Organic Farming in the Tropics and Subtropics

Exemplary Description of 20 Crops

Peanuts

These cultivation guidelines have been published by Naturland e.V. with the kind support of the Deutsche Gesellschaft für Technische Zusammenarbeit mbH (GTZ, German Agency for Technical Cooperation) financed by the Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ, Federal Ministry for Development Cooperation). The cultivation recommendations at hand for 20 crops of the tropics and subtropics being of significant importance for the world economy were written by various authors.

Naturland would like mention the following authors and thank them for their contributions:

Franz Augstburger, Jörn Berger, Udo Censkowsky,
Petra Heid, Joachim Milz, Christine Streit.

The cultivation guidelines are available in English, Spanish and German for the following crops:

banana, brazil nut, cashew nut, cocoa, coconut, coffee,
cotton, hibiscus, macadamia, mango, papaya, peanut,
pepper, pineapple, sugar cane, sesame, tea, vanilla.

The cultivation guidelines for Bananas, Mangoes, Pineapples and Pepper were revised in 2001 for the United Nations Conference on Trade and Development (UNCTAD) by Udo Censkowsky and Friederike Höngen.

In 2002 two more guidelines, for rice and date palms, were published in English.

All the authors emphasize, that the cultivation recommendations at hand can just provide general information. They do not substitute technical assistance to the farmers with regard to the location.

Furthermore the authors kindly call upon for critical remarks, additions and other important information to be forwarded to the address below. The cultivation guidelines will be updated regularly by Naturland e.V.

Naturland e.V.
Kleinhaderner Weg 1
82166 Gräfelfing
Germany
phone: +49 - (0)89 - 898082-0
fax: +49 - (0)89 - 898082-90
e-mail: naturland@naturland.de
website: www.naturland.de

We pass our gratitude to Peter Brul of Agro Eco for his helpful comments on the manuscript. Our best thanks are also devoted to all supporters of this publication, in particular Mrs Sybille Groschupf who cleaned up the text from errors in strenuous detail work and did the attractive layout..

Index

Organic peanut cultivation

1. Introduction

Domestic cultivation of peanuts began at least 4000 years ago in present-day north-western Argentina and in southern Bolivia. The plant probably reached China before the colonisation era; it also arrived in Africa during the 16th century and subsequently created a second centre of development by spreading through out the whole of Asia. Today, peanuts are cultivated in every tropical and subtropical country.

1.1. Botany

Peanuts (*Arachis hypogaea L.)* belong to the leguminosae family and to the subfamily of papilionoideae. It is a herbaceous, annual type of plant that grows to a height of 20-60 cm. Depending on the species, the plants may grow upright and sideways with their sidewards shoots to a breadth of 30-80 cm. The main stem usually remains upright. The taproots penetrate to a depth of 90-120 cm, creating branches within the upper soil levels that are then populated by rhizobia and mycorhiza. *Arachis hypogaea* does not grow in the wild, the wild species are perennial. The blossoms open up in the morning time, usually after self-pollination has taken place. The blossoming period usually begins 3-4 weeks after sowing, and can last for up to 2 months. All of the species are geocarpy reproducers, i.e. they sink a stalk-like structure called a peg into the ground after fertilisation, in order to grow the peanut seeds there.

1.2. Varieties and countries of origin

The many different types of peanuts are sorted into two different subgroups which can be intercrossed amongst each-other:

Arachis hypogaea
ssp. hypogaea (Virginia variety)
Long vegetation period, dark green plant, spreading, bunch form, many branches, mostly two seeds/pod, distinct dormancy period of 30-180 days, meagre resistance against *Cercospora,* anthracnose.
ssp. fastigiata (Spanish Valencia variety)
Short vegetation period, light green leaves, upright growth, pods with 2-6 seeds are concentrated around the main stem. Spanish varieties usually have two seeds/pod, Valencia varieties have pods with 3-6 seeds, thick stalks and far less secondary or tertiary branches than other Spanish varieties. No dormancy, no resistance to *Cercospora*, anthracnose.

Peanuts are cultivated throughout all tropical and subtropical countries, as well as in those temperate countries which enjoy long , hot summers.
The export of peanuts grown in organic farms has been discontinued in many countries owing to problems with aflatoxin. The further development of exemplary, organic cultivation systems has stagnated in many countries and cultivation for export, e.g. to Germany, is currently limited to USA, China, Egypt and Israel. The aflatoxin problem can be solved though. It is therefore dealt with thoroughly within this cultivation guide (comp. 3.1.).
In the USA, the yields from organic peanut cultivation are around 2.2 - 3.2 t/ha, in China 2.5 – 3.5 t/ha and in Zimbabwe around 2.8 t/ha of seeds in pods. The world average yield is around 1.1 t/ha and the potential yield around 9 t/ha.

1.3. Uses and contents

Peanuts are one of the most important food crops in the Tropics and Subtropics. The lion's share of the production is consumed locally in the producer countries. In many countries, farm systems which provide for daily needs generally have a very low yield. Any changes made to the cultivation systems in order to extract higher yields e.g. cultivation for the purpose of selling, have – if at all possible – social consequences, which must also be taken into consideration[1].
The peanut has a very useful protein and fat composition and therefore represents a valuable source of food for humans. The seeds are eaten raw, cooked or roasted, and also processed into peanut butter, sweets and snacks, or used to make soups and sauces. 40% of the world yield is used to make oil. A cake contains 40-50% easily digestible protein; peanut flour is won from it, and used to enrich foodstuffs with protein, for example manioc flour. Foliage and pressed cakes are used as protein-rich fodder. The pods are used for fuel, as raw fibres in fodder, as raw material for light construction boards, to obtain cellulose and for composting.

