the major limiting factor to increasing production. The low average rainfall of 300 mm limits the range of crops which can be grown on rain-fed land to mainly cereals. Many of the crops seen growing on such land were suffering from acute moisture stress. Some crops of wheat, barley and dhura had produced poorly filled or empty ears of grain with stunted vegetative growth. These conditions resulted in very low or nil yields of grain although some output was obtained from the crop in terms of fodder for livestock. Poor judgement of the amount of moisture received and stored in the soil and available for plant growth has led to the wrong choice of cereal sown eg barley may have produced relatively well in a field which, because of lack of adequate rainfall, could not have produced a sorghum crop.

Large areas of the Qa comprising the project area have no or very few wells with adequate water resources for agricultural production. The present concentration of wells appears to be around the main towns of Dhamar, Ma'bar, in the Qa Jahran to the East and North East of Ma'bar and a few wells at the Southern end of the Qa Haql. Depths of water in wells currently in use for agriculture is relatively shallow extracting water from the alluvial surface aquifers. Production also appears to vary from 1 pump per well to 6 pumps per well, estimated at 13,500 litres/hour to 150,000 litres/hour. No survey has yet been made of the number of wells used principally for agricultural production, but it is estimated between 150 and 250 at the present time in the 5 main Qa.

This low number of wells in such a large tract of land leads to the conclusion that water availability from surface alluvial aquifers, outside the main centres of well population already described, is low. Possibly insufficient capital is available in areas of low or no well population to dig more wells but this is dealt with in the following paragraph.

ii. Credit Facilities

Conversations with farmers and a tradesman in the areas of high concentrations of wells implied that the availability of credit presented no problems. Facilities were available to farmers with good wells to obtain credit from merchants, repayable over 2 years, for the purchase of pumps and engines. However, away from these areas many farmers complained that there was no company (sherika) which could advance them
credit to dig shallow wells and to enable them to purchase and install pumps and engines. It would be fair to point out that there would be considerable risk to traders' capital advanced to farmers attempting to dig wells in unproven areas.

iii. Expertise

As has already been mentioned, farmers in the Montane Plains have considerable expertise in the cultivation of crops grown under rain-fed conditions even if sometimes their choice of crops sown has been faulty or their expectation of further rainfall has not been fulfilled.

However, their lack of knowledge of improved husbandry methods and techniques on lift irrigation is a serious limiting factor to increased agricultural production. The West German Technical Assistance team based at Shoub, Sana'a, has experimented with new crop varieties, cropping patterns, fertiliser applications, pest control, irrigation frequency and systems of water distribution and much of the knowledge gained could be imparted to the farming community. Unfortunately no extension or advisory service exists which could relay this information from researcher to farmer. Some new varieties of crops have been grown and artificial fertilisers applied (until the prices rose so substantially) but the impact has been minimal to date without such a resident extension service.

Discussions with farmers and personal observation reveal for example, an appalling waste of irrigation water through seepage from unlined channels and through an inefficient distribution system in the fields. Due sometimes to the lack of or high cost of labourers, field sizes are far too large for the amount of water applied leading to over-watering and under-watering in the same field. There is a lack of knowledge of the amount of water needed at each application and the number of applications required to permit full agricultural potential of the crop to be realised.

The crop varieties used would appear in most cases to be the same varieties which are used on rain-fed land and these would not seem to have the potential for higher yields under lift irrigation with its attendant higher costs. The use of artificial fertilisers has been largely abandoned although their cost could probably be more than justified by the extra crop output provided the varieties used have the yield potential and sound husbandry practices adopted.

No attempt is being made to control pests or diseases because farmers believed that they did not cause severe losses although this may not be the case.

Planting distance (eg of potatoes) and seed rates (eg of lucerne) did not appear to be optimal resulting in low population densities and consequently reduced yields, wastage of irrigation water and severe weed competition.

The cultivation of vegetables and fruit crops was not understood and quality and
yield of produce were much below the potential of the crops. Weed control was poor and any weeding performed merely removed the foliage without disturbing the roots, often resulting in an increase in weeds.

