CULTIVATION PRACTICES FOR GROUNDNUT PRODUCTION IN INDIA

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1 INTRODUCTIC

There are no readymade formulae that one can apply over large areas to obtain a quantum yield jump over large areas from the current National average of 800 kg ha^{-1} pods of groundnut pods to the yields of the order reported from ICRISAT. (4-5 t ha^{-1} in Kharif and 6-8 t ha^{-1} in Rabi). However, by reducing the gap between the "research" management and the farmer's cultivation practices, and through well planned extension activities groundnut production can be increased substantially over large areas of the country.

Some farmers in India are already achieving up to 70% of the yield levels reported above, but they are too few to make an impact on the overall groundnut production in India. On the other hand, if a majority of farmers were to produce only slightly more than they do at present, then the impact on the National production would be significant. This is what we should aim for. At the current market prices, a good crop of groundnut can compete with any of the other cash crops, e.g., cotton or sugarcane. So an incentive for adopting a moderate input technology exists. In fact, our experience during Kharif 1987 shows that farmers with resources are willing to invest in the inputs necessary for obtaining a good groundnut crop, provided the returns are assured.

Effective demonstration is the best way to transfer any technology, for, "seeing is believing". The Government of India, ICRISAT, State Agriculture Departments and Oil Seeds Growers Federations (Farmers Co-op Societies) are collaborating in setting up such demonstrations. Kharif 1987 was the first season when demonstrations were laid out in five major groundnut growing States of India, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and Orissa.

ICRISAT has provided a generalised package of cultivation practices that helps to give 3 to 5 fold increase over the current yields of kg ha^{-1}. This package was originally evolved for rabi cultivation but was modified and tested for the first time in the 1987 Kharif season. The package of cultivation practices was based on data from experiments carried out in various parts of the world, on our experience at ICRISAT, on results of AICORPO experiments, and incorporates the expert opinion of ICRISAT specialists, breeders, physiologists, agronomists, plant protectionists and soil chemists. We are hopeful that it will be possible to raise groundnut production from the current 800 kg ha^{-1} in the Kharif to 1700 kg ha and from the current 1500 kg ha^{-1} in the Rabi to 2500 kg ha^{-1} over large areas during the next few years, by adopting a cost effective technology based on constraint analysis. Our experience shows that this could be done for only a small increase in the current cost of cultivation cost.

The present report is based on the expertise of several scientists at ICRISAT, and the limited experience gained from 1987 Kharif season trials. Obviously, this report is not complete because we are still learning and investigating about various components of groundnut production, and effective modes of transfer of technology.

2. COMPONENTS OF HIGH AND STABLE YIELDS

High yields of groundnut depend upon two factors, the genetic potential of the variety, and the provision of production technology suitable for realising at least some of this potential.

Groundnut varieties come in all "shapes and sizes", but the point of interest in the Indian context is the differences between "Virginia" and "Spanish" and "Valencia" groups of groundnuts. The virginia groundnuts have high yield potential, but require, a longer duration of 130–200 days to realise this potential. So if we allow virginia varieties, e.g. M 13, to mature fully (150–180 days), the yield levels accrued could be very high. The very high yields reported from Zimbabwe, the USA and Israel are from virginia runner varieties. In India, about 50% of Kharif groundnut is grown to runner varieties e.g Punjab 1, M 13, Karad 4–11.

Most spanish varieties are of shorter duration (95–110 days). They have determinate growth habit, a limited flowering period, fewer branches and larger leaves than virginia varieties and have pale green foliage. They lack seed-dormancy. Their yield potential is limited, and unless we have high plant populations and provide key inputs, yields from these varieties will be low. Almost the entire Rabi crop is comprised of spanish varieties, e.g. TMV 2. and because traditional cultivation practices are used, the yields, although better than those in the Kharif are low; Ca 1500 kg ha^{-1}.

For stability of yield, good crop husbandary is of prime importance. Soil management (structure, nutrition), water management, and management of diseases, pests and weeds are some of the components of good agronomy.

The effective crop growing period, in both Kharif and Rabi seasons is relatively short in India. The Kharif season starts in late June and ends in October. Temperatures range between 30 and 35 ^{o}C during this period, and are not restricting, (threshold temperature 10 C), the rainfall (amount and distribution) is a crucial factor. With such a short growing season (about 90-100 days), unless we practice good agronomy, the yields will be low. These practices are - (1) supplementary irrigation (2) high soil fertility (3) high plant density and uniform distribution of plants (4) optimum sowing date, (5) protection from excess water or scant water, (6) protection from weeds, and (7) protection from leaf loss (pests, diseases). With protective irrigation, a yield of 2-3 t ha^{-1} of dry pods is easily achievable from the existing varieties in the Kharif season. The underlying principle is to raise groundnut under irrigation and consider rains as supplementary to the irrigation.

In the Rabi season, short duration (110-130 days) virginia or spanish bunch varieties e.g. ICGS 11, ICGS 44, Kadiri-3, are more suitable than the currently grown bunch varieties because of their high yield potential. In this season, water supply, weed and insect pest management are important. Farmers invest more in Rabi crops than in Kharif crops because of assured yields from the former.

3. SOILS

Groundnuts are grown in India on all sorts of soils ranging from very clayey vertisols to sandy soils. Generally, any type of soil having pH of 6.5-7.0, high fertility, good moisture retention capacity and good drainage can be used for groundnut cultivation. However, fertile sandy loams, light alfisols, and well drained vertisols that are well supplied with calcium and a moderate amount of organic matter are ideal. Our best yields in the 1987 Kharif trials are from fine textured vertisols that are rich in organic matter and phosphates, and when the crop received two protective irrigations.

Nutritional requirements of the groundnut crop are given in Table 1. It is essential to determine the fertility status of individual soils. Generalised recommendations for fertilizer application are of little help. Fortunately, soil analysis facilities are available throughout India, and should be fully utilised. Our own soil analysis (Table 2) of a limited number of sites has shown that most soils had salt content ranging from 0.1-0.5 m.mhos/cm against an upper threshold of 1.0. When salt content is low, particularly, that of sodium, even the high soil pH, i.e. above 8.5, may not be directly harmful to the plants. However, both very high and very low pH cause secondary problems of nutrition availability and should be avoided. The optimum pH for groundnut is 6.5 to 7.2. The range of low pH that we observed was 5.3 to 5.7 in parts of Orissa (Sukinda area), Tamil Nadu (Neyveli area) and Karnataka (Bangalore area) (Table 2). Such low pH coupled with high aluminium and manganese contents, e.g., in Neyveli, may create toxicity problems. Liming is essential to raise the pH of such soils. By mixing finely-ground dolomite (lime) @ 5 t ha^{-1}, we could raise the pH from 5.7 to 7.0 in Karnataka, 5.55 to 5.81 in Orissa and 5.28 to 6.64 in Tamil Nadu. Our experience indicates that liming of acidic soils is beneficial to the crop.

At Sukinda (Orissa State), where soil pH was raised from 5.50 to 5.81 by aplication of lime, the number of pods per plant in the limed plot was substantially higher than that in unlimed plot. The limed plot had less electric conductivity (0.11 against 0.15 in unlimed plot), lower Zn concentration (0.84 ppm against 1.14 ppm), lower Fe concentration (35 ppm against 50-86 ppm) but there was no apparent effect on Mn concentration (52.8 ppm against 39.4-50.4 ppm). At Neyveli (Tamil Nadu State) mixing of finely-ground dolomite to acidic soils just before seed bed preparation resulted in a change of pH from 5.48 to 6.48 within a period of one month. It is customary and convenient to apply lime 2-3 months before sowing, however, our results indicate that if dolomite is finely powdered and if soils are moist, and temperatures high, the pH can be raised in a shorter period of time. It is, however, convenient to apply lime during land preparation. pH beyond 8.5 may not directly harm the plants unless salt concentration is also high (> 1.6 OC, normal <1.0). However, at high pH most micronutrients except Boron become unavailable. Iron chlorosis is a wide-spread problem in many soils e.g. alfisols at Gadwal, (Mahboobnagar District, Andhra Pradesh, pH 8.6) and Koppal (Raichur District, Karnataka State, pH 8.25) and in vertisols (Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu)(pH range 8.05-8.63). We do not know of any cheap and effective method to reduce the soil pH, but leaching of salts through proper drainage, incorporating FYM into the soil, and use of ammonium sulphate and gypsum will lower the pH.

The field that is selected for groundnut must have a fairly steep slope (0.8 to 2%) in at least one direction. This is a necessity for black clayey soils where prolonged water stagnation is of frequent ocurrence, making Kharif crop cultivation an impossible task. The best way to grow groundnut on such soils is to prepare raised beds with frequent drainage channels. In Maharashtra, at several locations, the growth of groundnut plants, root development, pod size and number of pods per plant on raised beds was much better than that on flat lands. Merely having a good overall slope will not suffice; the field must be graded properly to avoid undulations which will hamper the smooth run off of excess water.