Peanut seeds' contents[2]:

Contents	%
water	5,0
protein	30,0
fat	48,0
carbohydrates	15,5
Raw fibres	3,0
Ash	2,0

[1] RUNDGREN, G. (1998): Persönliche Mitteilung. Internationale Zertifizierung and Beratung.
[2] SAVAGE, G. P. and KEENAN, J. I. (1994): The composition and nutritive value of groundnut kernels. In: SMARTT, J.: The groundnut crop. Chapman & Hall, London.

2. Aspects of plant cultivation

2.1. Site requirements

The peanut is very adaptable, and is cultivated in continental areas with hot summers from the 45° northern to the 40° southern latitude.

2.1.1. Climatic requirements

Temperature

The rate of growth and vegetation period of the peanut are highly influenced by temperature. 30-34°C is optimum for germination (max. 45°C, min. 15°C). Under 20°C, the capacity to germinate, the rate of growth and development are rapidly reduced, and at around 14°C they cease altogether. 25-30°C is optimum for vegetative growth. Temperatures above 34°C can damage the flower formation. The optimum temperature influences the net rate of photosynthesis, the flower formation and the growth of the pods, and is therefore responsible for the greater yields outside the hot tropics[3]. Night-time temperatures should not sink below 10°C during the fructification process. Frost will always kill off the plant.

Light

The peanut can tolerate shade, it poses no problems when cultivated with trees or with other, mixed crops. When placed in shade, the leaves get bigger, and the number of reproductive organs lessens (there are too many of these anyway), meaning that the yield will only be reduced if the plant is subjected to extremely shady conditions. When the light is very intense, the peanut (a C_3-plant) achieves a comparable level of photosynthesis as C_4-plants. *Arachis hypogaea* is in a photoperiodic sense, practically neutral, although photoperiodic sensitive and insensitive varieties also exist.

Water

The optimum time to sow, which corresponds in many places with the rainy season, depends largely on the rain, as the yield sinks rapidly when the plants are sown outside the optimum planting time. The germination process requires enough air in the soil. A grown peanut plant can tolerate flooding conditions for up to a week, providing the water then flows away completely without leaving behind any stagnant pools[4]. In case of regular heavy reain fall during the vegetation period, the ground must be well drained, or the peanuts planted on ridges.

[3] FRANKE, G. (1994): Nutzpflanzen der Tropen and Subtropen, Bd.3, Ulmer, Stuttgart.

[4] WEISS, E. A. (1983): Tropical oilseed crops. Longman, London.

Peanut is more resistant to drought than cotton, yet less so than sorgo. Nitrogen fixing can be influenced by drought.

500-1000 mm of rainfall during the growth period will produce good yields among the late ripening varieties (up to 145 days vegetation period). 300-500 mm permits the planting of early ripening varieties (up to 100 days vegetation period). 250-400 mm of rainfall, when evenly spread, is sufficient for varieties that ripen extremely early. The type of soil, and its capacity to retain water after it has been saturated with water before sowing also play an important role. At least 300 mm of rainfall should be available between the plant's appearance and the main flowering period, in order to ensure sufficient vegetative growth, because there is a direct correspondence between the number of branches and flowers, and the eventual number of pods. Moist soil allows the pegs to penetrate into the ground more easily. Precise information on the average spread of the rainfall to be expected at the site is useful in choosing the correct variety, which will then ripen before the dry season. Stress due to drought during the ripening period of the seeds could lead to an infection by *Aspergillus flavus* (comp. 3.1.).

2.1.2. Soil requirements

The ideal soil for peanuts is a well-drained, light, loose, finely grained, sandy loam with plenty of lime and sufficient organic matter. It is also possible to achieve good yields on soils which neither harden nor crust over, nor create water-logging. During germination, the quite large cotyledons must be able to shoot upwards, and after flowering, the pegs must be able to penetrate the soil in order for the pods to expand.

The disadvantages of hard and heavy soils are:
More difficult harvest – especially manual (can be alleviated with the appropriate tools and by planting on ridges);
Possibility of malformed pods;
Harvest losses through pegs breaking off;
Pods become dirty and discoloured due to the soil sticking to them (might affect sales).

Peanuts grow best in a weakly acidic pH value (6.0-6.5); a pH value of 5.5-7.0 is still acceptable, and local can adapt themselves to pH values up to 7.8. Peanuts are sensitive to a high salt content in the soil (max. 4mS/cm).

2.2. Seeds

2.2.1. On farm seed production and seed preparation

Seed production requires great care during the harvest. The seeds should be harvested separately, preferably manually, whereby the pods should also be removed from the plant by hand to avoid damage. In order to avoid mould developing, and to maintain the germination potential in extremely wet regions, it may be necessary to apply drying substances. One simple solution is to store the well-dried peanuts in two sacks and then to add calcium chloride[5] as a drying substance [6].

The seeds are only removed from the pods shortly before sowing, because once opened, they rapidly lose their germination potential. The seeds coats should remain intact, in order to prevent diseases penetrating. It is advisable to thoroughly sort the seeds before sowing. Inoculating with rhizobium bacteria can increase the yield at certain sites, due to the difference in the effectiveness of rhizobium strains.