Poor working rates in cultivation operations through weak animal draught power results in higher production costs. Animals are generally under-fed and the level of nutrition for rearing cattle causes stunting or poor development resulting in weak adult cattle. The use of tractor power is increasing but the high horsepower tractors used fitted with very large single furrow mouldboard ploughs working at slow speeds and at unnecessarily great depths may cause soil problems and certainly adds to the cost of crop production. The amount of land levelling after tractor use is much higher than when animal power is used increasing production costs further.

iv. Labour

In some areas it was reported that a shortage of labour caused problems particularly for such operations as harvesting and water distribution. The high cost of labourers is also a problem. A moderate degree of mechanization and modified watering systems could alleviate this.

v. Land Tenure

This subject has already been dealt with by Prof R E Serjeant, but the system of crop division between landowner and tenant farmer could be the cause of disincentive by the tenant to introduce new crops, new varieties, inputs of manures and fertilisers etc where the cost of such inputs may have to be fully met by the tenant. This is a subject outside the scope of this report but it should be looked into and more detailed knowledge obtained in order to ascertain the true position.

vi. Size and Fragmentation of Holdings

Many examples of small size and fragmented holdings were encountered many being divided into small parcels of land several kilometres apart. This is a constraint on increasing agricultural production and causes production costs to be higher because of increased costs of supervision, travel etc.

vii. Shelter Belts

The Montana Plains area is an open practically treeless landscape and the lack of shelter belts causes buffeting of crops and increases transpiration and evaporation losses leading to poorer yields. The few shelter belts seen add considerably to the owners' incomes when they are cut down for timber every 8-10 years.

viii. Extension Service

As has already been mentioned there is already available a good deal of research data on new crops, new varieties, use of fertilisers etc, but this knowledge is not being disseminated to the farming community because of the lack of an efficient qualified
and effective extension service resident amongst the community which would go out
into the field to impart this information to farmers.

ix. Processing and Marketing

since there is a Marketing Consultant already investigating the problems of
processing and marketing it is not necessary to deal with them in this report. It
is however apparent that increased acreages of certain crops, particularly vegetables,
could be grown resulting in higher incomes to farmers if processing facilities and
market outlets existed.
SECTION 5c

TECHNICAL CONSTRAINTS WHICH MAY PREVENT THE FULL BENEFITS OF ADDITIONAL IRRIGATION WATER FROM BEING REALIZED

Practically all the current technical constraints on agricultural production mentioned in Section 5b would prevent the full benefits from additional irrigation water from being realised. It is assumed that the current ground water survey will indicate areas where shallow or deep wells could be dug or drilled and therefore the lack of water will not be treated as a constraint. The constraints discussed under sub titles are set in order of priority.

i. Credit

The major obstacle which would prevent the full benefits of additional irrigation water from being realised will be the availability of capital to farmers to dig shallow wells and equip them with pumps and engines. Facilities for the supply of loans repayable over a reasonable period of years should be made available to landowners and farmers who have land in areas where the ground water survey has indicated that adequate water at shallow levels exists.

It would appear that a very large amount of capital will be required for the drilling of deep boreholes and equipping them with submersible pumps and suitable engines. Enquiries made suggest that the cost of a completed borehole at depths in excess of 100 metres drilled partly through rock may be of the order of YR 200,000 per site. Depending on such variable factors as output from the well, period of pumping, method of water distribution, irrigation frequency and water demand by the crops grown, this well may be able to irrigate between 20 and 40 hectares of land. The initial capital investment would be between YR 10,000 and YR 5,000 per hectare and the variable costs of operating these pumps would also be high. Without grant aid only very high value cash crops are likely to justify this size of investment and high operating costs. Before large amounts of capital are invested a study of the costs and returns and probable net farm incomes from operating such units should be made.

ii. Agricultural Research and Extension

Lack of information on new crops and higher yielding varieties suitable to the area, crop husbandry methods and techniques including cultivations, planting distances and times of sowing, rates of fertiliser use, pest and weed control, irrigation frequency, method of application and amounts required are all factors which need investigation. The absence of reliable factual information based on the results of applied agronomic research on the above topics as applicable to the Montane Plains could prove to be a major constraint in increasing agricultural production. Even when this knowledge becomes available there is no advisory or extension service which could convey the information obtained by research workers to the farmer in the field.
iii. Labour, Animal Power and Farm Mechanization

The shortage of labour to cope with increased areas under cultivation and the lack of mechanized agricultural aids in such operations as harvesting and winnowing are likely to be major constraints. Lack of knowledge of the use of correctly matched tractors and implements is also a difficulty. If more irrigation water becomes available the present animal power would not be able to cope with the increased demand. Higher standards of animal nutrition and investigations into suitable animal drawn implements and harnessing would be required. The absence of mechanics trained to service pumps and engines and living in the agricultural areas would also be a limiting factor in cases of pump breakdown.

iv. Land Tenure

The present system of division of crop output may prove to be an obstacle to increased agricultural production. The division of the crop between landlord and tenant whether on a 3rd or 6ths or on a 50:50 basis needs to be clearly understood. Any tenancy agreement which places the burden of all the costs of increased agricultural inputs on to the tenant without a corresponding share of the costs being borne by the landlord would be a disincentive to increased production and a serious limiting factor in the exploitation of potential additional irrigation water.

