



Food and Agriculture
Organization of the
United Nations

Good agriculture practices (GAP)

Groundnut (*Arachis hypogaea* L.)



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(*Arachis hypogaea* L.)

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Abbreviations

ASEAN	Association of South East Asian Nations
BNF	biological nitrogen fixation
CA	conservation agriculture
CGIAR	Consultative Group on International Agricultural Research
CSA	climate-smart agriculture
DAP	diammonium phosphate
EM	effective microorganism
FAO	Food and Agriculture Organization of the United Nations
FYM	farmyard manure
GAP	good agricultural practices
ICM	integrated crop management
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	information and communications technology
ISO	International Organization for Standardization
IFDC	International Fertilizer Development Center
IPM	integrated pest management
ISBN	International Standard Book Number
LGP	length of growing period
MAP	ammonium acid phosphate
MOP	muriate of potash
NPK fertilizer	nitrogen phosphate potash fertilizer
PPE	personal protective equipment
SSP	single superphosphate
TSP	triple superphosphate
UDP	urea deep placement
USDA	United States Department of Agriculture

Executive summary

Groundnut, a significant oilseed crop in Myanmar, is predominantly cultivated by subsistence farmers in all the three regions of Central Dry Zone. However, it has untapped potential for increased productivity, quality, and market competitiveness through improved crop technologies and the adoption of good agricultural practices (GAP). The adoption of GAP techniques, harmonious with natural agroecosystems and Indigenous Peoples' knowledge, including organic manuring, integrated pest management (IPM), and climate-resilient crop varieties, can be easily adopted by resource-poor farmers. Effective management of limited resources is achievable by careful selection and use of high-quality, environmentally safe inputs like seeds and fertilizers. The current emphasis on consumer awareness necessitates safe, quality food production and resource efficiency, emphasizing the need for better organization of groundnut growers through project-guided marketing to sustain productivity and increase income.

Under the Food and Agriculture Organization of the United Nations' Global Agriculture and Food Security Climate-Friendly Agribusiness Value Chain (FAO-GAFSP-CFAVC) Programme, GAP dissemination for target crops, including groundnut, is a priority. This involves upgrading existing GAP standards based on Myanmar's and ASEAN's practices. The enhanced GAP version focuses on food safety, produce quality, worker health and safety, and environmental management. Implementing GAP will not only enhance food safety and quality but also promote ecological sustainability in groundnut production cropping systems.

Validation and contextualization were achieved through comprehensive research, stakeholder discussions, and insights from relevant stakeholders, including FAO experts.

GAP rollout involves capacity-building among lead farmer organizations, public-private partners, and value chain actors. The framework covers pre- and post-harvest practices for safe, quality groundnut production tailored to small and medium farmers. Key messages facilitate agronomic management practices, supported by farmer organizations, sensitization, technical assistance, and market linkages. On-farm demonstrations, farmer field schools (FFS), training, and information and communications technology (ICT) tools supplement GAP promotion.

Existing user-friendly integrated pest management (IPM) handbooks and FFS curriculum for groundnut support the framework, leveraging farmers' capacity-building and complementing affiliated GAP initiatives.

Glossary of good agricultural practices terms

The following terminologies frequently used in compliance with GAP are important for their understanding, planning and implementation.

Term/Terminology	Definition
Accreditation	The formal recognition by an independent body, generally known as an accreditation or certification body, operates according to international standards.
Active ingredient	Ingredient of a plant protection product that is chemically and biologically active.
Aflatoxin	A toxic secondary metabolite produced by some fungi, especially <i>Aspergillus flavus</i> and <i>Aspergillus parasiticus</i> . Those commonly found in nature are B1, B2, G1 and G2 aflatoxins.
Assessment	An appraisal of procedures or operations based largely on experience and professional judgment.
Audit	The International Organization for Standardization (ISO) defines an audit as a systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent audit criteria are met.
Audit & inspection	A systematic, independent and document process for assessing compliance to GAP standards.
Audit evidence	All the information collected during the course of an audit, which serves as the basis for the auditor to make an opinion and determine compliance with the requirements (standard) being audited against. Such evidence includes records, factual statements and other verifiable information (e.g. observation of work activities and physical examination of products, materials and equipment) that is related to the audit criteria being used. There must be sufficient audit evidence for the auditor to submit a final opinion.
Biodiversity	The variability among living organisms from all sources, including ‘inter alia’ terrestrial, marine and other aquatic systems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.
Calibration	Determination of the accuracy of an instrument, usually by measurement of its variations from a standard, to ascertain the necessary correction factor.
Certification	The provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements.
Certification body	A third party auditing organization that audits facilities against a specific international standard or code.
Checklist	An inspection and audit tool with documented questions that reflect the requirements, procedures, or policies of an organization. For GAP inspections/audits it can be used by producers, producer groups, certification bodies or organizations (approved by GLOBALG.A.P. as appropriate) which help producers to implement GAP standards towards obtaining certification (or GLOBAL G.A.P. certification).
Compliance Criteria (CC)	Information is provided to further illustrate each control point and how to successfully address the requirement(s) identified in the control point.
Control Points (CP)	Each of the requirements is requested by a standard (or GLOBALG.A.P. standards) to implement good agricultural practices. Within the GLOBAL G.A.P. standards, control points are classified as major musts, minor musts, or recommendations.
Control Points and Compliance Criteria (CPCC)	The comprehensive set of control points and compliance criteria that define the standard against which a producer’s performance is measured both internally and externally.