2.3. Sowing methods

2.3.1. Preparing seed beds

The seed bed should be prepared deep, loose and not too fine – to avoid it becoming muddy during rain spells. The upper 10 cm should be kept loose over a longer period in order to help the pegs to bore down and the pods have space to develop. Planting on ridges or in flat beds eases harvesting. They can be formed during sowing, or afterwards, whilst tilling the weeds. To protect against erosion, the ridges should run along contour lines so that water is kept within them. Furrows will help to further improve the water retention capacity. A large proportion of the weed seeds can be allowed to accumulate before sowing, then chopped down by very level working of the ridges/flat beds.

2.3.2. Sowing

An early sowing date will improve the season's productivity. Seeds should be sown at a uniform depth of around 3-5 cm, to facilitate an equal spread of plants, and to minimise losses in the seed bed. The seeds can be pressed down with a shoe or rolled. Peanut cultivation lend themselves to partial mechanisation, e.g. by utilising animal labour for 1. sowing 2. Hoeing/combing and 3. Cutting down for the harvest.

---

[5] Calcium chloride is not mentioned in the list of allowed products for plant and disease control (Annex IIB) of the European Regulation for Organic Agriculture (EEC) 2092/91. Prior to any use approval of the certification body is necessary.

[6] An air-sealed polyethelyne filled with peanuts is placed inside a sturdy cloth sack. 300 g of calcium chloride per 40 kg of peanuts are then filled into a wide-brimmed plastic bottle with a perforated lid. The bottle is covered with a finely-meshed cloth and placed in the middle of the peanuts. In this way, 80% of the seeds will remain capable of germinating for 10 months, although they will no longer be edible (ICRISAT (1992) Groundnut A Global Perspective.).

Crop density
For long vegetation periods:
Branching varieties (Virginia) 100,000-125,000 plants/ha
ca. 40 x 20 cm
For short vegetation periods:
Bush varieties (Spanish) 200,000-250,000 plants/ha, ca. 30 x 15 cm

High crop density
Is necessary for a high yield of seeds,
Shades the soil well,
Reduces branching,
Encourages rapid, uniform ripening,

In the case of mixed crops, the best system must be chosen to suit the site requirements, whether, for example, peanuts and maize should be sown together on the same ridges, or whether a row of the other crop should alternate with 1-2 rows of peanuts.

2.4. Cultivation systems and diversification possibilities

2.4.1. Crop rotation

Peanuts should only be planted in a three year crop rotation, at least, for otherwise soil-borne diseases can accumulate, and humus be lost due to excessive soil loosening during the harvest. The amount of nitrogen fixed in the upper soil layers by peanuts should not be over-estimated. Additional sources of nitrogen fixing should be planned within the crop rotation system. The nutrient content of the soil is especially depleted when not only the foliage, but also the weeds are used as fodder, thereby leaving little residue to be worked back into the soil. Nevertheless, peanuts possess good soil enrichment potential for non-leguminosae, and act as an excellent crop prior to planting grain. The previous crop should leave little in the way of weeds behind, and be harvested early, to allow plenty of time to work over the soil to permit early sowing to take place. The previous crop should be allowed to largely go to seed. Suitable crop partners include grain, sorgo, pearl barley, maize, rice, and also: sesame, bastard saffron, cotton, sweet potatoes and grain leguminosae such as mung beans (*Vigna mungo*) or cowpea (*Vigna unguiculata*).
An example of crop rotation in the USA[7]:
Sorgo followed by green fertiliser until March - peanuts – winter corn.

[7] BUZARD, C. (1998): Mündliche Mitteilung. Farmer, ecological Peanut plantations in New Mexico.

2.4.2. Mixed crops

Planting peanuts in mixed crop systems is very widely spread and is more the rule than the exception on small farm units in India, Africa and Latin America.

Some **advantages** are[8] [9] [10] [11] [12] [13]:
Avoidance of the total failure of a crop;
Greater total production per area (despite the losses caused by overshadowing of the peanuts as opposed to monoculture);
Reduction of transpiration especially in alley-cropping;
Greater diversity of diet;
Better regulation of erosion and weeds;
Reduced susceptibility to pests.

Due to their tolerance of shading, peanuts are especially suited to mixed cultivation together with tall-growing crops such as pearl barley, sorgo, maize, cotton, hibiscus (*Hibiscus sabdariffa*), manioc and sunflowers; and as an undersown crop together with such other crops as bananas, pigeon peas (*Cajanus cajan*), *Gliricidia sepium,* castor beans (*Ricinus communis*), sugar cane or permanent crops such as e.g. coconut palms, oil palms, rubber and cocoa[14].
When their vegetation periods are similar in length, other crops cultivated together with peanuts will benefit by a gain in yield (in contrast to monoculture sites, e.g. peanut and pearl barley). Even greater increases in yield have been observed for some crops – e.g. cotton –which have a vegetation period which is up to 3 months longer[15].
The success of cultivating in a mixed system, or in agro forestry systems, is dependent largely upon choosing site appropiate crops, the way the combination gels and from the correct placement of the peanut in the chronological order of the various