Low moisture holding capacity of the soil, quick drying and crust formation were problems in the lateritic soils of Tamil Nadu, Andhra Pradesh, Maharashtra and Karnataka. The hardness of soil physically restrict the full development of pods as was the case in lateritic soils in Tamil Nadu and in very clayey soils in Maharashtra. Addition of FYM can considerably reduce these problems. Usually 20 t/ha of FYM should be recommended. Even for black soils, FYM is essential because its application will improve the porocity and structure of the soil and make it less "sticky". It also provides most micronutrients. Addition of FYM should be a general recommendation.

FYM, besides cowdung, contains stubbles, stalks and other crop residues. Stubbles and crops residues may be conducive to the growth of pathogenic fungi e.g Sclerotium rolfsii that cause seedling mortality. Spreading FYM in a thin layer making it moist and covering it with thin polythene sheet for a period of one month in the hot sun, may induce slow, "moist" heating of FYM and thus kill most of the harmful organisms. This "solarization" needs to be experimented with.

In many villages, biogas plants have become common. The cowdung slurry is a rich source of organic matter. In parts of Maharashtra, (Sangli-Satara-Kolhapur districts), farmers add single superphosphate to the slurry before it is applied to the field. The advantages or other-wise of this practice are not fully known and merit investigation.

Under the present context of impoverished soils, there can not be a substitute to adding FYM to soils. FYM has several beneficial effects, on light and also on heavy soils, by improving soil structure and buffering capacity, water holding capacity, availability of micronutrients and adding some nitrogen. However, FYM is difficult to obtain. An alternative to FYM is to practice green manuring with crops like sannhemp, dhaincha and other legumes or by sheep penning.

LAND PREPARATION

The final seed bed should be fine-textured. After the first deep ploughing and 2-3 light ploughings, FYM should be mixed in the the soil, followed by harrowings. Before final preparation, all stubble, stones etc. should be removed. It is essential to remove stubbles and crop debris because they harbour pathogenic fungi such as Sclerotium rolfsii that later on may cause collar rot or root rot (see diseases section). After cleaning up the field, one or two harrowings should be given.

FERTILIZERS/SOIL AMENDMENTS

Analysis of soils from a limited number of sites have shown that most are deficient in phosphorus and potash, and some in iron and Zinc

(Table 2). Potash was found deficient in parts of Karnataka, Andhra Pradesh, Orissa, and Tamil Nadu, but not in Maharashtra. A dose of 50–100 kg of Muriate of potash (K=48%) (Table 3) just before the final seed-bed preparation may be advantageous in these areas. However, response to potash has been erratic. So a general recommendation may be wasteful in individual cases. The plants grown on deficient soils express symptoms of potash deficiency on the older leaves; the margins of leaflets start yellowing. This is usually followed by interveinal chlorosis and finally necrosis of the leaves, beginning at the margins and proceeding inwards until the leaf falls off. The youngest leaves are least affected. In Maharashtra, the potash is usually adequate, but we came across a field where potassium deficiency was acute. This highlights the importance of soil testing of individual fields.

Soils in parts of Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra are deficient in phosphorus. The plants grown on soils with accute phosphorus deficiency show severe stunting, leaf curl, and pink or voilet veination (from accumulation of anthocyanin pigements) on the stems and undersides of leaves. Such symptoms were noticed in Anantapur and Kurnool Districts of Andhra Pradesh. The plants however, recover when roots go deep and tap more soil. Mild symptoms of Phosphorus deficiency are expressed as greener than normal leaves and stunting of plants e.g. at Guledhalli (Karnataka State). Phosphorus when applied as superphosphate starts becoming available within 15–20 days after application if the soils are moist. The best availability of phosphorus is at pH 6.5. Soils should receive phosphatic fertilisers each year to build up the phosphate level. A dose of 200–400 kg ha^{-1} single superphosphate may be required. Soils having less than 10 ppm P by Olsen's method should receive phosphatic fertilisers. This should be mixed with soil just before the final land preparation. Alternatively, it can be applied in seed furrows before sowing. Single super phosphate is a mixture of Ca phosphate and Ca sulphate and is preferable over di-ammonium phosphate as a source of P because it will provide Ca and S also. Our experience shows that most crops in Maharashtra respond to phosphorus application. It is likely that the doze of phosphorus will have to be increased at least by 2 fold over the current doze of 40 kg P2 05. The reason for the popularity of DAP as a source of P is because it is available in granular form and So is easy to apply. Superphosphate should also be formulated in granular form.

Nitrogen is generally not given if the soils have been planted to groundnuts before. This is because native Rhizobia produce adequate nodulation and nitrogen fixation. If groundnuts were not grown previously, or if the preceeding crop was not fertilised, an initial application of nitrogen (10-20 kg N ha) can be beneficial. Ammonium sulphate is a better source of nitrogen than urea because it also supplies sulphur to plants. Nitrogen application may be necessary in the acidic soils of Tamil Nadu and Orissa where functioning of rhizobia may be hampered. Liming of acidic soils will improve the nodulation. To ensure good nitrogen supply, waterlogging should be avoided. In well drained soils, oxygen is available to roots for respiration. This improves the ability of roots to absorb nitrogen from soil, and for rhizobia to fix more nitrogen.

Generally, Zn is not deficient. However, soils in parts of Karnataka (Raichur District) and Andhra Pradesh (Mahabubnagar

District) are deficient in Zn (Table 2). Application of 10 kg ha Zn SO4 (commercial) resulted in increase of Zinc content from 0.8 ppm to 4.31 at Neyveli (acidic soil), from 0.8 ppm to 2.52 at Musaravakkam in Tamil Nadu, and 0.44 ppm to 0.96 at R.K.Shala in Karnataka(Table 4). Usual practice at ICRISAT is to apply 30 kg ha Zn SO4 once in every 3 years. In acidic soils, e.g., in Orissa, Zinc deficiency is not a problem.

Boron deficiency has been indicated as a problem in Maharashtra (Dhule district) and use of boronated phosphate is being tested. The results indicate that a response to boron application has been obtained from light vertisols at a few places. The boron deficiency problem needs to be studied carefully. Boron deficiency causes a "hollow heart' condition in kernels. It will be worthwhile to study whether this condition can be eliminated by boron application. However, varietal character e.g. in JL 24 in which, there are large hallow grooves in cotyledons, should not be confused with boron deficiency. The critical level of Boron in soils has been estimated at 0.15 ppm - 0.20 ppm by hot water Soluble method in Calcareous soils. In acidic soils Boron may not be deficient. Whenever B additions are needed, 0.5 to 0.75 kg ha^{-1} is adequate. Higher doze beyond 2 kg ha^{1} may be toxic.

There is very little information on Molybdenum (Mo) requirements in groundnut and characteristic symptoms of Mo deficiency have not been described, perhaps, becsuse most soils have high pH. Mo is perhaps, the most "micro" of the micronutrients. However, Mo is essential for Rhizobia to function properly. When Mo is deficient, the bacteria cannot fix sufficient N for the plant which then shows symptoms of nitrogen deficiency. Mo becomes unavailable in acidic soils. Liming increases the availability of Mo. Therefore, for acidic soils, liming should be recommended. This coupled with application of Mo will ensure its proper availability. Fertilisation with Mo is inexpensive and easy and therefore should be viewed as a means of ensuring adequate N fixation for the crop. Twenty five grams of Sodium molybdate (Na_2MoO_4) is adequate for one ha.

Manganese appears to be adequate in most soils, however, in acidic soils of Orissa and Tamil Nadu, toxicity may result from excess of this element. However, we have not observed the typical symptoms of manganese toxicity i.e. brown spots on leaf margin, delayed flowering and maturity and impaired fruit development. Manganese deficiency does not seem to be a common problem. However, more detailed studies are required.

6.SEED BED

We have mentioned the problem of chlorosis resulting from water stagnation. This problem is acute in heavy and also in light soils with high pH, e.g., in Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Groundnut is very sensitive to water-logging and this must be avoided. Traditionally, groundnut is grown on flat land without proper gradation and slope and the problem of water logging becomes severe. To overcome this, a broad-bed and furrow (BBF) system is suggested. (Fig 1). The raised beds should be 1.2 m wide and 15 cm high and with two furrows of 30 cm width on either side to drain out excess of water. This width of the raised bed will accommodate 4 rows of groundnut at 30 cm distance between row. The Kharif 1987 trials have indicated that growth of groundnut on raised beds was more vigorous, the leaf size larger and the foilage greener than crops raised on flat beds. The groundnut plots of ICG(FDRS) 10 sown on raised beds and on the flat in adjacent plots at Guledhalli (Karnataka) and Teosa (Maharashtra) or of ICG FDRS 10 and ICGS 11 at Dhule in Maharashtra, clearly showed the differences in growth and foliage colour. With the same row and plant spacing of 30 x 10 cm, the crop on raised beds achieved complete canopy cover by the 30th day after emergence but on flat land, growth was less than normal. The crops grown on BBF showed good root development and thus suffered less from deficiencies. This was clearly seen at Nardane and other places in Maharashtra where the crop on flat land showed acute potash deficiency and general yellowing of foliage. The crop on raised bed showed excellent root growth and nodulation, vigorous plant growth, and greener foliage. The difference in root growth were spectacular.