Term/Terminology	Definition
Food safety	The assurance that food will not cause harm to the consumer when it is prepared and consumed according to its intended use.
Good agricultural practices (GAPs)	Practices that address environmental, economic, and social sustainability for on-farm processes, resulting in safe and quality food and non-food agricultural products (FAO).
Hazard (as it relates to food safety):	A biological, chemical, or physical agent that could contaminate food at any stage and cause an unacceptable health risk.
Hazard (as related to GAPs)	A biological, chemical, physical or any other property that may result in a situation that is unsafe for workers, consumers, or the environment.
Hazard Analysis Critical Control Point (HACCP)	A food safety system that identifies hazards, develops control points throughout the flow of food, sets critical limits, and monitors the effectiveness of these control measures.
Hazardous/toxic	Explosive substances such as flammable substances, oxidizing agents and peroxides, toxic substances, substances causing diseases, radioactive substances, mutagenic substances, corrosive substances, irritant substances; and other substances, either chemicals or anything which may cause harm to humans, animals, plants, properties or environments.
Internal controls	A substance or any article including chemicals, microorganisms or microbial toxins which may be harmful to humans, animals, plants, property or environment.
Pesticide	A hazardous substance used in agriculture regulated by DoA in line with Pesticide Law (Pyidaungsu Hluttaw Law No. 14/2016)
Plot	An area in which a crop is planted and is not connected to other areas. In case the area is connected to others, the production management including inputs, cultural practices and personnel of the area, is clearly distinctive.
Quality Management System (QMS)	The organizational structure, procedures, processes and resources needed to implement quality management.
Record	A document containing objective evidence illustrating activities being performed and/or results achieved.
Risk	The chance that a condition or set of conditions will lead to a hazard.
Risk assessment	An estimate of the probability, frequency and severity of the occurrence of a hazard.
Sample/sampling	Selecting a portion of a group of data in order to determine the accuracy or propriety or other characteristics of the whole body of data.
Self-assessment	Internal inspection of the production system and the registered product carried out by the producer or a sub-contractor, based on the GLOBALG.A.P. checklist (or checklist from another GAP scheme).
Standard	A document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose (ISO).
Traceability	The ability to retrace the history, use or location of a product (e.g. origin of materials, processes applied or distribution or placement after delivery) by means of recorded identification markers.
Verification	Confirmation by examination of evidence that a product, process or service fulfils specified requirements.
Visual inspection	An inspection of external appearances of an entity such as a produce, product or apparent environment condition. This is examined by eyes, but other sensory evaluations may be applied depending on the quality factors to be inspected. Additional tools such as magnifying glasses could also be used. Inspection of working procedure and process is also included.

Term/Terminology	Definition
Worker	Any person or a farmer who has been contracted to carry out a task. This includes farm owners and managers, as well as family members carrying out tasks on the farm.

Source: Edmund, Thomas. March 2017. GAP Audit Training Manual.

CHAPTER 1 – INTRODUCTION

1.1. Scope of groundnut good agricultural practices

The GAP framework covers good agricultural practices required for groundnut production with ensuing food safety, produce quality, environmental management and safeguarding workers health and safety in line with Myanmar 2018 GAP guidelines, and ASEAN GAP recommended practices at the pre- and post-harvest crop management stages. The objective is to produce good quality, safe and suitable groundnuts for consumption and processing taking into account inclusive good agricultural production and processing standards.

1.2. Groundnut (*Arachis hypogaea* L.) origin and history

Groundnut (*Arachis hypogaea* L.) also known as peanut and belongs to the Fabaceae family. It is native to South America (Talawar, S., 2004). It is a leguminous oilseed crop cultivated in the semi-arid and subtropical regions of the world. As a legume crop, groundnut improves soil fertility by fixing nitrogen, thus increasing the productivity of other crops in the semi-arid cereal cropping systems. There has been a current, increased awareness in the cultivation of groundnuts, not only as food but also as soil fertilizer. Groundnuts are the principal source of digestible protein, cooking oil, and vitamins for the people of many developing countries. Developing countries in Africa, Asia and South America account for over 97 percent of the world groundnut area and 95 percent of its total production. The most important groundnut growing countries are China, India, Myanmar, Nigeria and the United States of America (Biswas, S., and Bhattacharjee, S., 2019). In many countries, groundnut cake and haulms are used as livestock feed. Groundnut is also a significant source of cash income in developing countries, contributing significantly to livelihoods and food security. (Okello, D. K., *et al.*, 2013). In Myanmar, about 12 to 13 percent of groundnut production is used for direct food consumption, and another 10 to 12 percent as seed (Wijnands, J. H., *et al.*, 2014).

1.3. Nutritional, medicinal and industrial uses of groundnut

Groundnut is a source of high protein and caloric content. Oleic acid, a monounsaturated fatty acid, and linoleic acid, a polyunsaturated acid, constitute approximately 80 percent of the total fatty acid composition of groundnut. Nutritionally, a high content of linoleic acid -being an essential fatty acid- is preferable and has been known to lower total blood cholesterol and low-density lipo-protein levels (Asibuo, *et al.*, 2008). Groundnut seeds contain 40 to 50 percent oil, 20 to 50 percent protein, and 10 to 20 percent carbohydrate, and are also rich in fat-soluble vitamins: A, D, E, K and water-soluble vitamins; B-Complex vitamins, like Riboflavin, Niacin and Thiamine; and, vitamin C. Important essential minerals, such as calcium, copper, iron, magnesium, phosphorus, potassium, selenium and zinc are also present in groundnut (Sahoo *et al.*, 2017). The oil contains 36 to 72 percent oleic acid, 13 to 48 percent linoleic acid and 6 to 20 percent palmitic acid. The oil cake after oil extraction is rich in protein used as human food or as feed. The cake contains 40 to 50 percent easily digestible protein, 20 to 25 percent carbohydrate and 5 to 15 percent residual oil (Wijnands *et al.*, 2014).

Table 1. Nutritional characteristics of groundnut kernel

Characteristics	Content 100-1 g		
	Raw	Roasted	Defatted flour
Calories (g)	564.0	582.0	371.0
Proteins (g)	26.0	26.0	45.0
Fat (g)	47.5	48.7	5.8
Carbohydrate (g)	18.6	20.6	30.0
Calcium (mg)	69.0	72.0	127.0

Table 1. Nutritional characteristics of groundnut kernel			
Phosphorus (mg)	401.0	401.0	800.0
Iron (mg)	2.1	2.2	3.5
Thiamine (B1) (mg)	1.14	0.32	0.75
Riboflavin (B2) (mg)	0.13	0.13	0.35
Niacin (mg)	17.2	17.2	2.5
Source: Biswas, Sritama & Bhattacharjee, Subhradip. 2019. Groundnut: Multifarious utilities of the 'King of Oilseeds'. 1. 373-377.			

1.4. Economic importance

Myanmar is reported to be the world's seventh largest producer of groundnut, with an annual production totaling 0.76 million tonnes and 1.58 million tonnes, respectively (FAO, 2019). Myanmar's CDZ is regarded as the country's "oil bowl" (Belton and Win, 2019).

Due to diverse agroecological conditions, a wide variety of oilseed crops are cultivated in Myanmar. Oilseed crops are third in importance after cereal crops and pulses, while groundnut is an important edible oil and food crop in the country. Thousands of smallholder farmers in Myanmar grow groundnuts for household food consumption and marketing in the local market, which is then sold in big cities markets with value addition by the middle functionaries. In Myanmar, groundnut is classified as a major oilseed crop because of the high oil content in the grain. (San Sint, 2019). Groundnut is mainly produced in CDZ as sole crop or in double cropping systems and is an especially important crop for rainfed subsistence farmers. Both groundnut and sesame are the sources of cooking oil and food for home consumption, the oil cake and stover are used as livestock feed, and any surplus can be sold for cash (Phyo, 2008). The edible oils traditionally consumed are also groundnut and sesame oil. Sesame oil is estimated to account for between 5 and 10 percent of total edible oil consumption, while groundnut oil accounts for the remaining 90 to 95 percent (Fujita and Okamoto, 2006).