---

[8] SCHROT, G., BALLE, P., PELTHIER, R. (1995): Alley cropping groundnut with *Gliricidia sepium* in Cote d'Ivoire. Agroforestry Systems 29: 147-163 1995.
[9] TONYE, J., TITI-NWEL, P. (1995): Agronomic and economic evaluation of methods of establishing alley cropping under a maize/groundnut intercrop system. Agriculture, Ecosystems and Environment 56 (1995) 29-36.
[10] AZAM-ALI, S. N., MATTHEWS, R. B., WILLIAMS, J. H., PEACOCK, J. M. (1990): Light use, water uptake and performance of individual components of a sorghum/groundnut intercrop. Expl Agric. (1990), volume 26, pp.413-427.
[11] WATERWORTH, J. V. (1994): Intercropping cotton and groundnut in low and high rainfall areas in Eastern Zambia. Expl Agric. (1994), volume 30, pp. 461-465.
[12] ROY, A. R., SAMSAL, B. C., BHATTACHARJEE A. K. (1990): Effects of Intercropping oilseeds and pulses in roselle (*Hibiscus sabdariffa*). Expl Agric. (1990), volume 26, pp. 407-411.
[13] PETER, G., RUNGE-METZER, A. (1994): Monocropping, Intercropping or Crop Rotation? Agricultural Systems 45 (1994) 123-143.
[14] ICRISAT (1994): Sustainable Groundnut Production in Southern and Eastern Africa. Proceedings of a Workshop 5- 7 Jul. 1994, Mbabane, Swaziland.
[15] NORMAN, M. J. T., PEARSON, C. J. and SEARLE, P. G. E. (1995): Ecology of Tropical Food Crops. Cambridge University Press.

species. For example, cultivation in an agro forestry system must always be at the beginning of a cycle (planting within the first 3 years may be possible – according to which other crops are grown), because the plant's natural attributes preclude it from being planted .

2.5. Supplying nutrients and organic fertilisation management

2.5.1. Nutrient requirements

The amount of nitrogen gained from symbiotic N-fixing is difficult to evaluate; it lies between 30% and 80%, meaning that the balancing out of a supply of nitrogen can be either negative or positive. If both foliage and pods are harvested, then around 90 % of the total nitrogen will be leaving the field.

Nutrient demands of peanuts (kg/ha)[16] (results are from conventional cultivation methods):

Plant part	yield	**N** [kg]	**P** [kg]	**K** [kg]	**Ca** [kg]	**Mg** [kg]	**S** [kg]
Pods	3 t/ha	120	11	18	13	9	7
Foliage	5 t/ha	72	11	48	64	16	8
Total		192	22	66	77	25	15

2.5.2. Fertiliser

An additional of nitrogen as a fertiliser is largely unnecessary for peanuts. The rhizobium-bacteria's capacity to fix nitrogen is increased by adding sulphur and calcium, and decreased by using a nitrogen-rich fertiliser. Peanuts generally react better when the previous crop is fertilised than to a direct addition of fertiliser, yet direct fertilisation can be an advantage in the case of the light, sandy soils – that are, after all, often used to grow peanuts. Due to their symbiotic relationship with the mycorrhiza-fungus, peanuts are very efficient in their use of phosphorous. If the foliage is to be harvested as hay, both calcium and potassium can be particularly strongly depleted. Yet the availability of calcium in upper layers of soil is a very important nutrient requirement. Lime should be uniformly worked in 8 cm around the stem, as not only the roots take on nutrients, but also the pods as they grow – and these would remain empty in the case of a calcium deficiency.

[16] GASCHO, G. J. and DAVIS, J. G. Mineral Nutrition of Groundnuts. In: SMARTT, J. (1994): The groundnut crop: A scientific basis for improvement. Chapman & Hall, London.

2.6. Biological methods of plant protection

Many forms of resistance by peanuts against pests and diseases are already known, and new, resistant strains are continually being developed. The international research institute ICRISAT Centre is devoted to this topic, and regularly publishes its results, as well as those of various other countries[17].

2.6.1. Diseases

The most important ways of avoiding diseases are:
Crop rotation
Choosing the right variety
Sufficient supply of nutrients
Uprooting infesting plants to stop the disease spreading
Destruction of any infested plant parts after the harvest

important diseases / infestation	Preventative measures
Anthracnose (Cercospora spp.) Infestation by harvest residues and spore dispersal.	Crop rotation; remove all infested harvest residues. Plant resistant varieties.
Rust (Puccinia arachidis) Rapid spreading. Infestation by “wild” peanuts.	Plant resistant varieties.
Fungus growth (Aspergillus flavus)	comp. chapter 3.1. Plant resistant varieties.
Root and wilt diseases Sclerotium rolfsii, Rhizoctonia spp.	Crop rotation; transmitted by seeds
Pseudomonas solanacearum Bacterial wilt Many host plants.	Plant resistant varieties. Crop rotation with paddy rice.
Peanut mottle virus, Peanut stripe virus, Rosette virus. Vector: *Aphis craccivora;* Seed borne disease	Plant resistant varieties.
Tomato spotted virus. Vector: Thrips; Remove host plants.	Also mechanical transmittance. Mixed crops with grains

2.6.2. Pests

Cultivation measures to prevent infestation by pests include:
Mixed crops and diversification of the plantation
Provide alternative food sources (nectar/blossoms) for parasitic insects

[17] Ausführliche Darstellung der Diseases and Pests incl. umfassender Zusammenhänge sind beschrieben in:
SMARTT, (1994), The Groundnut Crop.

Integrate habitats for natural enemies (e.g. selective weeding)
Include hedges and trees within the system
Plant different varieties in strip form, e.g. alternate resistant with other types
The following preventive measures are not intended to offer a general all-round recipe for success, they represent examples of solutions which have been tested on certain sites. Yet if problems with pests re-occur on the site, the cultivation system itself should be inspected, and if necessary, changed.