Good uniform growth and close canopy also reduces the bud necrosis disease problem. Raising groundnut on broad beds reduces the weed problem. Crops on BBF are more amenable to the use of the soil-digger for harvesting than were those on flat beds. It was the opinion of several farmers that even the manual lifting of groundnut was easier on BBF than on flat beds and fewer pods were left in the ground in BBF system. BBF should be recommended for all soils, and particularly for clayey soils in high rainfall areas.

The BBF system needs a graded slope of land, 0.8-2.0%. The BBF then could be formed across the slope. The furrows should lead to a main drain at the end of the field.

We have been using a BBF system, that accommodates 4 rows of groundnut spaced at 30 cm interval on each bed, giving a plant population of approximately 260,000 plants ha^{-1} (Fig 1). The seed rate required is about 100-120 kg ha^{-1} depending on seed size and the variety sown. The current bed formers available at some farms are not suitable because they open furrows that are 45 cm wide. This is wasteful. This furrow should not be more than 30 cm wide. ICRISAT has developed a bullock-drawn wheeled tool-carrier for making raised beds and furrows. This can be suitably modified to fit into a variety of farming operations in India. However, this implement is expensive (Rs.15000). A simple bullock-drawn implement for making broad bed and furrow, consisting of a pair of ridgers attached to a wooden plank has been developed at ICRISAT (Fig 2). Efforts are underway to attach a row-marker to the above implement so that the formation broad bed and furrows, and row marking on the bed can be done simultaneously. This implement will cost around Rs.500-600.

Most farmers in India sow groundnut with a local seed-drill having three tynes. The BBF system with three rows spaced at 30 cm on a raised bed of 1 m width and furrows formed at 1.2 m interval would be easily adopted by farmers because of ease and experience of sowing with the three tyned seed drill. From our experience, this system should be as productive as 4 row system. Such a system will be ideally suited to soils that are hard, narrower beds means better lateral movement of water to reach the central row. Experiements are now in progress to study their effectiveness.

7. SEED

Seed is the costliest input in groundnut cultivation, and the utmost care should be taken to use good quality seed. Farmers must be taught to save and use their own seed. The common belief that seed obtained from elsewhere gives better results than that of their own seed is probably not true. The suspicion about rapid gentic deterioration of a variety e.g JL 24 is also not true. The last section of this report on harvesting and drying gives procedures that will help farmers to make good use of their own seed. Irrespective of the seed source, it is essential to test the seed viability just before sowing. Seeds that look apparently healthy may be affected by fungi and so be non-viable (Table 6). Soaking the seed overnight in water and then putting them in a moist cloth bag for 2-3 days will give an indication of their germination ability. Most housewives routinely do this for chickpea, moong beans and moth beans.

Even when 100% germination is observed, allowance will have to be made for soil factors that can reduce emergence. Deep sowing, testa damage during seed dressing and sowing, damage from soil insects/birds and soil pathogens may cause a loss of 5-10% of seed. Increasing seed rate by about 10% over and above the recommended rate will ensure optimum plant density.

It is essential to carry out the germination test a few days or just before sowing. The results of germination test carried out 2-3 months before sowing may not be applicable at the time of sowing, and thus result in erroneous estimates of seed rate.

8.SEED DRESSING

It is now generally accepted in India that seed dressing is a must. Our data show that contamination of seed with pathogenic fungi can reduce germination although the seed may look healthy (Table 6). Most Co-operative Societies and Government agencies give a packet of Thiram along with seed. However, we noticed a serious quality problem with thiram. The thiram from parts of Maharashtra and Tamil Nadu was not finely powdered, and so did not stick to the seed coat. Normally, when finely powdered thiram is used, an application of 2.5-3 g kg^{-1} of seed is adequate. However, at many places the thiram was substandard and contained 40-45% active chemical instead of 75% that was mentioned on the label. Under such circumstances, a mere increase in dosage will not solve the problem because application of powder over and above 3 g kg^{-1} seed does not improve the coating on seed and is wasteful. Mercurial fungicides such as agrosan should not be used because they may increase the incidence and severity of some seedling diseases. Although we have no evidence on the usefulness of seed dressing with insecticides, this has been a common practice in African countries and fungicide-insecticide seed-dressings, e.g thiram-T, were available. For our purpose, seed dressing with 2.5 g of thiram plus 2 g of lindane dust per kg of seed should be recommended. This will protect seed from soil insects such as ants. The insecticide component may be particularly useful when the conditions for seed germination are unfavourable. Seed dressings should applied just before sowing.

Use of seed-dressing drums made of hard metals can cause damage to seed. It is best way is to use large polythene bags for seed dressing. Usually 5-10 kg seed can be dressed by shaking them with the dressing in the polythene bags for about 1 minute.

9. SOWING

To ensure good emergence and optimum plant spacing, dibbling is best. Until seed-drills that can distribute seeds at a fixed distance are developed, sowing by dibbing should be recommended. A low cost seed drill is being developed at ICRISAT. The sowing depth is critical. Seed placed at 4-6 cm depth resulted in better plant stand and better yields than did seed sown at a depth was 8-10 cm (Table 7). Sowing behind the plough, or by local seed drills, fails to maintain optimum seed-depth resulting in staggered emergence. So dibbling, although expensive, is recommended. The labour should be trained to place seed at a palm's width apart. After sowing, seed should be covered with soil and the soil compacted. Walking women labour along the rows is a good method of compaction. Traditionally, sowing is taken up when soils are moist (vapsa condition as it is called in Maharashtra). After sowing, farmers work the soil with thorny branches of Acacia. This may avoid a problem of crust formation, but proper compaction is not ensured. When sprinklers are used, compaction may not be necessary.

10. SOWING DATES

Groundnut is grown in India throughout the year, so sowing dates are not restricting unless temperatures are below 10 C for prolonged periods. Essentially, two conditions must be met: fairly high temperatures during sowing and the seedling stage (first 25-30 days) and flowering stage (30-45 days) followed by rather lower soil temperatures (around 25 C) during the at pod forming stage. Thus sowing with the first rains in June gives better results than later sowing. Alternatively, sowing in June with 1 or 2 irrigations followed by monsoon rains will increase the numbers of pods per plant and therefore give higher yields. For Rabi season, better results are obtained with October or November sowing than with December sowing at ICRISAT. It was the opinion of the researchers of the Agricultural Universities that November sowing in Maharashtra does not produce a good crop. The low temperatures during December and January were cited as the reason for this. When temperature records from Dhule, Sangli, Kolhapur and Amraoti were checked it became clear that temperatures are not restricting and only rarely did the temperatures declined to 10 C (threshold temperature). Unless there are other factors that affect the growth, it should be possible to sow groundnut in November. Besides ensuring high yields, November sowing has a major advantage. The crops raised from November to March require less water than those raised from late January to May. In the Dhule area of Maharashtra, a few farmers have already resorted to Rabi sowings in November.

A general understanding of growth stages of groundnut and the temperature requirements to complete these will clarify the issues raised above. Table 7 describes the temperature - growth stage relationship.

We have not experimented with rabi-summer (March-April sowing) cultivation.

Early-sown crops in either season perform better than later-sown crops The number of pods per plant is 2-3 times more in June (Kharif) or October (Rabi) sown crops than July or December sown crops. Early-sown crops also largely escape from pests and diseases and from end of season drought in the Kharif season. Early sowing is particularly useful to effect escape from bud necrosis disease. In parts of Tamil Nadu, a period during late September to early October, i.e., between ceasation of the South-west Monsoon and intiation of the North-east Monsoon, is considered safe for harvesting. Early sowing thus allows crops to mature during this period in this area and so avoids harvest problems.

11. APPLICATION OF PESTICIDE WITH SEED

Application of systemic soil insecticides is not a common practice. But our experience from on-farm trials has shown clear benefits from this practice. Carbofuran 3G applied at 1 kg ai ha^{-1} (30-35 kg ha^{-1}) has shown beneficial effects at almost all locations. The important seedling pests are thrips and leafminer. Thrips, Scirtothrips dorsalis caused severe damage to seedlings in Tamil Nadu, Maharashtra and Karnataka and they are already known to be a serious pest in Orissa. Crops treated with carbofuran showed normal growth while untreated plants had stunted growth and distorted foliage from thrips damage. Carbofuran also controlled the leafminer pest in Tamil Nadu and Karnataka for a period of 30 days after sowing. Additional advantages of using soil systemic insecticides may be through the control of soil pests including whitegrubs and nematodes. Nematode problems are not widespread but our data (S.B. Sharma, ICRISAT -

personal communication) shows that they are found in high density in parts of Karnataka and Orissa. Carbofuran-treated plots had lower density of nematodes than had non-treated plots.