1.5. Morphological characters

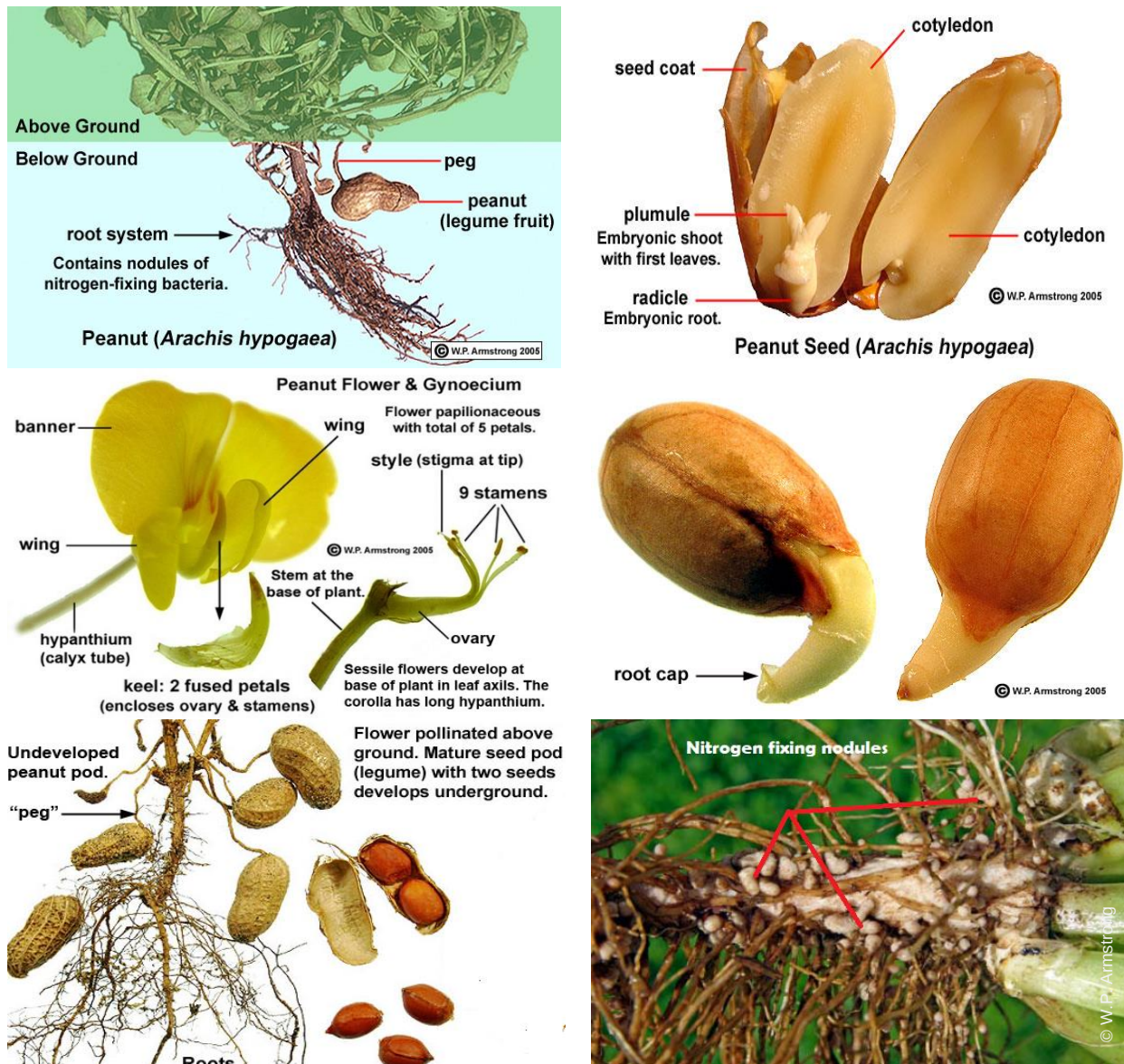
Groundnut, an annual plant/herb (legume) is considered as the "King of Oilseeds". It is also known as earthnut, monkey-nut, goobers or peanut in British and American terms (Biswas and Bhattacharjee, 2019). In terms of the features of a groundnut plant, its main stem develops from a terminal bud of the epicotyl and two cotyledonary laterals grow on opposite sides; it has tetra-foliate leaves, with leaflets on the main stem differing in shape and size from those on lateral branches. Like other leguminous crops, such as clover and alfalfa, the peanut root system contains nodules of nitrogen-fixing bacteria that convert inert atmospheric nitrogen into ammonia.

After fertilization, the developing pod is forced downwards, into the ground, by the proliferation and elongation of a special structure called "peg", stemming from cells below the ovary (also known as intercalary meristem by experts). The pod typically contains two seeds, each with a papery seed coat. The germinated peanut seeds show the embryonic root (radical) and root cap. The root cap protects the delicate meristematic root tip as it pushes into the soil. A tiny embryonic plant comes out at germination within the two fleshy halves (cotyledons) of seed. The cotyledons provide carbohydrates and protein for the developing embryo until it develops into a seedling with functional roots and photosynthetic leaves.