Important pests	Preventative and combative methods
May bugs, termites	Deep ploughing is practised at some sites, which is not advisable in organic farming at (sub)tropical sites.
Insect (Hilda patruelis)	Often together with cashew.
Stem borer (Elasmopalpus lignosellus)	Irrigation and early sowing offer protection.
Cucumber beetle (*Diabrotica*)	Plant resistant varieties.
Thrips, vectors for TSWV/BNV-viruses	Plant resistant varieties.
Spodoptera	Mainly caused by use of insecticides. In India, castor beans were planted, where the eggs could easily be spotted on their leaves and collected.
Groundnut leafminer (*Biloba subsecivella*)	Mixed cultivation with maize, millet, sorgo. Keep apart from soya; imago drift across after the soya has ripened. Irrigation helps.
Hairy caterpillars	Working the soil kills off the pupa.
Aphis craccivora, vector for various viruses e.g. Peanut mottle virus	Plant resistant varieties, or plant during times of low vector population (drought). Mixed cultivation with maize, millet, sorgo. In mixed cultivation with very hairy beans in Africa, aphids get caught in them. No mixed cultivation with cowpea *(Vigna unguiculata)*.
Jassids Cicadidae	Mixed cultivation with maize, millet, sorgo

2.7. Crop cultivation and protection

2.7.1. Weed management

The slow growth of the peanut’s early phases, with accompanying lack of ground coverage, can lead to a massive growth of weeds in the plot. This needs to be taken into account when planning the crop rotation. Before the shoots emerge, around 7 days after sowing, the soil can be curried with a light harrow (eventually even against the direction of sowing). As soon as the roots have taken hold, the soil can be curried again, this time longitudinally, with a spike-tooth harrow. The best time for this is the hottest time of day, when the plants are limp, and less likely to be damaged[18]. After this, it is usually sufficient to hoe the ground twice (on the 14th day, and before the 60th day after sowing). Actually, hoeing could be reduced to once on the 40th day. After the main flowering period, no more mechanical work is necessary, as this harm the roots, leading eventually to white-rot, whereby the pegs and young seeds could be damaged. In general, tractor usage will lead to damage being caused and a higher risk of infection.

At least three phases are necessary for good yields when the soil is only to be hoed by hand, if this is to be reduced to two times, then this should take place between the 21st and the 42nd day after sowing. Upwards of 10% ground coverage by weeds during the sensitive beginning and middle growth phases will lead to a reduction in the yield. When hoeing by hand, fertiliser can be added between the 30th and 40th day. To reduce the amount of weeds that grow, ridges can be gradually formed so that only so little soil needs to be moved to prevent covering up the lower branches and buds, or the main stem being scraped, which could raise the risk of infection by stem and collar rots.

2.7.2. Irrigation

Apart from reducing the build up of aflatoxin, well co-ordinated irrigation will also produce higher yields. The use of mineral rich well water can lead to the pods becoming extremely hard and difficult to open, due to an over-abundant mineral enrichment. Irrigation is usually stopped before the harvest as soon as two thirds of the pods have ripened. After two more weeks, the harvesting can begin, when the soil is sprinkled directly beforehand in order to loosen it, and ease the work. If the temperatures allow it, peanuts can also be planted during the dry season when irrigated, so that eventually, two harvests are possible per year.

2.8. Harvesting and post harvest treatment

2.8.1. Time of harvesting

Because the leaves of some varieties are still completely green when the pods are already ripe, occasional uprooting must be performed, in order to ascertain the optimum harvesting date. Bush varieties mature in 110-130 days after sowing, branching varieties in 130-150 days. The individual seeds are ripe when:

The structure of the pods is easily recognisable,

These have been largely filled by the seeds within,

The inner walls of the pods has taken on a darker colour (brown). The testa have then attained the typical colour for their variety.

---

18 WEISS, E. A. (1983): Tropical oilseed crops. Longman, London.

As soon as 60-70% of the pods are ripe, any further delays in harvesting will result in losses. The optimum period for harvesting is very short. If this is not kept to, and harvesting is begun either 5-10 days before this time or after it, then up to 25-50% of the production may be lost. Harvesting too late, especially in hard and dry soils, will result in the pegs breaking off, as they will already have become quite brittle. The pegs often stay stuck in the soil when the plant is pulled out. In order to precisely determine the correct time to harvest, four different criteria have been adopted in the United States. When at least one of the criteria has been fulfilled, and is then confirmed by another one being fulfilled, then the time is ripe to commence the harvest[19]:

Number of days after sowing the sum of the units of warmth

Relative Colour-Evaluation (e.g. the inside of the pods, the oil of a methane oil extract).

The following method has proved its worth for branching varieties: The outer layer of the pods (exocarp) is scraped away with a penknife to reveal the mesocarp. The colour is then evaluated using a special colour chart.

Weight ratio of the seeds and pods

Measurement of a specific ingredient (Arginine Maturity Index).

If the soil is moist when the harvest reaches maturity, then the seeds will quickly begin to germinate, without a dormancy period (especially bush types).

2.8.2. Harvesting methods

The pods from freshly harvested plants still have a moisture content of around 35-50 %, and need to be rapidly dried to a moisture content of around 20-25% so that can easily be separated from the plants. The best method is to pre-dry them in windrows for 2-3 days. After the tap roots have been cut away, the plants are stacked on their leaves with the pods facing downwards.

The **advantages** of this are:

Rapid drying

Avoidance of contact with the soil

A reduction of attacks by insects and the risk of infestation by *Aspergillus spp*.