Carbofuran is expensive, so it can be substituted with thimet (phorate) 10 G. This should reduce cost without reducing the advantages. Thimet, however, is more toxic to humans than carbofuran.

Carbofuran or Thimet may add to the cost of cultivation by Rs.600-1200 ha^{-1}. Therefore, experiments are necessary to determine the chemical, dose and timing of application of insecticide that will ensure good protection to seedlings. This was practiced at one location with dimethoate @ 200 g ai ha^{-1} which gave encouraging results.

12. **VARIETIES** : This information is taken from AICORPO and was compiled by Dr. P.S. Reddy, NRCG, Junagadh.

Kharif Season

Zone 1 : Northern Zone comprising Uttar Pradesh, Haryana, Bihar, Northern Rajasthan.

Varieties : MH 1, (spanish) MH 2 (Valencia)

BG 1, M 145, M 197, RSB 87, T 28, T 64, G 201 (Semi-spreading)

PG 1, M 13, M 37, M 335, RS 1, Chandra, Chitra (Spreading)

Zone II : Western Zone comprising Gujarat, Southern Rajasthan

Varieties J 11, Gaug 1, GG 2 (Spanish)

	Gaug 10, GG 11 (Spreading)
Zone III	Central Zone comprising Madhya Pradesh, Maharashtra (excluding Sangli, Satara, Kolhapur, Solapur, Osmanabad and Nanded districts)
Varieties	Jyoti, AK 12-24, SB XI, JL 24, TG 17 (Spanish) Gangapuri, Kopergaon 3 (Valencia) TG 1, Kopergaon 1, UF 70-103 (Semi-spreading) Karad 4-11 (Spreading)
Zone IV	South Eastern Zone comprising Orissa, Northern Andhra Pradesh
Varieties	Kisan, Jawan, AK 12-24 (Spanish)
Zone V	Peninsular zone comprising Karnataka, Andhra Pradesh, Southern Maharashtra. TMV 2, ICGS 11, Spanish improved, S 206, Dh 3-30, JL 24, KRG 1, DH 8 (Spanish) Kadiri 2, Kadiri 3 (Semi-spreading) Kadiri 71-1, S 230 (Spreading)
Zone VI	Southern Zone comprising Tamil Nadu, Kerala
Varieties	TMV 2, TMV 5, TMV 7, POL 1, TMV 9, POL 2, TMV 12 JL 24, CO 1, CO 2, ICG FDRS 10, ICG FDRS 4 (Spanish), TMV 11 (valencia)

TMV 1, TMV 3, TMV 10, ICG 2271 (spreading)

In addition to above varieties, ICGS 11 and ICGS 44 have done well in multilocation testing in Kharif season as follows:

ICGS 44 - Tamil Nadu, Orissa

ICGS 11 - Maharashtra, Andhra Pradesh

ICG FDRS 4 - Maharashtra, Andhra Pradesh

ICG FDRS 10 - Maharashtra

Rabi Season Varieties : TG 17 (Maharashtra)

TG 2 (Saurashtra)

TMV 2 (Tamil Nadu, Andhra Pradesh, Karnataka)

AK 12-24 (Madhya Pradesh, Orissa)

J 11 (Gujarat)

SB XI (Maharashtra)

CO 1 (Tamil Nadu)

KRG 1 (Karnataka)

ICGS 11 Peninsular India

ICGS 44 Peninsular India

ICG 21 (Maharashtra)

ICG 2271 (Tamil Nadu)

13. WEED MANAGEMENT

Weed control is essential for good yields of groundnut. Although almost all farmers are aware of this, high labour costs of manual weeding and problems of labour availability often result in only a partial control of weeds. In black soils weeds often overwhelm the crop. Usually 3-5 hand-weedings are required. It appears that there is no substitute for using herbicides. At ICRISAT we use Alachlor (LASSO) at 1.5 kg ai ha^{-1} as a pre-emergence herbicide. This chemical is not available in India. Basalin (R) (Fluchloratin) incorporated into the soil @ 1.0-1.5 kg ai ha^{-1} about 3 weeks before sowing has given excellent weed control in Tamil Nadu. Even after weedicide application, one or two manual weedings may be required. Alachlor or Basalin controls most of the weeds, an important exception being *Cyperus rotundatus*.

14. WATER MANAGEMENT

The importance of good water management cannot be over-emphasized. About 80% of the fresh plant weight is water. It should suffice to say that high plant populations and high levels of inputs should be used when irrigation is available as rainfall is assured. Even in kharif season, the success will be assured if irrigation is considered as a basic input and rain as a supplement. Inadequate water could be as harmful as excessive moisture. Crops that are sown in June under irrigation should receive water after sowing, followed by another light irrigation after 4-5 days. After the seedlings have emerged, the next irrigation should be given when flowering commences. This is because young plants need much less water than do older plants (Fig 4). By this time the monsoon usually sets in, so only supplementary irrigation may be necessary if when prolonged droughts occur. The period of greatest sensitivity to drought is that of peak flowering, followed by pegging and pod maturation; the seedling stage is the least sensitive. For Rabi crops, a similar pattern of irrigation should be followed. Withholding irrigation between early growth and flowering has shown a beneficial effect on yields.

For Rabi season, the irrigation interval can be as long as 20 days during December-January or as short as 7 days during April-May. (Table 7). A rule of thumb is to apply water soon after wilting is noticed. Wilting is most visible during the afternoons, so inspection of crops during early morning or late evening hours (when plants recover) will not give a correct idea as to water needs.

Traditionally, farmers apply water by flooding the field. This practice wastes water, creates waterlogging and chlorosis and results in seedling mortality from fungal pathogens particularly when temperatures are high. Seedling mortality is a serious problem in rabi season in many area e.g. Orissa. Use of sprinklers are advisable to save water and avoid side-effects, such as those mentioned above, but they are not indispensible. If the broad bed and furrow system is followed, it is better to first run the water down the slope rapidly to wet the soil, then reduce the rate of inflow of water, so as to allow the water to percolate laterally.

How much water should be given at each irrigation is difficult to say but wetting to a depth of 13-15 cm will be adequate. The best rule is to apply less water but more frequently.

At ICRISAT we use gated pipes (Fig 2). For the four-row bed system, gates at 150 cm, and for the three-row bed system, gates at 120 cm, should be ideal. Gates are instantly adjustable by hand to any rate of flow, from fully open to fully closed, thus giving good control over water flow. Use of gated pipes reduces the work load and labour requirement considerably.

15. CALCIUM MANAGEMENT

It is now generally accepted that gypsum ($Ca SO_4$, 67%) application is beneficial to groundnut and several farmers use it. This is a good practice. Gypsum is supplied to farmers by many Government agencies and Oil Seed Cooperatives on subsidies ranging from 25% to 90% (In the latter case, only a nominal sum is charged to farmers, e.g., by Andhra Pradesh Oil Seed Growers Federation). Gypsum is applied @ 400-500 kg ha^{-1} to soil around the plants, and then lightly mixed in to the soil. It is essential to make Calcium available to pod zone because it is absorbed by pods from soil and used for pod development. The Calcium absorbed through roots or tops do not translocate to pods (The reverse is true). Moderate Ca deficiency appears first on fully developed leaves as localized pitted areas on lower surface of leaves which subsequently develop into brown necrotic spots. Such spots may have outer chlorotic halo similar to that of <u>Cercospora</u> leafspot. Severe calcium dificiency results in chlorosis, wilting, and death of terminal buds. In pods it is expressed as unfilled pods, darkening of plumule of the seed embryo, and reduced pod development. Empty pods, normally called "pops", are frequent in Ca deficient soils, particularly in acidic soils.

Gypsum sells for less than Rs. 30 per tonne but the bulk of cost (Rs.150-300 per tonne) is consumed by transport. So when subsidies are removed, it may cost Rs.100-150 to apply gypsum to one hectare. In most black soils, which have high Calcium contents, gypsum is either not necessary or the dose can be reduced. However, gypsum application should be generally recommended because it provide Ca, it provides S, it has impurities that also provides Mg, it reduces pH

Usually 2 sprays in Kharif (25 and 45 after sowing) and 3 sprays in Rabi season (25, 45, 65 days after emergence) may be required and should be recommended.

18. ZINC MANAGEMENT

The best way to overcome Zinc deficiency is to apply Zn SO4 to the soil. However, when plants show Zinc deficiency symptoms, e.g. veinal chlorosis, Zinc will have to be applied. Often Zinc deficiency symptoms can be confused with Manganese deficiency symptoms. However, soil or plant analysis will indicate the Zinc deficiency (Table 4).

Foliar spray of Zinc is applied as Zn SO4, 0.5% solution, to which lime is added to make lime-strength of the final solution 0.5%. (100 liters of water containing 0.5 kg Zn SO4 plus 0.5 kg lime). Best results are obtained when the spray is given once or twice before pod-swelling starts (i.e., before 40-45 days after sowing).