v. Size and Fragmentation of Holdings

The problem of small size holdings and management of split blocks of land and the time wasted in travel between them could become more acute if more irrigation water became available.

vi. Shelter Belts

With the introduction of new and perhaps more delicate crops the absence of shelter belts may cause more acute problems. These shelter belts of suitable quick growing trees could in themselves provide a useful return to the farmer in building timber and fuel.

vii. Processing and Marketing

If additional irrigation water becomes available and improved husbandry methods adopted the extra output of crops currently being grown and the introduction of any new crops may prove a strain on the processing and marketing arrangements currently in force. An increase in the supply of a particular crop because of more water and acreages under irrigation may upset the current price structures. This section is being dealt with by the Marketing Consultant with whom consultations have been made on this and other points closely associated with the effect of introductions of new crops etc.
GUIDELINES FOR IMPROVING AGRICULTURAL PRODUCTION - MONTAGE PLAINS

The agriculture of the Montage Plains may be classified into two separate areas, namely rain-fed and pump irrigated land and the problems of increasing production in these areas are quite distinct.

i. Rain-fed Land

In years of adequate rainfall, rain-fed land contributes the major part of the cereal production of the area. This land is watered by rain falling either directly on to the large central portions of the Plains or indirectly by rain on the low hills and lava outcrops being led on to the surrounding cultivable areas.

The level of agricultural production depends almost entirely on the amount of moisture the soil has received. In lean years inadequate moisture is the major limiting factor to increased yields and no other additional inputs are likely to have any appreciable effect on increasing yields. Under such conditions local varieties have become adapted to the environmental conditions through centuries of cultivation and natural selection.

Testing and multiplication of better yielding strains selected from within existing local varieties may improve the yield potential but this is a long term process and is unlikely to lead to an immediate increase in productivity. Seed dressings against smut and other seed-borne diseases will reduce losses in yield and better care and storage of seed grain will improve germination percentage. The application of artificial fertilizers is not likely to give an economic response in terms of increased yield against the increased costs of such extra inputs when soil moisture shortage is the major limiting factor.

Testing of introduced varieties of wheat, barley, sorghum and lucerne can be attempted but the inadequacy of soil moisture in most years will probably limit the yields to the level of the local varieties.

Trials with drought resistant forage grasses could be made in an attempt to improve the quality and quantity of grazing in marginal land surrounding the cultivated areas. It may be possible to introduce suitable tree species which would survive the local conditions after initial establishment to provide wind breaks and shelter belts.

However it is considered that in general the scope for increasing agricultural production from these rain-fed areas is extremely limited.
Prop Irrigated Land

It is estimated that between 2,000 and 2,500 hectares of land could be irrigated from wells currently in production and this area could be increased if the present hydrogeological survey reveals the existence of more water from deeper aquifers (but see Section 5c on constraints). The output from these areas could be increased considerably by the use of inputs such as fertilisers, pesticides, improved water distribution and application rates, reduced water transmission losses, improved weed control, use of mechanization, better seed rates and crop spacing, optimum times of sowing, better rotations and the introduction of higher yielding varieties of crops and new crops.

New Varieties

Under lift irrigation local varieties of the major crops do not appear to possess the yield potential to provide an economic return when the costs of lifting and distributing irrigation water are taken into account. Experiments carried out at Shoub Farm and by FAO show that certain imported wheat, sorghum, maize and potato varieties produce a far greater yield than the local varieties when grown under improved crop husbandry practices. No information is available on imported barley or lucerne varieties at present. Research workers in Saudi Arabia under less favourable conditions have obtained annual forage dry matter yields from lucerne of over 30 tonnes/ha from 12 cuts under good fertiliser and irrigation management. Local varieties do not appear to be able to yield anything approaching this level of production.

The use of higher yielding varieties would satisfy the farmers own requirements for grains, fodder and forage on a smaller acreage of land thus releasing more acreage for cash crops or alternatively would allow them to grow more cereals and sell surplus grain production for cash.

New Crops

The climatic conditions in the Montane Plains are suitable for the Summer production of a wide range of temperate fruit and vegetable crops. Problems of market outlets or processing facilities have already been referred to and these would limit the range of crops which could be economically grown. Many of these crops would require testing under local conditions before firm recommendations could be made.