The quicker the pods are dried after being uprooted, the less aflatoxin is created. Nevertheless, care must be taken not to dry them too quickly, as this could result in a weakening of the testa, which protects the seeds from decay.

Manual harvesting is still widely practised in many countries where it is more profitable, because fewer pods are left in the soil, and they are also less likely to be damaged. Planting on ridges, especially in hard soils, can make the harvest easier. The plants can be extracted by hand with a hoe; this can be made easier still by

[19] ICRISAT (1992): Groundnut A Global Perspective. Proceedings of an International Workshop 25-29 Nov. 1991 ICRISAT Center. International Crops Research Institute for the Semi- Arid Tropics, Patancheru, A.P. India.

cutting below all of the rows with special uprooting blades (pulled either by tractor or animals). In light soils, harvesting machines, similar to those used for potato crops, can be used, and for heavy soils, special peanut uprooters. Purely mechanical harvesting is also often carried out in two stages, with the peanut plants being dried first in windrows in order to reduce the amount of drying necessary in the artificial drying processes. The first machine uproots the plants, shakes off the soil and lays them on the ground upside-down, similarly to manual harvesting. In the second stage, a threshing machine picks up the pre-dried windrows.

2.8.3. Post harvest treatment

Making hay

Foliage from peanut plants provides excellent, protein-rich fodder, with similar nutritional values as lucerne (alfa alfa), and is therefore often also harvested. It can be cut down just before the uprooting takes place and dried into hay. One method of carefully drying after the whole plant has been harvested is to dry the foliage on hay racks, or upright poles, after it has been left to wilt for a short while on a windrow. Otherwise, the valuable leaf parts can get lost.

Threshing

After being dried out in the field, the pods are separated from the plants. The best results are gained when the moisture content is between 20-25 %, because then the pods can be separated easily and completely. If the content is lower, then the pods and seeds will be more susceptible to damage. By far the best method is to separate them by hand. Sometimes, the pods are carefully beaten off with a stick, or, stationary threshing and pick-up threshing machines are used.

Drying

Directly after being threshed, the pods are dried, either artificially or in the sun, until they attain a moisture content of 6-7 %. Delays must be avoided at all costs to reduce the risk of infestation by *Aspergillus flavus,* which rapidly increases. Under 9%, the creation of aflatoxin is retarded, but protection against storage pests, whose activities create aflatoxins, is only attained at levels under 7 %. For this reason, a moisture content of 6-7% is necessary. Problems can often occur when the harvest is carried out during wet weather, and the produce insufficiently dried afterwards. Only at less than 6% will the seeds become damaged (they break during shelling). In cases of extreme sunshine and heat, it may be advisable to carry out the drying process under a roof. The weight loss during drying is compensated for by an increase in quality and a reduction of the risks involved.

In regions where insufficient sunshine is available to dry out the seeds after harvesting, possibilities need to be created to artificially dry the produce, in order to reduce any post-harvest losses and the risk of toxicity problems (e.g. mobile dryers).

Examples:

In Egypt, the peanuts are first dried out in the sun, after threshing, 11-12, cleansed by the wind, and then filled into sisal sacks. The sacks are stacked up under roofs in a special way that allows plenty of air to circulate between the gaps, in order to dry out the peanuts during the next 10 days to a final moisture content of 6-7 %[20].

In the USA, special transport trucks are used that are equipped with ventilation apparatus and gas-firing. Immediately after threshing, the peanuts are dried inside at a maximum temperature of 45°C (best under 35°C), and with a minimum of 10 m³ per minute of circulated air per m³ of peanuts. In order to save energy, ventilation phases can alternate with phases without ventilation.

Sorting

Because usually only a few seeds are infected with aflatoxin, sorting is an effective and important preventative measure after the harvest. Strongly infected pods and seeds are either highly discoloured, or will have shrunk. They can either be sorted manually or mechanically; electronic colour sorting has made it possible to sort out practically all of the aflatoxin infected and bad seeds.

Storage

The main factors which need to be observed in storing is a low moisture content of the seeds (see: drying) and low ambient temperatures. High seed and/or room moisture content, coupled with high temperatures, are the main reasons for the creation of aflatoxins.

Prevention is achieved by:
Sufficient air circulation
Regulation of the relative air humidity
Suitable cooling

Sorting out the damaged and discoloured pods before they are stored
Unshelled peanuts are far easier to store than shelled, because the protective testa remains intact. If they are not to be sold in the pods, they should be shelled only immediately before being sold.

Storage pests: Most storage pests reach the seeds through a broken pod or testa, which means that careful sorting provides good protection. One exception to this rule is *Attagenus fasciatus*, one of the few storage pests that bore into the pods. Some varieties have formed a special resistance against storage pests due to protective substances in their pods and testa. Adding clay powder (0,5% attapulgite) helps against some pests e.g. *Corcyra cephalonica*. Most storage pests cease their activities at a moisture content of the seeds below 7 % and below 20 % air humidity.

[20] SEIF EL-NASR, H. I. (1998): Personal note; professor and organic peanut farmer in Egypt.

3. Product specifications

3.1. The aflatoxin problem

Peanuts are extremely susceptible to infection by the fungi *Aspergillus flavus*. All cultivation measures should be well-planned, to take this aspect into consideration.