19. Diseases

At present one soil-borne, two foliar, and one virus disease are generally important. Soil-borne diseases can be to a large extent controlled by clean cultivation, removal of debris from the field/and/or deep burying them, application of thiram (3 g kg^{-1} of seed) and application vitavax by watering can to the plants. The main disease that causes seedling mortality is a root rot caused by Sclerotium rolfsii. This disease is of considerable importance in the Rabi season. In parts of Andhra Pradesh and Orissa, this disease causes seedling mortality at 10-25% incidence. Intensive research is warranted to develop control measures for the soil-borne diseases.

20. Rust

Rust is an important yield reducer in the Kharif season. It is not a serious problem in the Rabi season, except in areas where temperatures and humidity remains high by virtue of such areas being near to oceans, lakes, or when they receive frequent rains. In many coastal areas of Andhra Pradesh, Tamil Nadu and Karnataka, and in some parts of Southern India that receive rains from the South-east Monsoon, rust is common throughout the year. Rust is caused by Puccinia arachidis Small copper - coloured pustules appear on the lower leaf surface of the older leaves, and rapidly increase under favourable conditions. The foliage dries up and the crop has a burnt appearance.

21. Leafspot

Late leafspot is a common disease of groundnut in India. It occurs every year in the Kharif season in entire India, except in the extreme North (Punjab, Haryana, Himachal Pradesh and Kashmir) or in the years when rainfall and humidity are low for prolonged periods. Commonly called as "Tikka" disease, it is caused by Cercosporidium personata. It may appear early in the season as in the Coastal areas or generally late, 60-70 days after sowing, in most areas in North of Tamil Nadu. In the former situation, a total yield loss can occur while in the latter, 20-70% of the potential yield can be lost. Effective control of this disease through fungicide application or through use of resistant cultivars can raise the groundnut production by over 20% in the Kharif season.

The rust disease can be controlled by spraying calixin @ 250 g commercial product ha^{-1}. Rust and leaf spot diseases can be controlled by spraying a mixture of dithane M-45 and Bavistin. For leafspot control, dithane M 45 should be applied at 10-15 days interval after a few leaf spots are noticed on the older leaves. Usually 3 sprays are applied, but upto 8 sprays are needed to provide good control.

In recent years varieties with high yield potential and resistance to rust disease and "tolerance" to late leafspot disease have been developed. e.g. ICG FDRS 4, 10. However, they suffer from strongly ribbed pods, lower shelling percentage and lack of seed dormancy. Initially, strongly ribbed pods seemed to be a disadvantage but farmers do not seem to be concerned. However, rust and leafspot resistant lines with smooth pods are likely to become available soon.

A major break through in Kharif groundnut production (increased and stable production) can be achieved by popularising rust and leafspot resistant varieties.

22. Bud necrosis

Called by different names such as bud rot, bud blight, ring mosaic, ring spot, and confused with rosette disease (which is not present in India) and nutritional disorders, this diseases has become important in drought affected Kharif seasons and in the Rabi seasons also. It is widespread in India and areas where large scale and year round cultivation of groundnut, beans, legumes, solanaceous plants, and crop plants of the Compositae family occur, the incidence of this dieseease remains high. The disease is caused by tomato spotted wilt virus and transmitted by the thrips Frankliniella selultsei. It causes an array of symptoms in groundnut, e.g., ring spots/dots (chlorotic or necrotic) on young leaves, chlorosis, drooping or bending of petiole, stunting, production of excessive number of side-branches, death of terminal buds and death of plant. The last sysmptom occurs when high temperatures prevail and when seedlings are affected.

The disease can not be controlled with common insecticides. If insecticdes, e.g. dimethoate, are sprayed too frequently, the disease incidence actually increases. The reasons for this are not known. The best strategy to control the disease is through early sowing (June in Kharif and October -November-March in Rabi and February in Rabi summer season)and close planting. The latter is desired not only for BND control but also for high yields. Usually 30 x 10 cm spacing (row-plant) is adequate. Use of good quality seeds and seed dressing with thiram will ensure control of seedling mortality from soil pathogens, and thus ensure good plant density.

Recently, cultivars with field resistance to this disease have become available. They are high yielders too. e.g. Kadiri-3, ICGS 11, ICGS 44, ICG 2271, and many others are being screened.

20. PEST MANAGEMENT

Kharif groundnuts encounter widespread damage from whitegrubs Holothrichia spp. in the North. This pest can be controlled by application of thimet (Phorate) @ 2.5 kg ai ha^{-1} with seed. Spraying of host trees in June and July, with carboryl or endosulfan kills the beetles and reduces the grub problem. In the South, in localised areas e.g. Chittoor and Mahbubnagar districts of Andhra Pradesh and

Raichur district of Karnataka, the red hairy caterpillar is a menace in some years. This pest can be easily controlled with insecticides. Alternatively in small fields, hand-picking can be practiced. Both white grub and hairy caterpillars are prevalent only in the Kharif season.

Among seedling pests, in both Kharif and Rabi seasons thrips and leafminer are common, the former being a regular and the latter, a sporadic pest. In Tamil Nadu, and in Orissa, *Scirtothrips dorsalis* can be considered as a major pest. It effects the crop right from the seedling stage and therefore control is necessary. Application of carbofuran (or thimet) with the seed protects the crop for about a month after sowing from the major pests (thrips and leafminer). If systemic soils insecticides are used, no further spray to control thrips may be necessary. Alternatively, application of dimethoate @ 200 g ai ha^{-1} about 15 days after emergence is necessary.

Leafminer increases in numbers very rapidly during dry conditions in the Kharif season and is also a common pest in the Rabi season. This pest must be controlled to ensure good yields. The best way to control this pest is to apply insecticides when mines are first seen on leaflets. Following the initial large scale invasion of moths in a field, large numbers of mines can be seen. Insecticide application at this stage is highly effective. Later applications do not protect the crop properly. Usually 1 or 2 sprays timed at new mine formation can give effective control. Dimethoate, 200 g ai ha^{-1}, has also been found effective at ICRISAT. It is cheap and easily available. Monocrotophos 100 g ai ha^{-1} is a suitable alternative insecticide (AICORPO recommendation).

Spodoptera litura is mainly a pest in the Rabi season in some areas. Insecticide application when 1 egg mass per meter row is noticed is effective. Monocrotophos 100 g ai ha^{-1} is a suitable insecticide.

Recently *Heliothis armigera* has caused damage to groundnut at Neyveli (Tamil Nadu), Gadwal (Andhra Pradesh) and Sukinda (Orissa). Endosulfan, 700 ml ai ha^{-1}, can control this pest. Monocrotophos is a suitable alternative pesticide.

21. HARVESTING

Harvesting of the Kharif crop starts from September to October, and in the Rabi season, the harvesting is done from April-June depending on the sowing date.

In the Kharif season, and particularly on light alfisols, the soils become hard and it may be essential to give light irrigation a few days before harvesting to soften the soil surface and prevent pod losses. Bunch cultivars are easier to harvest than spreading types and are therefore preferred in light soils.

Farmers are well-versed in judging pod maturity. When maturity is reached, the inside of the shell has darkened veins, the outside becomes less spongy and the veins more pronounced. Towards maturity, most bunch cultivars show a yellowing of foliage and leaf-fall with increasing leaf-spot attack. These factors indicate that the crop is approaching maturity, however, it is necessary to judge maturity before a decision is made to harvest the crop. Most Spanish bunch varieties lack seed dormancy and delayed harvesting allows some seeds to germinate within pods, causing heavy loss of yield. Frequent examination of pods from whole plants is therefore necessary before a decision is made to harvest the crop. Plants from bunds etc or isolated plants should not be taken for observations.

Generally, it is assumed that maturity is a genetic character of a variety. However, our experience has been vastly different. The same variety, e.g., JL 24, matured in 75-116 days, in the same area, and sown within a week of each other and all grown with protective irrigation. This indicates that the soils and nutrition play important roles in maturity. The quickest maturity of 80 days after sowing in JL 24 was in a field where the soil was a light vertisol, and where a dose of phosphate 4 times that of normal dose of 40 kg P_2O_5, and gypsum @ 400 kg ha^{-1} were applied and the crop was grown or raised beds. The longest duration of 116 days was when JL 24 was grown on a vertisol that had high pH, and low in phosphorus content and the crop was grown on flat land. It is our general impression that raised beds are somehow linked with faster maturity.

Harvesting of Kharif crops in States such as Tamil Nadu poses severe restrictions on harvesting time because of the bimodal rainfall pattern. With the South-west monsoon not receding until the middle of September and the winter rains (South-east monsoon) beginning from October, there is always a chance that the mature crop or harvested produce is caught by rains. To avoid this uncertainty, it is necessary to develop a cheap, possibly wood-fired groundnut drier, for such areas.