The list of vegetables which could be grown is a long one and some of these already grow well in the area. Under improved crop husbandry techniques they could yield both quantitatively and qualitatively far better than at present. The list includes beans, peas, beetroot, brussel sprouts, cabbage and cauliflower (both Summer and Winter varieties) carrots, celery, lettuce, cucumber, leeks, onions, radish, spinach and tomatoes. In view of the limited local demand any increased production would have to be exported. Because of the perishable nature of most of these crops and competition
from other countries in the Northern latitudes there would appear to be very little prospect in securing such an export trade. The future for increased vegetable production in excess of the small local demand is poor.

The Summer production of groundnuts would link in well with the Winter production in the Tihamas giving a twice yearly cropping sequence. Trials have been carried out on the production of sugar beet in the Montane Plains and yields were said to be "extraordinary". In the harvesting season, October to November, there would certainly be no problems of lifting under muddy conditions as often happens during wet Autumn in Northern Europe. Sugar beet tops would form a useful supplementary food for cattle and the by-product from the refining process, sugar beet pulp, is also a most useful concentrate ration for livestock. The introduction of a sugar beet enterprise into the local farming system would however be a slow task. Assuming that 100 hectares could be grown in the first year or so it is estimated that this acreage would produce about 3600 tonnes of beet which after refining would yield 300 tonnes of sugar. A processing plant would have to be provided and with these small quantities it would be doubtful if such a plant could be justified. The economics of growing such a crop would have to be carefully and fully investigated before consideration could be given to the installation of even a small refinery.

The production of soya beans could be a potentially high value cash crop with export possibilities. Its cultivation is simple and the crop may be harvested in 2-3 months from sowing. It may therefore be used as a quick catch crop or successively cropped during the Summer.

The climate would appear suitable for the production of citrus and deciduous fruit tree crops such as peaches, plums, apricots, pears, apples and cherries and other trees such as almonds, walnuts, fig and olives. These crops require of course a long term investment and a high working capital charge before they begin to produce returns. They may not therefore command favour with the farming community. However this charge could be reduced by inter row cropping with vegetables and lucerne in the early years. Soft fruits such as currants and strawberries may also be under-cropped.

New Inputs and Practices

Whether new crops or new varieties of existing crops are introduced they will demand far higher standards of crop husbandry and higher agricultural inputs before their full yield potential can be expressed. Times of sowing, plant density, water demand, fertiliser rates, pest and weed control and crop rotations will all have to be at an optimum level. When introducing new crops or new varieties the complete package deal of crop husbandry methods and techniques and input requirements must be communicated to farmers otherwise there will be disappointing results.

Times of sowing and plant densities are haphazard at the moment and optima have to be determined. Water distribution and methods of application are wasteful and must be
improved. Because of their present high cost doubts have been expressed regarding the use of imported fertilisers but lack of adequate soil nutrients can ruin the results of other increased inputs. It is firmly believed from past experience that used in optimum amounts the application of fertilisers can produce economic returns. Although not a serious problem at the moment, pests and diseases must be controlled by plant and seed hygiene and the judicious use of pesticides. Weed competition in many pump irrigated areas is increasing leading to reduced crop yields and hand weeding methods should be improved. The use of herbicides in weed control in an unsophisticated farming community is fraught with danger and their widespread use is not recommended at present. Farmers already appreciate the value of rotations in improving yields, reducing pests etc and the introduction of new crops may be beneficial in widening the rotation.

The quality of some crops suffers because no attention is paid to safeguarding the produce from damage. The cultivation of tomatoes is a prime example. No staking of plants or removal of side shoots is practised with the result that the small multi-branch cutting rest on the ground and in the water allowing entry of pests and disease and the production of poor quality fruit.

The use of seed dressings to control pests and disease should be encouraged with adequate warnings that dressed seed should not be used for human consumption.

The use (or misuse) of irrigation water is appalling and has been referred to several times before. Lined channels to reduce seepage losses and better alignment of water channels to reduce the distance the water flows would conserve water and reduce costs and permit increased acreages to be irrigated from existing wells. Furrow or smaller irrigation basins would increase efficient water application and an increase in the number of waterings would increase yields provided other inputs were at a satisfactory level.

The planting of shelter belts is necessary in most situations to reduce wind velocity and decrease leaf damage to sensitive crops.
SECTION 5e

RESEARCH INTO MAJOR AGRONOMIC PROBLEMS

It is apparent that Section 5d has highlighted the lack of precise knowledge of the performance of crops under local conditions and the necessity for the investigation of several problems which can only be solved through systematic research.

These problems are:

1. Can yields of rainfed crops be improved either by the introduction of new varieties or by selection within the existing population?