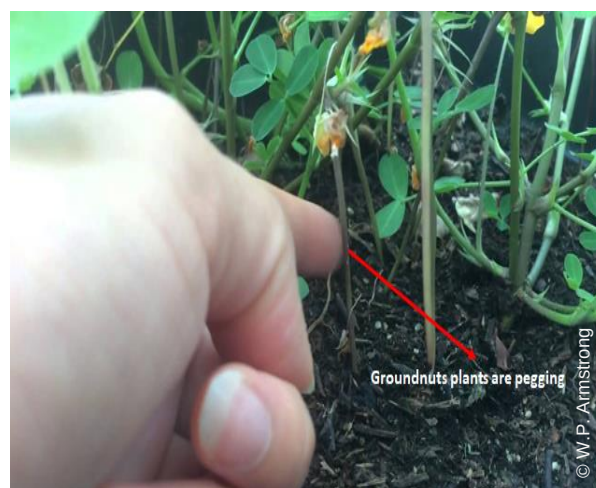
The mature peanut flower has an elongate, tubular hypanthium (calyx tube) which is not a pedicel. The pollen tube has to grow through this tube to reach the two ovules in the ovary at the bottom of the flower, directly at the axillary bud. After self-pollination, the petals, including the hypanthium, dehisce and remain on the tip of a developing "peg" at the base of the ovary (named "gynophore" by Darwin). The peg enlarges and grows down and away from the plant forming a small stem-like structure (with the groundnut embryo at its tip) that penetrates the soil; this process is called "pegging." As the peg

elongates, a cap of cells forms next to the withered style. The cap protects the ovary as it is pushed into the soil. This is similar in function to the root cap at the tip of a root. After the developing ovary has pushed a few centimetres into the soil, downward elongation of the peg ceases. The ripening ovary becomes parallel to the ground surface where it completes its development. After fertilization, the peg (stalk) of the peanut curves downward and the developing fruit (legume) is forced into the ground. The groundnut pods complete their growth underground.

Figure 1. The peanut: Amazing geocarpic legume



Source: Armstrong, W. P. 2020. The Peanut: Amazing Geocarpic Legume. <https://www.waynesword.net/ecoph8b.htm>



Source: Armstrong, W. P. 2020. The Peanut: Amazing Geocarpic Legume. <https://www.waynesword.net/ecoph8b.htm>

1.6. Groundnut production status in Myanmar

Groundnut is one of the most important oilseed crops in Myanmar, mostly grown both in rainfed and irrigated areas, especially in CDZ regions. According to Wijnands *et al.*, (2014), Myanmar is increasing the production of groundnuts at a steady pace since 2003 and is the seventh largest producer of groundnuts. The productivity and yield of groundnut is still very low as compared to the world average. It is highly important to increase edible oil production through increased productivity and reduction of the yield gap.

Groundnut is primarily produced in the central regions under rainfed conditions. Magway and Mandalay contribute significantly to crop production with a total of 149 639 and 120 477 ha, respectively. According to the more recent statistics, the production volume of groundnuts in Myanmar was approximately 1.6 million tonnes in 2018 as compared to 1.37 million tonnes in 2010.

Table 2. Harvested area, production and export of groundnut in Myanmar

Year	Area harvested (000 ha)	Total production (000 MT)	Yield (MT ha ⁻¹)	Export	
				Volume (000 MT)	Value (million USD)
2014–15	949	1 525	1.61	50.11	58.71
2015–16	952	1 548	1.63	47.59	60.55
2016–17	989	1 598	1.62	100.43	114.27
2017–18	1 034	1 608	1.56	70.27	73.27
2018–19	1 058	1 588	1.5	70.65	86.39

Source: Myanmar Agriculture at a Glance, 2019. MoALI

1.7. Constraints/causes of low yield and productivity of groundnut in Myanmar

Based on the FAO-GAFSP project GAP situational analysis, various constraints were identified, of which some of the below summarized relate to the major challenges in effective target crops GAP promotion, including groundnut. The following are the main constraints in achieving high yield and productivity of groundnut:

- cultivation of groundnut on marginal (rainfed, eroded) and lands with poor fertility status;
- water scarcity and limited access to supplementary irrigation facilities at critical growth stages of the crop, subjecting the crop to drought;

- poor agronomic and low GAP implementation;
- resource-poor farmers cultivate low affordability-for-quality crop inputs as the crop;
- less capital availability for crop management and lack of appropriate storage facilities;
- use of low yielding and late maturing groundnut varieties;
- high incidence of diseases and insect pests and less capacity of farmers to apply and integrated crop management (ICM) approaches; and
- inadequate availability of high-quality inputs and certified seeds of improved varieties.

1.8. Planting seasons and crop calendar

Groundnut is cultivated in two seasons. monsoon crop is sown in May/June and harvested in August/September. With winter being the major sowing season, the crop is cultivated in October/November with residual moisture from the monsoon season and is harvested in January /February.

Groundnut Crop Calendar												
Seasons	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Monsoon					S*			H**				
Winter	H									S		
*S: Sowing **H: Harvesting												
Seasonal Calendar of Groundnut												

Source: DOA-Extension Division, 2020. Yearly Reports of Crop Production, Internal Report. Department of Agriculture, Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, Myanmar

CHAPTER 2 – CROP PRODUCTION REQUIREMENTS

2.1. Crop production requirements

2.1.1. Climatic requirements

2.1.1.1. Temperature

For rapid seed emergence, soil temperature above 21 °C is required, while optimum temperature for rapid seedling development is about 30 °C. Temperature above 35 °C inhibits the growth of groundnut (Nautiyal, 2002). The optimum temperature for vegetative growth is 27 to 30 °C, 24 to 27 °C for reproductive growth and 30 to 34 °C for pod formation. Low temperature at sowing time delays germination and increases the likelihood of seed and seedling diseases as well as infestation by sucking pests (Ajeigbe *et al.*, 2014).

2.1.1.2. Moisture/rainfall

The average annual rainfall for groundnut production is 584 to 660 mm (23 to 26 inches). The relative humidity during the cropping season is generally around 70 percent (Cummins, 1986), with evenly distributed rainfall between 450 mm (18 inches) and 1 250 mm (49 inches) for good growth and yield. Early maturing varieties require 300 to 500 mm (12 to 20 inches) while medium to late maturing varieties need 1 000 to 1 200 mm (39 to 47 inches) rainfall. (Okello *et al.*, 2013). Drought also increases the probability of pre-harvest aflatoxin contamination due to infection by *Aspergillus flavus*. Use of improved, early-maturing and drought-tolerant groundnut varieties, crop diversification and improved soil and water management practices would provide the opportunities to alleviate the adverse effects of drought on groundnut productivity (Ajeigbe *et al.*, 2014).

2.1.1.3. Soil requirements

In order to encourage pegging and pod development, the topsoil should have low clay contents (less than 20 percent). In the case of high clay content percentage in the topsoil, the groundnut pegs will break at harvest. Soil compaction can also be a problem if the fine sand fraction of the topsoil is high. This situation can be aggravated in soils where the organic residues are low. Well-drained, coarse-textured and sandy loam or sandy clay loam soil with a pH of 6.5 to seven is ideal for groundnut production. Such soils produce clean pods bright in appearance, fetching high prices in the market. Soils with high soil pH cause micronutrient deficiency, namely boron, copper, iron and zinc. Sodic and saline soils should be avoided for groundnut planting. Saline soil and soils with a pH of less than 5.5 are unsuitable for groundnuts. Heavy soils or clayey soils are not suitable because of harvesting losses. Pegging is also difficult on heavy soils, unlike sandy loam soils, which facilitate pegging. (Ajeigbe *et al.*, 2014). Similarly, the Department of Agriculture (DAR, 2004) reported that loamy soil, including 44 percent of sand, 35 percent of silt and 21 percent of the clay enhances root formation and plant growth leading to better pod formation, thus giving the highest yield.