Harvesting of rabi groundnut needs more frequent monitoring of the crop, particularly for bunch varieties. Maturity date of bunch varieties is indicated by yellowed foliage, but in the absence of leaf-spot in this season, defoliation does not occur as in the Kharif, so this criterion cannot be relied upon. The spreading-bunch varieties, ICGS 11 and Kadiri-3 have seed dormancy of about 2-3 weeks, so pod-losses from germinating seed within the pods is at a minimum.

Lifting of groundnuts is usually done manually. However, and particularly on flat beds, large number of pods are left in ground.

22. DRYING

Unless appreciable rainfall occurs soon after harvest, field drying should suffice. Recommendations for handling of produce after lifting differ for kharif and rabi seasons.

For the kharif season, lift the plants, invert them with the pods uppermost in windrows for about 2-3 days. Pick the pods and spread them out in a thin layer to sun dry for a further 3-4 days until seed moisture contents are less than 8%. Store them in gunny bags.

For the Rabi season, high temperatures of 40-45 C during the harvest period, April-June, can cause problems. If pods are exposed to direct sunlight, the temperature of seed within pods may rise above 60 C resulting in loss of viability and of quality. To avoid this, pods should be picked from the plants and spread out in thin layers under shade. If drying has to be done in the field, plants should be arranged in heaps or stacks in such a way that pods are shaded by the foliage (Fig 5).

23. STORAGE

Groundnuts kept for seed or for local consumption should be stored in the shell in bags. Sprinkling of 5% lindane dust over the pods will protect them from insect damage. The walls and the floors of the store should be swept clean and dusted with lindane.

[illegible]ED PRACTICES FOR GROUNDNUT PRODUCTION

Select a well-drained soil

Cultivate the land early, apply recommended fertilisers and soil amendments, and FYM, and prepare broadbeds and furrows.

Plant good quality seed (germination ability of 95-100%)

Sow with a recommended variety and with a seed dressing

Apply recommended post emergence fertilisers and soil amendments

Apply protective irrigation if needed

Cultivate and keep down weeds (use pre sowing herbicide)

Protect crop from pests and diseases and nutritional deficiencies

Harvest at correct time and dry well (in shade for rabi crop)

Store groundnut in shell and treat with lindane.

Table 1. Nutritional requirement (kg/ha) of groundnut pods and haulms.

Pods T/ha	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B
1	58	5	18	11	9	4	2	0.09	0.08	0.05
2	117	10	36	23	18	9	4	0.19	0.16	0.11
3	174	15	54	34	27	13	6	0.29	0.24	0.16
4	232	20	73	45	36	18	8	0.38	0.32	0.22
5	290	25	91	56	45	22	10	0.48	0.41	0.27
6	348	30	109	68	54	26	12	0.58	0.49	0.33

Source (A) Macro and Micronutrients by Nodulating and Non-nodulating Peanut Lines, K.L. Sahrawat, B. Srinivasa Rao, and P.T.C. Nambiar, ICRISAT, JA 677 of 10 Mar 87

(B) Peanut Science and Technology, Edited by Harold E. Patee and Clyde T. Young, Am Peanut Res Educ Soc, Inc, 1982 ble 2. Nutritional Status of different soils in India

tate	Location	Cultivation Practice	pH	EC(m.mhos./(m)	Available PPM			OC %	Fe PPM	Mn PPM
					Zn	P	K			
Orissa	Sukinda	High input	5.81	0.11	0.84	13.25	50.0	0.58	35.04	52.8
		State	5.55	0.15	1.14	15.25	59.0	0.66	86.0	39.4
		Local	5.61	0.15	1.10	14.0	65.0	0.68	50.9	50.4
Karnataka	R K Shala	High input	7.03	0.26	0.96	10.25	84.0	0.46	9.5	13.2
		State	5.73	0.28	0.60	4.25	40.0	0.45	17.0	29.2
		Local	5.30	0.16	0.44	1.75	28.0	0.42	14.2	28.6
	Guledhalli	High input	8.25	0.38	0.42	14.0	88.0	0.32	2.5	5.3
Andhra Pradesh	Gadwal	High input	8.59	0.19	0.30	6.0	88.0	0.33	6.8	6.8
		State	8.25	0.19	0.30	6.0	88.0	0.33	6.8	13.2
		Local	6.51	0.11	0.42	1.5	65.0	0.30	8.2	26.2
	Garikapadu	High input	7.58	0.35	3.0	19.75	169.0	0.52	6.0	15.8
		State	7.76	0.31	1.70	26.25	203.0	0.60	8.9	10.0
		Local	7.66	0.20	1.84	22.0	156.0	0.56	5.7	10.0
Maharashtra	Wai	High input	8.08	0.33	6.2	10.5	159.0	0.69	4.8	17.4
		State	8.05	0.35	0.96	9.75	159.0	0.66	4.8	13.0
		Local	8.06	0.37	0.80	25.5	288.0	0.57	2.8	7.0
	Dhule	High input	8.62	0.46	0.74	7.75	234.0	0.63	4.0	8.8
		State	8.61	0.51	0.74	7.0	319.0	0.66	3.9	14.7
		Local	8.63	0.48	0.84	6.0	319.0	0.60	4.1	14.8
Tamil Nadu	Neyveli	High input	6.64	0.42	0.80	38.5	100.0	0.87	7.0	37.0
		State	5.28	0.24	0.60	31.0	75.0	0.88	5.8	31.7
	Sample I 3/6/87	Local	5.44	0.18	1.60	32.25	75.0	0.66	8.4	46.6

Sample II 6/7/87	High input	6.48	0.64	4.31	34.25	119.0	0.96	6.58	29.8
	State	7.48	0.43	0.72	38.5	175.0	0.87	5.74	18.8
	Local	5.48	0.15	0.72	30.5	94.0	0.69	8.0	43.0
Mussravakkam	High input	7.89	0.41	0.80	9.75	121.0	0.27	4.4	17.4
Sample I 3/6/87	State	8.13	0.22	0.70	9.75	65.0	0.18	6.4	17.4
	Local	8.36	0.27	0.80	8.5	45.0	0.20	3.8	16.2
Sample II 7/7/87	High input	8.50	0.20	2.52	17.25	63.0	0.27	4.58	10.0
	State	8.22	0.22	0.90	18.5	53.0	0.26	4.38	9.0
	Local	8.50	0.16	0.63	10.75	38.0	0.24	3.95	7.75
Critical Level		6.5-7.2	X1.0	1.2	X10	X100	1.0	?	3.8

Table 3. Nutritional contents of various fertilisers produced in India.

Fertilisers	Nutrients (percentage) N	P	K
A. SINGLE CARRIERS			
1. Nitrogenous fertilisers			
Ammonium Sulphate	20	-	-
Urea	46	-	-
Calcium ammonium nitrate	28	-	-
2. Phosphatic fertilisers			
Single Super phosphate	-	7	-
Triple super phosphate	-	20	-
3. Potassic fertilisers			
Potassium sulphate	-	-	40
Muriate of Potash (potassium chloride)	-	-	48
B. DOUBLE CARRIERS			
Diammonium phosphate	18	20	0
Gromor (Coromandel Fertilisers)	28	12	0
C. TRIPLE CARRIERS			
Sampurna (Zuari Agrochemicals)	19	8	16
Vijay Complex (Madras Fertilizers)	17	7	14
IFFCO Grade-1	10	11	22
IFFCO Grade-11	12	14	13

Table 4. Zinc contents of plants grown on soil with and without basal dose of 10 kg Zn SO 4 ha-1 (Kadegaon Seed Farm, Wai, Maharashtra State - Rainy Season, 1987).

Plot Number	Treatment	pH	Zn content (ppm) in	
			Soil	Plant
1	Zn SO4 10Kg/ha	8.08	6.20	30
2	without Zn SO4	8.05	0.96	20*

* Marginal value.

Table 5. Effect of bed heights on peanut yield*

	Pod yield (lbs/acre)			
	Type of bed			
Year	Furrow	Beds 0-2"	Beds 3-4"	Beds 5-6"
1963	1304	1883	2126	1983
1964	2136	2281	2472	2746
1965	3059	3041	3241	3570
Mean	2166	2402	2613	2766

Yoakum, Texas, Yields of irrigated peanuts. Peanut Culture and uses page 317.

Table 6. Seed infection by fungi in groundnuts obtained from various States from Rabi season 1986-87 harvest.