2. Can yields of irrigated crops be improved by the introduction of new, higher yielding varieties?

3. What new crops can be introduced into the existing farming system which could provide economic returns to the farming community?

4. Is the use of artificial fertilisers economically justified? If so, what are the optimum application rates for each of the crops grown?

5. What pest and disease control measures can be introduced?

6. What are the optimum times of sowing and plant densities for maximum economic performance of crops grown under irrigation?

7. Can herbicides be introduced into the area and what hazards may be expected from their use?

8. What rates and frequencies of application of water are needed for optimum economic crop production?

9. Is deep ploughing really necessary? What other tools, small implements and machines can be introduced into the farming scene?

10. The biggest problem of all is - how can the results of research work be communicated in the most efficient way to the farmers in the field? There are no qualified extension and advisory personnel resident amongst farmers in the area and there is no experimental farm where results of research work can be demonstrated.
PROPOSALS FOR A RESEARCH PROGRAMME AND UK STAFF REQUIREMENTS

The previous section defines the major problems which influence economic agricultural production. It is considered that the Montane Plains area does not have at the moment a high potential for a great increase in agricultural production. Market outlets are few and constraints are many but some increase in production and in productivity can be achieved when more factual information is gained through research.

The problems already described would form the basis for a research programme. This would not require the expenditure of vast sums of money nor warrant the services of many UK staff. It is considered to be of prime importance that any research programme should be initiated during the life of the present project so that there is no vacuum between the end of this and the start of any new project. Already some murmurings of discontent from people living in the two areas have been overheard regarding the number of project staff circulating in the area when very little can be seen to be happening on the ground. This is inevitable in the type of survey that this project is carrying out but if HMG wishes to implement a follow-up programme it is essential that this should get off the ground quickly.

It is for this reason that it is suggested that a basic research team be engaged and operating in the field by mid 1975 with sufficient funds to allow it to commence a research programme.

When the feasibility of further exploiting the soil and water resources of the area is known, the research team could be expanded if the situation so demands.

In the first instance a plot of land with a good well is proposed for the Dhamar area. This area has several advantages — good local communications, it is the centre of the Governorate of the area, it is fairly centrally situated between the North and South extremities of the area and it contains a fairly high proportion of the wells in the plains.

An area of 10 hectares with a well capable of producing at least 28,000 litres per hour is required. A pump and engine have to be installed; stores and office accommodation provided; tools, implements, agricultural supplies purchased and accommodation for expatriates arranged. Staff to run the farm and counterpart staff, clerks and supervisors can be engaged locally.

One agronomist would be needed initially to start research work on the major agricultural crop with minor work into fruit and vegetables.

One extension worker would be required who could set up a portion of the research farm for demonstration purposes and arrange for demonstration plots at farms in the Mabar and Yerim areas.
Enquiries made suggest that there would be no difficulty in obtaining land on a 5 or more year lease for the central experimental and demonstration farm and farmers in Qitab and Mabar areas have intimated that they would be willing to allow portions of their farms to be used for demonstration purposes.

As results of research work begin to emerge and provided that the present survey indicates the availability of large underground water resources a second agronomist specialising in fruit and vegetables could be appointed. The research and demonstration work could then be intensified including the training of local staff. It is emphasised that a second agronomist would be needed only if more ground water becomes available.

Much research work on some crops has already been carried out in the Yemen and the results of this could be tested for a year under local conditions thus short circuiting the usual period for research work. If results agree with previous work they could be demonstrated in the field by the extension team very quickly.

Examples of this are the work already done by the FAO Sorghum Specialist in the screening of varieties likely to be successful in the area and the work of the West German Technical Assistance team on wheat, maize, potatoes, the use of fertilisers etc. However, much primary research work still needs to be initiated particularly for the other crops already described in the foregoing section.

Summarising this section it is proposed that:-

a. A research programme be initiated to investigate the problems posed in Section 5a paying particular attention to the husbandry of cereals and potatoes in the first instance.

b. The appointment of one agronomist and one extension worker be made as soon as possible preferably by June 1975.

c. An experimental/demonstration farm to be established in the Dhamar area.

d. Demonstration plots to be arranged in the Ma'bar and Yarim areas.

e. The research and demonstration programme to be intensified by the appointment of a second agronomist in 1976 provided only that the current survey clearly indicates such a need.

This is not a large UK Staff requirement nor a tremendously ambitious programme of research. The current soil and water survey should be able to indicate by 1976 whether there is a potential for the economic exploitation of these resources in the Montane Plains area. The Consultant considers that there is not likely to be a vast underground source of water which can be exploited in this area and any