2.2. Crop production technology

2.2.1. Site selection

Selection of land for growing groundnuts is an important consideration for the production of safe and quality groundnut produce. The biological and chemical history of the site prior to use for production must be considered. Soil can contain pathogenic microorganisms, persistent chemicals and heavy metals. Sites with a history of previous chemical contamination due to industrial use, used for hospital wastes, livestock farming, and other hazardous waste disposal purposes should be avoided. Lands situated in proximity of sewage and drainage lines should not be selected as cultivation sites. The soil should be tested for heavy metals beyond the permissible level¹. Information about prior use of the

¹ According to Codex MRL for Agricultural Produce in Myanmar, Maximum limit for heavy metals, Lead: NMT 10.0 mg kg⁻¹ or 10.0 mg L⁻¹ (10.0ppm), Arsenic: NMT 5.0 mg kg⁻¹ or 5.0 mg L⁻¹ (5.0ppm), Mercury:

site/site history, enlisting current and potential hazards on the site and adjacent to the site of cultivation should be recorded and kept at the farm. A site map must indicate/demarcate production sites with slopes, exposure to erosion and other hazards with areas designated for storage of chemicals, location of roads, watercourses, and drainage or sewage lines. To ensure produce quality, food and environmental safety, the following key guidelines as per Myanmar and ASEAN GAP should be followed:

If the risk of chemical, biological and physical contamination is high and cannot be controlled, the site must not be used for production and postharvest handling of produce. An alternative site should be selected and assessed for risks (ASEAN GAP)

- The risks of contaminating produce with chemical and biological hazards from the previous use of the site or from adjoining sites must be assessed for groundnut cultivation and a record is to be kept of any significant risks identified.
- Where a significant risk of chemical or biological contamination of produce has been identified, either the site is not used for the production of fresh produce or remedial action is taken to manage the risk. If remedial action is required to manage the risk, the actions need to be monitored to check that contamination of the produce does not occur, and a record is kept of the actions taken with monitoring results.
- Highly degraded areas must be managed to minimize further degradation, while for new sites, the risk of causing environmental harm on- and off-site is assessed for the proposed use and a record is kept of all potential hazards identified.
- The location of any contaminated sites on the property, which are unsuitable for the production of fresh produce, should also be recorded.

Site selection and site management

Refer to [Myanmar GAP Guidelines](#) at Annex 1, for practices at S.No. 1.1 and [ASEAN GAP Guidelines](#) at Annex 2.2 for practices at S.No 2.2.1, Annex 2.3 for practices at S.No. 2.3.1

The record of the field production sites should be kept as per the details given in Annex 3 (Form-1. Site Inspection; 1 to 5 and Surrounding Areas; 1 to 3).

2.2.2. Land preparation

Deep tillage with moldboard ploughs up to a depth of 25 to 30 cm should be followed by disc/harrow to level and pack the soil. Fertilizer should be properly incorporated into the soil before final seedbed preparation. It is highly important, to ensure weed-free and clean cultivation, to remove stumps of the previous crop, properly dispose of it and/or use it as farmyard manure or for compost-making, instead of burning it and causing air pollution.

“Zero tillage is ideal, but the system may involve controlled tillage in which not more than 20 to 25 percent of the soil surface is disturbed.”

In the case of rainfed areas, ploughing should be done before rainfall for retention of soil moisture and increasing soil permeability for better germination and root growth. Apply well-decomposed farmyard manure at 12 to 16 cartloads ha⁻¹ (five to seven cartloads acre⁻¹) of well-decomposed cattle manure followed by its incorporation into the soil. In the case of lands with moderate or high slopes, ploughing should be done across the slope, not parallel, to prevent soil erosion.

NMT 0.5 mg kg⁻¹ or 0.5 mg L⁻¹ (0.5ppm), Cadmium: NMT 0.3 mg kg⁻¹ or 0.3 mg L⁻¹ (0.3ppm); ASEAN guidelines on limits of contaminants for health supplements.

2.2.3. Recommended varieties, seed and seed quality

2.2.3.1. Seed selection

According to the findings of the project GAP situation analysis, 63 percent of interviewed farmers ranked access to quality seed of improved varieties as one of the main issues.² Proper selection and handling of groundnut seed is highly important because of its susceptibility to physical damages and pathological contamination. Damaged or split kernels should be avoided because of low germination risk. Seeds are also sensitive to fungal rot; therefore, treatment with recommended fungicides should be performed to control seed-borne diseases. DoA recommended seeds of approved varieties should be used

(see Table 3). Germination should not be less than 80 percent, with physical and analytical purity of 98 percent. It is better to shell the seed two weeks before planting to prevent any damage. Hand shelling should be practised to avoid physical damage, such as breakage and skin peeling of the seed. After shelling, removal of shrivelled, immature, mouldy, skinned and small seeds is highly important for ensuring uniform and recommended plant standards. Seeds should be free of deformities, wrinkles and cracks.

Obtain and maintain good quality groundnut seed: Preserve unshelled groundnut seed for sowing-Shell the seeds only two weeks before the planting-Shell manually to avoid physical damage to the seeds-Remove undesirable seeds.

An easy way to test seed germination: Conduct the test at home using soft tissues/cloth or through a sample of soil collected in a simple container→ Randomly select 20 or 100 seeds from the seed stock→Evenly place the seeds in a trench of 1–2 m long (3–6 feet) and cover with 3–5 cm of moist soil→Keep the soil moist on daily basis and observe for 5–7 days to see the germinated seeds; the number of seeds out of the total seeds shows the viability and germination percentage.

2.2.3.2. Recommended varieties

To improve productivity, yield stability, high market return and insect pest resistance as well as the nutritional value of groundnut, the following DoA recommended varieties should be used for groundnut cultivation.