Location	Source	Cultivar	% seed infected by fungi			
			A.flavus	A. Niger	Others	Total
Mussaravakkam (T.N.)	Foundation seed	Co 1	16	5	3	24
	"	Co 2	10	5	2	17
Neyveli (T.N.)	Breeder's seed	C 1	8	4.5	2	14.5
		VR 1	2	1	1.5	4.5
		Co 1	5.5	1.5	2	9.0
		TMV 2	3	1.5	2	6.5
Andhra Pradesh	?	TMV2	4	2	2	8
		K3	3	3	4	10
		NG 268	6.5	2	3	11.5
		J 11	0	0.5	0	0.5
		JL 24	13	12	2	27
Gujarat	GAU	G2	21	18	2	41
	GAU	JL 24	33	15	3	51
	Growfed	G 10	11	13	1	25
	Growfed	JL 24	23	11	3	37
	Growfed	G 2	7	11	3	21
	Growfed	J 11	0	1	0	1
Tamil Nadu	?	TMV 12	9	7	2	18
	?	TMV 7	6	4	5	15

Table 7. Effect of sowing depth on pod yield of two groundnut cultivars, ICRISAT Center rainy season, 1984.

Cultivar		Pod yield (kg ha^{-1})		SE
		Sowing depth	Sowing depth	
		4-6 Cm	8-10 Cm	
Robut 33-1		5200	3400	+182
J 11		2930	2220	
	SE	± 251		
	Mean	4060	2810	
	SE Mean	± 129		

Table 8. Irrigation Schedule for rabi groundnut (sowing date Nov 15, duration 125 days after sowing)

Days after sowing	Month/date	Irrigation	Growth Stage
1	Nov 16	1	Seed emergence
4	Nov 20	2(very light)	"
30	Dec 16	3(light)	Seedling
50	Jan 5	4(light)	Flowering
70	Jan 25	5(light)	Pod forming/ beginning seed
87	Feb 12	6(Full)	Pod filling
102	Feb 27	7(Full)	
114	Mar 11	8(Full)	Pod maturity
124	Mar 21	9(Full)	
132	Mar 29	10(Full)	
139	Apl 6	11(Full)	Harvesting*

Harvesting starts around mid-April, depending on the maturity of cultivar. Irrigation should be stopped about 10 days before harvest.

Table . Growth stages of groundnut (CV TMV 2 - Spanish bunch) in relation to the temperature requirement (Kharif 1982 and Rabi 1982-83 Season)

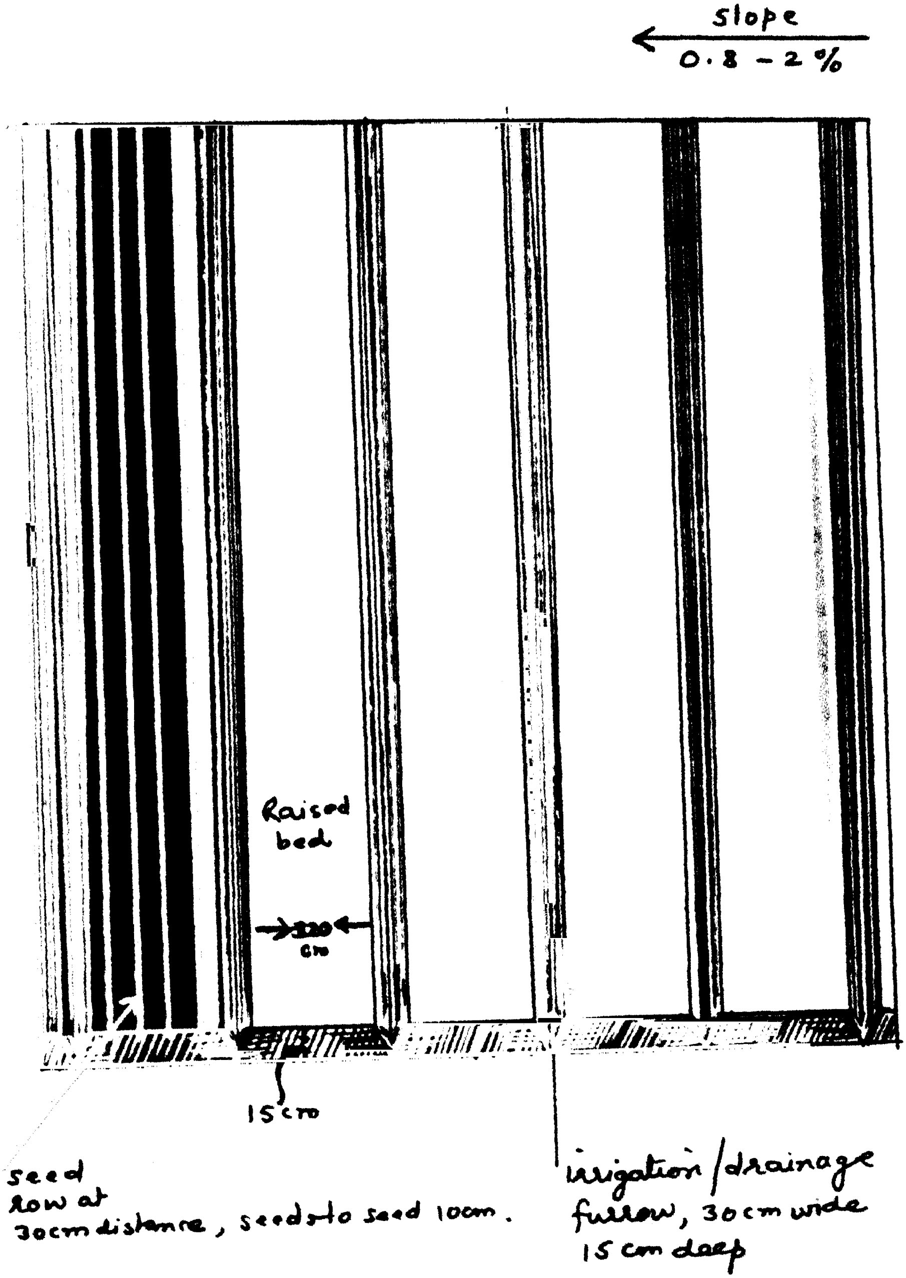
Growth Stage	Description	Cumulative Temperature (day degree) requirement*	Duration of Growth Stages**	
			Kharif	Rabi
-	Emergence	250	6	11
RI	Beginning bloom	650	25	41
RII	Beginning peg	880	32	50
RIII	Beginning pod	1000	39	58
RIV	Full pod	1200	45	64
RV	Beginning seed	1400	51	70
RVI	Full seed	1715	61	80
RVII	Beginning maturity	2170	75	92
RVIII	Harvest maturity	3000	105	112
	Harvest		110	122

* Based on mean minimum and maximum daily temperatures and minimmum threshold of 10 C

* Kharif sowing date 15 June and Rabi, 15 December, modified after Boote (1982) and J.H. Williams (ICRISAT) personal communication.

Fig 1.