Aflatoxin in food can affect the health of both man and animal. The poison aflatoxin is created by fungi of the species *Aspergillus flavus* and *Aspergillus parasiticus*, which are widely disseminated in tropical and subtropical soils. Importing countries have set maximum tolerance values for the presence of aflatoxin in foodstuffs, in order to protect consumers. For consumers in the producing countries, the risks due to the poison are more difficult to ascertain, because the larger part of the peanut harvest is consumed or sold on local markets. Thereby, there are also no “dilution” effects caused by large quantities, meaning that both humans and animals can be subjected to high doses of aflatoxin. Additionally, malnutrition leads to immune systems being weakened. In addition to the huge health risks involved, it also stimulates the growth of a whole row of chronic diseases, first and foremost of which is cancer of the liver. By heeding the preventative measures outlined, economic or health problems regarding an aflatoxin infection should not even arise.

Infection before the harvest

The fungi penetrates the pods during their growth period whilst still in the soil, this takes place in two ways:

A) Infection through invisible damage to the pods or seeds:

Mechanically damaged or bitten pods will quickly be infected by the fungi, which feeds primarily on dead and dying tissue.

Hot, dry soil conditions abets attacks by termites, which are vectors for the fungi’s spores.

Alternating phases of rain and drought causes the pods to split open, and producing high aflatoxin values in the seeds.

B) Invisible infections of the pods:

Many pods are infected after the pegs have been pushed down into the soil. Yet when the plant enjoys good growing conditions, the fungi may remain inactive and no significant amounts of aflatoxin are produced; this is because peanut plants have a natural protection mechanism: The growing plant produces immune substances (phytoalexin), which have a anti-microbe and fungus-suppressing effect (arachidin). All cultivation measures that encourage healthy, natural growth in effect support this protection mechanism.

The production of phytoalexins sinks towards maturity, as well as due to water deficiency, and ceases altogether if a drought continues. In contrast, the fungi *A. flavus* is still able to proliferate and create aflatoxin at much dry conditions, before it also finally ceases all activity. It is encouraged at average temperatures of 26-30°C in the upper 5 cm of the soil. In dry periods, the peanut plant folds its leaves together, meaning that the ground receives even less shade, so that soil temperatures rapidly increase. In hot, dry conditions, *A. flavus* grows very rapidly, this is possibly due to its enemies dying off, for they breed best in hot, humid conditions, when they can keep *A. flavus* under control.

Sufficient irrigation is an effective way prevent the production of aflatoxin (especially during the final 4-6 weeks of the vegetative period), even when the soil temperatures are perfect for *A. flavus,* and 50% of the pods are infested.

Production of aflatoxin after harvesting
When the fungi has actually penetrated, it can create aflatoxin during the drying process, and transport and storage periods. Humidity and temperature are the two main factors. Even manufactured goods, such as peanut flour, are at risk. Although detoxification methods exist, the best approach is always prevention[21]. Measures designed to prevent the build up of aflatoxin have already been described in the previous chapters.

Shipping overseas
A special set of problems arise when peanuts are shipped in containers. Even when a correct examination to test for aflatoxin has been performed in the country of origin, before the harvest was loaded, the shipping conditions may still stimulate the production of aflatoxin to such an extent that the consignment is ruined within a few weeks of being loaded. An aflatoxin test at the port of arrival will therefore reveal entirely different results to the one performed before loading. If the allowed values are exceeded, the entire consignment must be disposed of.
Temperature fluctuations inside the container can be quite extreme, especially when the container is shipped on the deck. The peanuts “sweat” and then, after the outside temperatures have cooled down, water condenses and trickles down the walls. If condensation comes into contact with the peanuts, or drops down on them, this causes an increased infestation of Aspergillus in that spot.

Counter measures[22]:
Drying the peanuts down to a moisture content of 6-7% before shipping them.
Shipping in cooled, ventilated containers (is expensive, yet will avoid the loss of the entire load).
Cover the walls all around with special moisture-soaking foils, or at least cardboard.

[21] KEENAN, J. I. and SAVAGE, G. P. (1994): Mycotoxins in groundnuts, with special reference to aflatoxin. In: SMARTT, J.: The groundnut crop. Chapman & Hall, London.
[22] AUGUSTAT (1998): Mündliche Mitteilung. Naturkostbranche, Erdnußimport.

3.1.1. Aflatoxin testing

After arriving in a European harbour, a test will be carried out according to the **“Dutch Code of Practice”**. The permitted levels of aflatoxin as well as the number of samples required varies from country to country.

Example of upper limits, the unit used is ppb (parts per billion) = microgram/kg

Germany:

Aflatoxin B1 and B2: 4 ppb

Switzerland, Austria and Scandinavia:

Aflatoxin B1: 1 ppb,

Aflatoxin total: 5 ppb

England:

Peanuts used in processing: total: 10 ppb,

Peanuts to eat directly: total: 05 ppb

The Netherlands:

Aflatoxin B1: 5 ppb

United States:

Aflatoxin total: 15 ppb

The European Commission has changed the common regulation for aflatoxins recently. Actually, the following limits are valid in Europe:

a) Peanuts used in processing 10 ppb
b) Peanuts used for direct consumption 4 ppb.

3.2. Peanut seeds

3.2.1. Processing

Peanuts are traded in various quality grades, and are processed in the snack, confectionery, chocolate and baking industries. Peanut seeds are processed into peanut butter and peanut oil, peanut oil is then turned into margarine. Charges which are no longer edible, are then processed into candles, soap and application creams.
The following describes the various production steps in processing peanuts:

<u>Shelling</u>
Th yield of seeds lies around 50% and 80% (normal 70%). Manual shelling is the most careful way of shelling, and yields the highest percentage of unharmed seeds. Shelling machines consist of a drum with corrugated strips and an inner cylinder equipped with rubber beating strips. Seeds and broken up shells fall out through slits, the shells are then blown away by air.