Table 3. Recommended groundnut varieties in Myanmar

Variety name	Growth cycle (seed to seed)	Average Yield potential (kg ha ⁻¹)	Shelling percent	Oil content (percent)	Remarks
Sinpadaethar-1	95–100	1 121–1 261	74–75	53–54	Short duration/good for irrigated areas
Sinpadaethar-2	105–110	1 261–1 345	70–73	52–53	High yield potential/good for irrigated areas
Sinpadaethar-3	120–130	1 821–2 662	68–70	52–53	Good for irrigated areas, alluvial soils
Sinpadaethar-5	105–120	1 541–1 821	68	50–51	Resistant to leaf spot disease
Sinpadaethar-6	105–115	1 401–1 681	74	48–49	Drought resistant
Sinpadaethar-7	90–95	1 681–1 961	74	49–50	Short duration, high yield potential
Sinpadaethar -8	100–105	1 541–2 241	72–75	47	All season, especially for CDZ
Sinpadaethar-11	100–105	1 541–2 521	73	48	Resistant to leaf spot, High yield potential

² GAP (Good Agriculture Practices) Situational Analysis: Problems and Prospects Analysis for GAP Promotion in Magway, Mandalay and Sagaing Regions under Climate-Friendly Agribusiness Value Chains Sector (CFAVC) Project & Global Agriculture and Food Security Programme (GAFSP) Myanmar, March, 2020.

Table 3. Recommended groundnut varieties in Myanmar

Sinpadaethar-12	105–110	1 401–1 681	72	46–47	Drought resistant
Sinpadaethar-13	105–110	1 681–2 241	74	44	High yield potential
Magway -16	95 –100	2 241–2 802	70	48	Draft resistant and high yield potential
Magway -17	100 –105	2 521–2 662	72	44–56	Short duration and high yield

Source:

DAR. 2018. Released New Varieties. Department of Agricultural Research, Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, Myanmar, 168 pp.

DAR. 2019. Research outcomes after 65 years of DAR's effort (in Myanmar). Department of Agricultural Research, Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, 202 pp.

Details of planting/propagation materials (seeds) such as variety, source of supply, amount of supply and the date of supply for seeds, seedlings and plant propagations should be recorded as per Annex 3 (Form-1. Seed selection; 1 to 3, Form-2. Seed Seedling⁻¹; 1).

2.2.3.3. Seed rate

Seed rate depends on various factors such as seed quality, germination, and variety, time of sowing, soil condition, and availability of labour, preferred crop management practices, and crop utilization. A seed rate (seed without shell) of 75 to 80 kg ha⁻¹ (167 000 plants ha⁻¹) (about 1.2-basket acre⁻¹ of groundnut seed) for spreading and semi-spreading types and 95 to 100 kg ha⁻¹ (220 000 plants ha⁻¹) (about 1.5 baskets acre⁻¹ of ground seed acre⁻¹) for bunch and semi-bunch types is recommended.³ The DOA recommended seed rate (groundnut pod with shell) is 168 to 224 kg ha⁻¹ or six to eight baskets acre⁻¹ of groundnut pods with shell or 1.5 to 2.0 basket acre⁻¹ of groundnut seed without shell. Seed rate should be increased if the seeds are planted deep, soil moisture is limited, soil temperature is low, or the soil is compacted or trashy/cloddy and germination is less than 80 percent.

Seed and planting materials: Refer to Annex 1, practice 1.3, 1.6 of Myanmar GAP groundnut 2018 and Annex 2.1 practice 2.1.2, Annex 2.2 practice 2.2.2 and Annex 2.3 practice 2.3.2 of ASEAN GAP guidelines for further guidance

2.2.3.4. Seed inoculation and treatment

In groundnut, a bacterium responsible for fixing nitrogen in the root zones/nodules provides a good amount of nitrogen to the soil, which is not only utilized by the existing crop but also by the next crop. It also improves soil fertility, soil structure and texture. Rhizobium inoculation could be beneficial in newly cleared fields, rice fallows, fields with eroded soils and low fertility. Seeds should be treated just before sowing with Rhizobium culture as starter for early and effective initiation of nodulation.

Rhizobium inoculation: Gets the best from your legume crop, increases no cost soil fertility beyond the current crop and sustains farm productivity and resource efficiency (GRDC, 2017)

Before deciding about the inoculation of groundnut seed, it is important to follow the following steps:⁴

- use the right inoculant for groundnut: other legume crops such as soybean or green gram/cow pea inoculant should not be used for groundnuts;
- check the expiry date on the packet of rhizobium before use;
- make sure that the inoculant is stored at the right temperature (at or below 12 °C);
- keep the inoculant under the shade as exposure to the sun reduces its effectiveness;

³ Peanut cultivation, <https://www.bakhabarkissan.com/peanut/>

⁴ Rhizobium inoculation: Get the best from your legume crop. Department of Employment, Economic Development and Innovation Agri-Science Queensland.

https://www.daf.qld.gov.au/_data/assets/pdf_file/0005/58946/Rhizobium-brochure.pdf

- check soil pH—apply lime if it is less than 5.5 as acidic soils reduce the efficacy of inoculation;
- ensure that sufficient soil nutrients are available for increased efficiency of inoculants; and
- do not plant and apply inoculum in dry soil as dry soil reduces bacteria survival and effectiveness:
 - Ensure intimate contact between the inoculant and seed. The rhizobia have to penetrate the root within 24 to 72 hours.
 - Sow the seed within six hours after treatment. If applying inoculant to the seed (as a peat slurry), sow as soon as possible after treatment.
 - Physically separate the fertilizer from the seed and rhizobium. Rhizobium is much more sensitive to the fertilizer's 'salt effect' than seeds and seedling.

Figure 2. Step 1: Materials required are inoculant, adhesive, seed mixing bowl and spoon



Figure 3. Step 2: Preparing the slurry by mixing inoculant and sticks



Figure 4. Step 3: Mix the slurry with seed until uniformly coated



Figure 5. Step 4: Place the inoculated seeds on clean surface to dry and plant as soon as possible



Seeds should be treated with DoA recommended safe fungicides to prevent soil borne disease The (3–6) kg of Furadan insecticide is applied in the rows to prevent soil born pests and stem borers (DoA recommendations).

Seed treatment: Refer to Annex 1 practice 1.3, 1.5 of Myanmar GAP guidelines 2018 for groundnut, Annex 2.1 practice 2.1.5, Annex 2.2 practice 2.2.5, 2.2.8 Annex 2.3 practice 2.3.6 and Annex 2.4 practice 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.5 of ASEAN GAP guidelines for further guidance.

Maintain a record of seed treatment with details of chemicals used for seeds, seedlings and plant propagations as per the details given in Annex 3 (Form-2, Seed Seedling¹; 2).

2.2.4. Sowing method

As a monsoon crop, groundnut should be planted immediately after the onset of monsoon rain when there is sufficient moisture for seed germination, normally after heavy rainfall. Appropriate planting geometry is highly important for maximum yield and quality of groundnut as well as ease in other cultural operations, such as weeding, interrow cultivation, and disease and insect pests' control.