SEED BED - Broadbed and Furrows



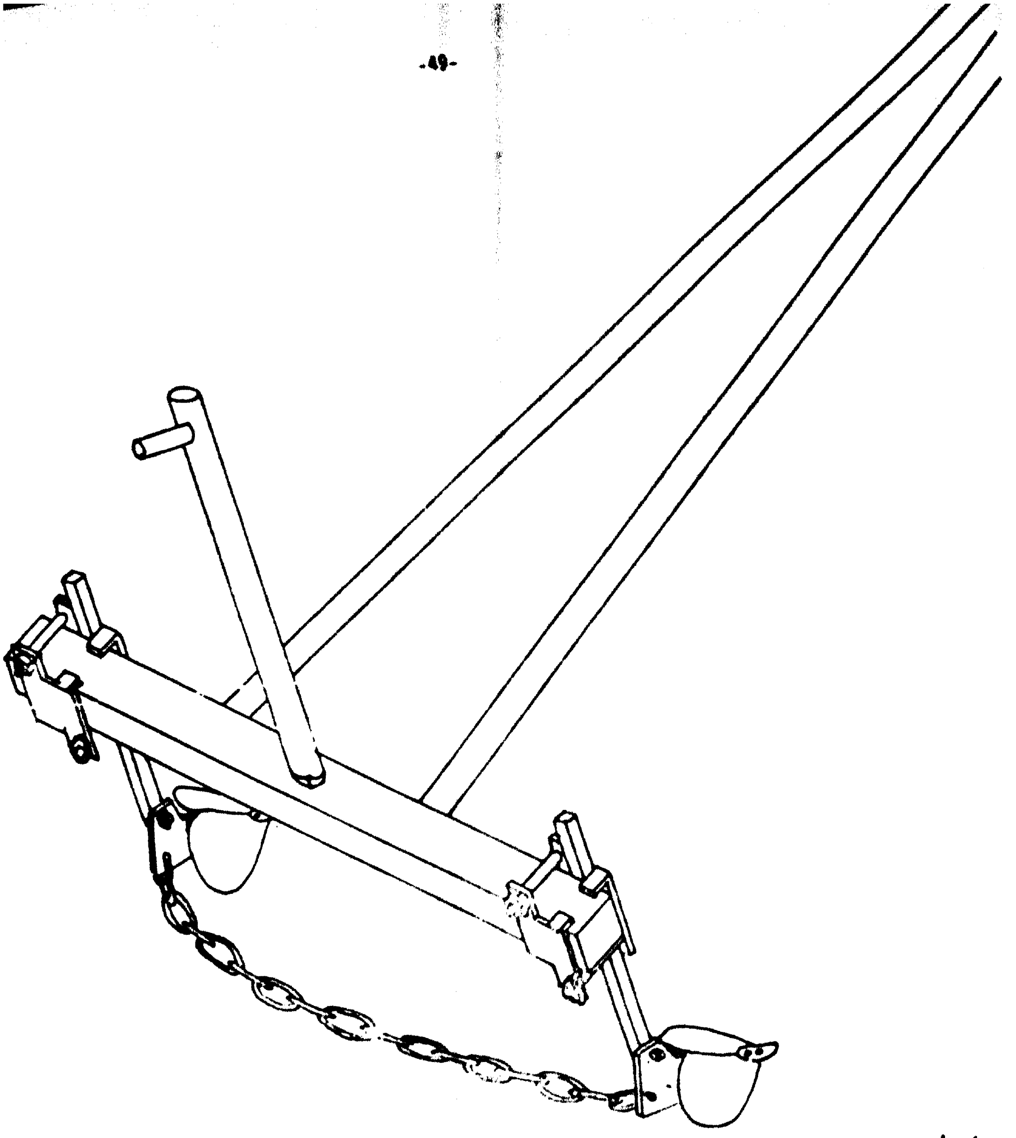


Fig 2 - A low cost broad bed and furrow maker

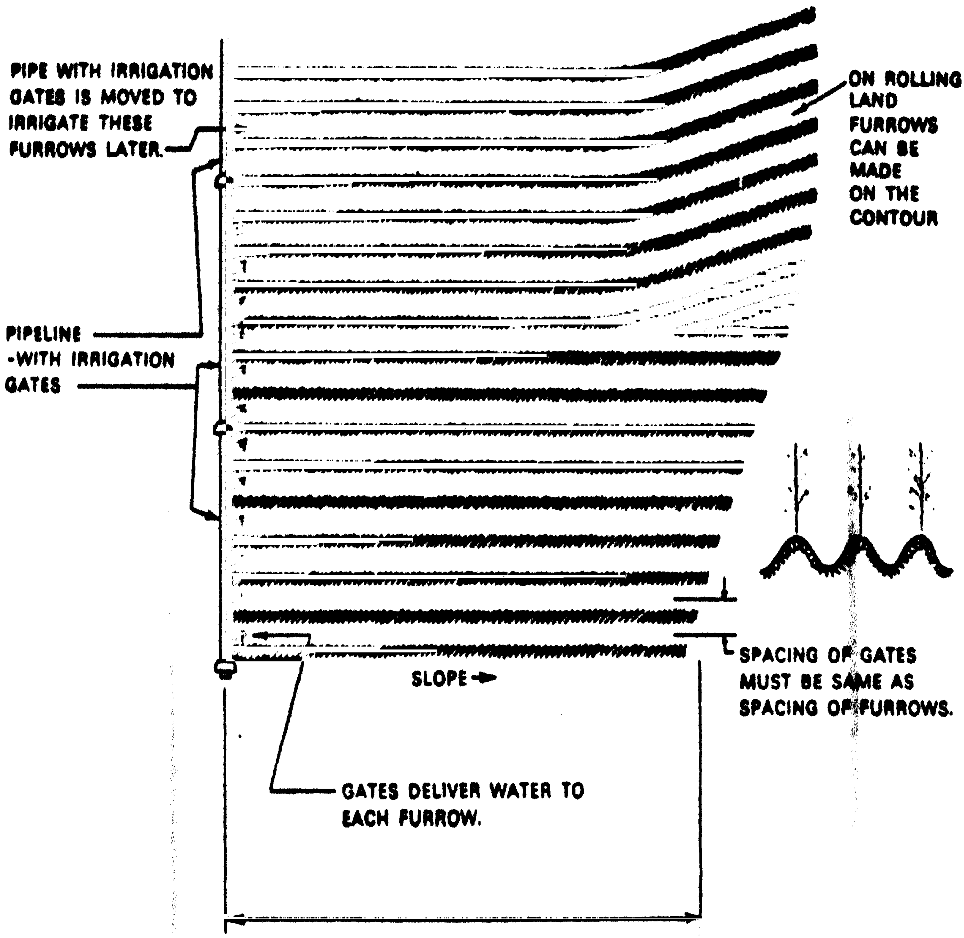
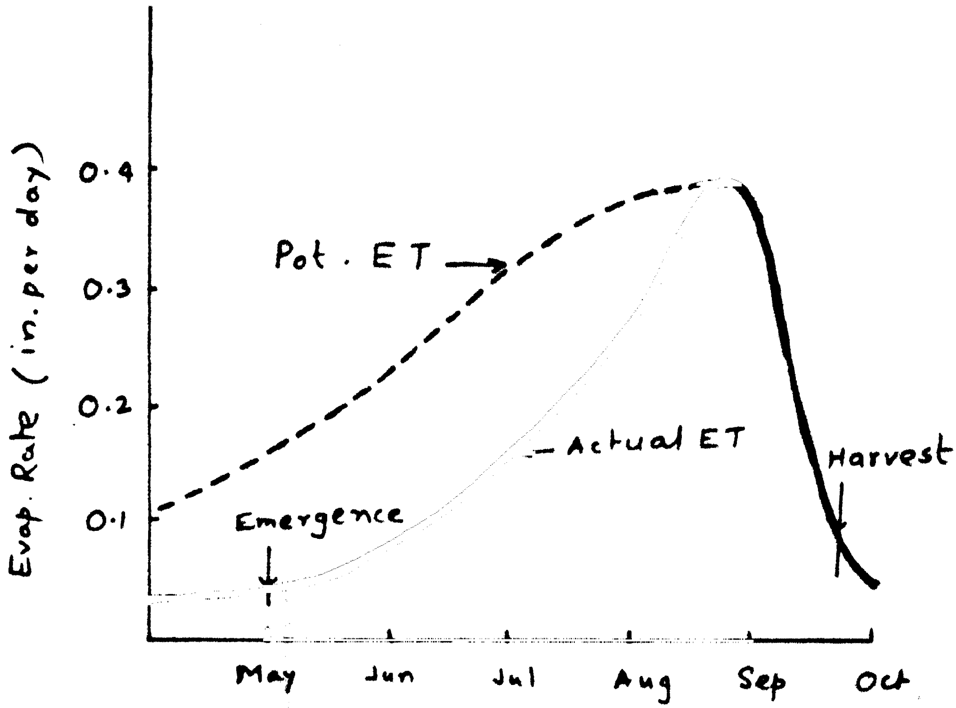


Fig 3 - **GATED PIPES FOR FURROW IRRIGATION**

Fig 4.



Comparison of a typical potential evapotranspiration and actual evapotranspiration in a south-western United State peanut field (from peanut culture and uses, page 365)

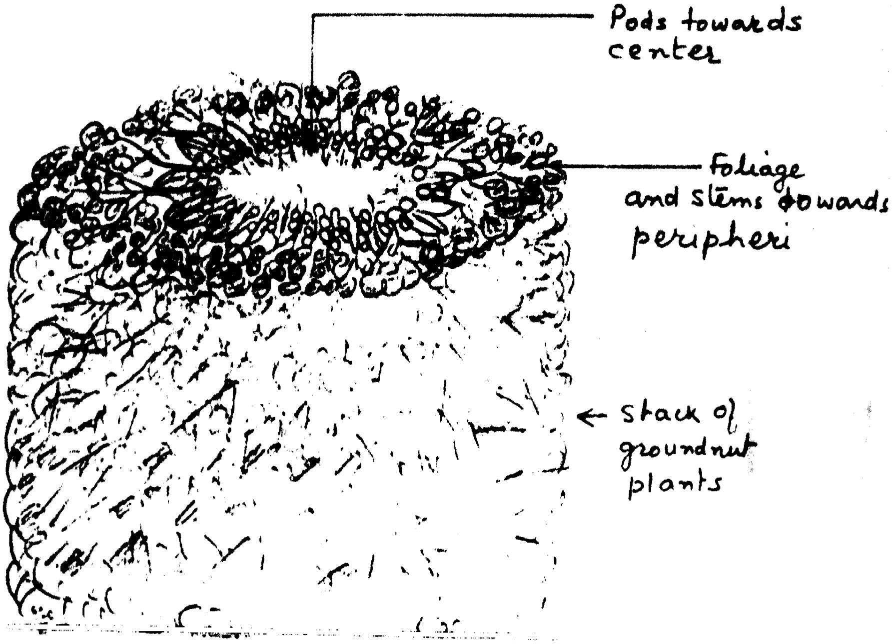


Fig 5: Drying of groundnut in field. This procedure reduces direct exposure to sun-rays and ~~pa~~ ensures proper drying without causing loss of viability. The inside Temperature of pods exposed to sun during April-June may rise to over 60°c.