<u>Blanching</u>
Blanching consists of removing the outer skin of the seed by a ‘dry or wet method’.

During the ‘dry method’, the seeds are heated up to a temperature of 139°C and then rubbed together to remove the skin.
During the ‘wet method’, the seeds are pushed through sharp meshes which cut into the skins. The skins are then removed with a jet of warm water, and finally dried to a moisture content of 5%.

Roasting
Peanuts are often roasted in a 150°C bath of Soya or peanut oil. Peanuts in their pods are roasted in large drums at temperatures of around 160°C for 40-60 min. Higher temperatures should be avoided to prevent the oil from evaporating out of the seeds into the pods, or the pods from becoming too dark.
Selecting, sorting and packing

Before they are packed, foreign particles are first removed (stones, pod residues etc.) and the peanut seeds sorted according to quality grades. Selecting into quality grades is based on the number of seeds per ounce (one ounce = 28.35 grams).

Quality grade	number of seeds per ounce (1 oz = 28.35 g)
Large	30-40
Medium	40-60
Small	60-100

3.2.2. Quality requirements

These quality requirements for peanuts, with their minimum and maximum values, are generally issued by the authorities or importers. Yet agreements may be reached between individual manufacturers and importers upon different values, providing they still conform to official requirements.

Quality requirements	Minimum and Maximum values
Appearance	specific – acc. to Quality grade
Taste and smell	Variety-specific, fresh, not mouldy
Purity	Free of foreign substances such as sand, stones, shell rests, insects etc.
Water content	max. 5.0 %
Peroxide units	max. 1.0 milli-equivalent peroxide per kg fat
Free fatty acids	max. 0.5 %
Residues	
Pesticide	Not measurable
Bromide and ethylene oxide	Not measurable

Heavy metals	
Lead (Pb)	max. 0.50 mg/kg
Cadmium (Cd)	max. 0.10 mg/kg
Mercury (Hg)	max. 0.03 mg/kg
Micro-organisms	
Total organisms	max. 10,000/g
Yeasts and mould fungi	max. 500/g
Enterobacteriaceae	max. 10/g
Coliform	max. 10/g
Escherichia coli	Not measurable
Staphylococcus aureus	max. 100/g
Salmonella	Not measurable in 25 g
Mycotoxins	
Aflatoxin B1	max. 2 µg/kg
Sum of Aflatoxins B1, B2, G1, G2	max. 4 µg/kg

In order that the quality requirements are upheld, and no contamination of the fruits occurs, preparation should take place under clean, hygienic and ideal conditions.

3.2.3. Packaging and storage

Wholesale packaging (bulk)
In order to be exported, peanuts are usually packed in wholesale units (bulk) in tins, or bags made of sealable, shrink-foil which is impermeable to steam (e.g. polyethylene or polypropylene) of 10 kg each. Before sealing, either an inert gas (e.g. nitrogen) may be added (nitrogen flushing) and/or the container vacuum-sealed.

Function of the product packaging
If the peanuts are to be packaged in small, consumer units, instead of in bulk packages, then the product packaging should fulfil the following functions:
Protect it from loss of aroma and against undesirable smells and tastes from its surroundings (aroma protection).
Offer sufficient conservation properties, especially against loss or gain of moisture.
Protect the contents against damaging.
Provide a surface area for advertising and product information.
The following materials can be used for the **product packaging**:
Single-foil plastic bags (polyethylene or polypropylene)
Aluminium cans

Transport packaging

Some form of transport packaging is required in order to ship the bulk or singly packed peanuts. In choosing a type of packaging, the following should be heeded:

Transport packaging made, for example, out of cardboard, should be strong enough to protect the contents against being damaged by outside pressure.

The packaging should be dimensioned to allow the contents to be held firmly, but not too tightly in place.

The dimensions should be compatible with standard pallet and container dimensions.

Information printed on transport packaging

The transport packaging should display details of the following:

Name and address of the manufacturer/packer and country of origin

Description of the product and its quality class

Year harvested

Net weight, number

Batch number

Destination, with the trader's/importer's address

Visible indication of the organic origin of the product[23][24]

Storage

The peanuts should be stored in dark areas at low temperatures (under 18°C) and relative humidity. Under optimum conditions, peanuts can be stored for up to 1 year.

If the organic product is being stored in a single warehouse together with conventionally grown peanuts mixing of the different qualities must be avoided. This is best achieved using the following methods:

- Training and informing of warehouse personnel
- Explicit declarations/labels in the warehouse (silos, pallets, tanks etc.)
- Colour differentiation (e.g. green for the organic product)
- Incoming/dispatched goods separately documented (warehouse logbook)

It is prohibited to carry out chemical storage measures (e.g. gassing with methyl bromide) in mixed storage spaces. Wherever possible, storing both organic and conventional products together in the same warehouse should be avoided.

[23] When products from organic farms are being declared as such, it is necessary to adhere to the requisite government regulations of the importing country. Information concerning this is available from the appropriate certification body. The regulation (EEC) 2092/91 are applicable to organic products being imported into Europe

[24] Ecological products must be protected from contamination by non-compliant substances at each stage in the process, i.e. processing, packaging, shipping. Therefore, products originating from a certified organic farms must be recognisably declared as such.