Table 4. Planting geometry for groundnut

Variety Types	Plant x Plant Distance (inches)	Row x Row Distance (inches)	Plants population per hectare	Seeding depth (inches)
Erect type	4	12 – 15	(322 000 – 258 000)	1.5 – 2
Bushy/branching type	6	18	(143 000)	1.5 – 2

Source: DOA-Extension Division, 2020. Yearly Reports of Crop Production, Internal Report. Department of Agriculture, Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, Myanmar

Seeding depth is very important as sowing deeper may adversely affect crop performance, causing delayed emergence, elongated hypocotyl, poor shoot and root development, poor nodulation (nodules formation) and low level of nitrogen fixation consequently decreasing the yield. One of the critical factors limiting the yield of groundnut is low plant population, which can be improved by the use of proper planting methods.

Sowing method and planting geometry: Refer to Annex 1. Practice 1.6 and 1.13 for care and management under Groundnut Myanmar GAP guidelines 2018 Sowing method and planting geometry should be recorded as per Annex 1 (Form- 1. Cultivation Method; 1 to 3).

Figure 6. Row spacing for planting groundnut



Figure 7. Row spacing for planting groundnut



Figure 8. Groundnut crop infested with weeds



Figure 9. Pegs exposure due to late weeding



2.2.5. Manures and fertilizers

2.2.5.1. Inorganic/chemical fertilizers

Type, dose, method and time of fertilizer application depend on existing soil physical properties, such as soil texture (clay, silt, loam) and soil structure, soil moisture and relative humidity, existing nutrients (K, N, P and necessary micronutrients), soil pH, organic matter, type of fertilizers applied to the previous crop, previous crop grown (leguminous or non-leguminous, deep or shallow rooted), risk of nutrient losses due to fertilizer application, degree of soil erosion and irrigation practices.

As per the FAO-GAFSP project GAP situation analysis, 49 percent of respondent farmers are unable to apply fertilizers as required by improved crop management regimes. The fertilizer application is carried out only at sowing time and about 62 to 185 kg ha⁻¹ of compound fertilizers (25–75 kg acre⁻¹) such as 15:15:15 or 10:10:5 (NPK) are used as basal application only. Fertilizers should be applied in line with DoA technical recommendations on a site-specific and soil analysis basis. To avoid low quality/low grade fertilizers, procure fertilizers from DoA approved fertilizers from registered suppliers. The equipment for application should be regularly checked for proper function and should be operated by trained workers. Name of the fertilizing product or material, date, treatment location, application rate and method, and operator name should be properly documented and kept on record.

Fertilizers, soil additives and soil substrates: Refer to Annex 1 practice 1.6 and 1.13 of Myanmar Groundnut GAP guidelines 2018, Annex 2.1 practice 2.1.3, 2.1.9 Annex 2.2 practice 2.2.3, 2.2.8, 2.3.13 Annex 2.3 practice 2.3.3, 2.3.4 Annex 2.4 practice 2.4.1 and 2.4.5 of ASEAN GAP guidelines for further guidance.

10.5.1.1. Nitrogen and nitrogenous fertilizers-type, method and time of application

Role and importance of nitrogen: Nitrogen is required for the vegetative and reproductive growth of groundnuts, nutrient absorption, photosynthesis, and production of assimilates for the developing pod. The nitrogen requirement of groundnut is significantly higher than cereals due to high protein content. Soils where groundnut is cultivated are often poor in fertility and deficient in nitrogen. Groundnut, as a leguminous crop, has the capability to obtain its nitrogen from symbiotic nitrogen fixation up to 60 to 80 percent by root nodules and soil nitrogen up to 20 to 40 percent (Singh *et al.*, 2004, p.23). However, the nitrogen supply of groundnut is very crucial, and deficiency is observed during early growth stages until 45 days after emergence (DAE) and at pod-formation stages. During the reproductive stage, nitrogen is mobilized continuously from leaves to the developing pods, hence deficiency occurs at this stage too. For these reasons, nitrogen must be applied to groundnut at these stages.

Nitrogenous fertilizers: Commonly available source of nitrogen as chemical fertilizers are, urea with 46 percent nitrogen available in granules or crystalline form, ammonium nitrate with 34 percent

nitrogen in solid granular form, and ammonium sulphate with 21 percent nitrogen, and 24 percent sulphur (*Fertilizers and their Use, Agriculture Extension Service, University of Tennessee USA*)

Rate of nitrogen application: Nitrogen fertilizers should be applied according to DoA site-specific recommendations, on soil test basis. In the case where soil tests are not available, nitrogen at 20 to 40 N kg ha⁻¹ for rainfed crop, and at 30 to 50 kg ha⁻¹ for irrigated crop, should be applied for higher pod yield (Singh and Basu, 2005 p.18).

Method and time of application: To obtain maximum pod yield and increase N fertilizer use efficiency, nitrogen should be applied as split application with 50 percent as basal dose, followed by two split applications as top dressing, with 25 percent at 30 DAE and remaining 25 percent at 70 DAE (Singh and Basu, 2005 p.18). According to Shapiro et.al, 2008, N fertilizers can be applied as broadcast, pre-plant banding or side banding at planting, depending on type of fertilizer, planting geometry, soil moisture, and soil type. In case of side banding and row application, fertilizers should be applied five to eight cm to the side of the plant/planting area and three to five cm deeper than the seeds.

10.5.1.2. Phosphorus and phosphate fertilizers-type, method and time of application

Role and importance of phosphorus: P is an important component of various enzymes, proteins and involved in many biochemical processes. P deficiency is manifested in many forms, such as poor plant growth, low shelling percentage and oil content. P is very critical at flowering and pod formation stages. Phosphate application stimulates root growth and builds groundnut resilience to dryness. According to Singh et al, (1994, p 165), groundnut responds to P application by increasing shelling percentage, oil yield and improved nodulation. P also stimulates flowering in groundnuts and helps in better seed setting, besides enhancing the activity of Rhizobia and nodulation.

Phosphate fertilizers: Commonly available phosphate fertilizers are diammonium phosphate (DAP) with 18 percent N and 46 percent P₂O₅, available in granular form, triple super phosphate (TSP) with 46 percent P₂O₅, available in solid granular form, and single super phosphate (SSP) with 20 percent available in solid granular form. Phosphate fertilizers, however, should be applied on site-specific basis to ensure their effective utilization by the plants (*Fertilizers and their Use, Agriculture Extension Service, University of Tennessee USA*).

Rate of phosphorous application: P fertilizers should be applied on site-specific basis after soil testing for soil phosphorus. The application also depends on soil structure, losses of phosphorous due to erosion, flooding and other abiotic stress factors. Groundnut responds significantly to phosphorous fertilization when the soil test indicates that phosphorous is below optimum—very low or low. In the case where soil tests are not available, 75 kg P₂O₅ ha⁻¹ should be applied for the highest pod yield, shelling percentage and oil contents (Rath et al., 2000).

Method and time of phosphorous application: Before considering the method of application of phosphorous to the groundnut, it is imperative to place phosphorous below the soil surface in proximity to the plant's growing roots, so they may absorb phosphorous for increased fertilizer use efficiency. Phosphorus should be applied in two equal split doses; 50 percent as basal dose and 50 percent at 30 DAE. Optimum fertilizer method of application also depends on the phosphorous in the soil. Broadcasting and incorporation is an efficient method of building phosphorous in the soil and ensuring uniform distribution of the nutrient in the case of broadcast cultivation of the crops, making it possible for the crop to have uniform access to the nutrient. P if applied but not incorporated in the soil leads to risk of phosphorous losses (Wiens, 2017).

10.5.1.3. Potash and fertilizers-type, method and time of application

Role and importance of potash

Potassium is an important nutrient for groundnut and increases its peg formation, synthesis of sugar and starch and helps in pod growth and filling (Dwivedi et al., 1997). Potassium deficiency symptoms first appear in the older leaves, characteristically developing mottling or chlorosis. The yellowing of leaves starts from the tips or margins, extending towards the centre of the leaf base. Drying up of the leaf margin with necrotic symptoms and reddish colouration of tip of branches are the main symptoms of

potassium deficiency. The stem becomes red accompanied by excess storage of starch and the leaves become light green.

Potash fertilizers: Commonly available potash fertilizers are potassium chloride, with 60 percent potassium, available in solid granular form, muriate of potash (MoP) with 60 percent K_2O , potassium sulphate, with 50 percent potassium, and 18 percent sulphur available in solid granular form and potassium nitrate with 13 percent nitrogen and 44 percent potassium available in granular or crystal solid form (*Fertilizers and their Use, Agriculture Extension Service, University of Tennessee USA*).

Rate of potassium application

The right rate of K should be administered to the plant on soil-test basis, previous potash fertilizers applied to the crop, crop uptake, its residual effect, previous crops cultivated, soil chemical properties, soil structure and texture, and level of potassium losses from the soil. However, if the soil tests are not available, then 25 to 50 kg K_2O ha⁻¹ should be applied to rainfed crop and 40–75, K_2O ha⁻¹ to irrigated crop (Singh and Basu, 2005).

Method and time of potassium application

Method and time of potassium application to groundnut depends on the climatic, soil physical and chemical characteristics, and crop growth stage. In areas with cool seasons and soils with low potassium fertility, banded application is recommended, besides other factors such as when the quantity of fertilizer is too small, development of root system is poor, and soil has low potassium levels. However, placement of potassium as band or dressing should be administered enough away from the plant so that the salt content may not negatively affect seed germination or seedling growth. Foliar application is also recommended, especially when the uptake or demand of plant for K is steady or in case of deep-rooted plants (Bell *et al.*, 2017). The broadcast method is also used for potassium application, but it should be subsequently incorporated into the soil to facilitate roots-to-fertilizer contact and effective uptake. Due to the less mobile nature of K, a full dose should be applied before or during sowing time, except in coarse textured (sandy) soil, due to a high rate of leaching, whereby K application is also recommended at the early growth stages of the crop (Ravichandran & Sriramachandrasekharan, 2011).

10.5.1.4. Compound fertilizers (NPK)

Smallholder farmers usually apply compound fertilizers with a different nutrient ratio of the three major nutrients (NPK) due to their difficult access to soil analysis, cultivation of multiple crops and facing financial constraints. Blended fertilizers result in high yield but are not addressing other nutrients, especially micronutrient deficiency in the soil. Different blends of NPK fertilizers are available in Myanmar, i.e. 20:20:10 (NPK), 15:15:15 (NPK), 20:10:05 (NPK), 30:10:10 (NPK), 20:20:10 (NPK), 15:15:15 (NPK), and 15:10:05 (NPK) for various types of soils and crops cultivated. However, it is highly important to apply compound fertilizers on a site-specific, soil test basis, to avoid soil toxicity, optimize the nutrient requirement and uptake in increasing the yield of groundnut, and the benefits of interactions between the organic and inorganic fertilizers, as well as increased fertilizers use efficiencies. As reported from a research study by Subrahmaniyan *et al.*, (2000), the application of NPK (kg ha⁻¹) with a ratio of 17:34:54 resulted in better growth and yield parameters, with a pod yield of 1 848 kg ha⁻¹. Prabhakaran *et al.*, (1998) also reported that NPK (kg ha⁻¹) with a ratio of 17:34:54, combined with gypsum at 500 kg ha⁻¹ and a micronutrient mixture at 12.5 kg ha⁻¹, enhanced the yield of groundnut. NPK fertilizers should be applied as basal dose as row or band application. In the case of broadcast application, the fertilizers should be fully incorporated into the soil (TNAU Agritech Portal).

10.5.1.5. Essential and micronutrients

Groundnut also needs other essential elements, especially calcium (Ca), magnesium (Mg), sulphur (S), and several micronutrients required in relatively small quantities but sometimes critical for improved plant growth, development and productivity. Soil phosphorus (P) and sulfur (S) levels are low in coarse-textured soils of Myanmar's CDZ (Thant *et al.*, 2017 p.95). The imbalance and deficiency of micronutrients affect the absorption of other macronutrients as a result of the synergistic and antagonistic reactions of micronutrients.

Deficiency of Ca results in reduced pegs, poor pod formation, thus low yield and quality. Apart from these secondary nutrients, groundnut is also sensitive to the deficiency of micronutrients such as boron (B), iron (Fe) and zinc (Zn). Similarly, Zn is required for improved nodulation, chlorophyll content and pod yield. Fe deficiency has been observed in alkaline calcareous soils, where bicarbonate ions hinder the uptake and translocation of Fe in the plant. Boron is also important for seed setting and seed quality besides synergizing groundnut's absorption of nitrogen (Meena *et al.*, 2007). The following essential micronutrients play an important role, preventing potential deficiency conditions. Below indicated is the rate, method and time of application for improved agronomic and yield characteristics of groundnut:

Sulphur (S): Sulphur improves nodulation and pod yield, reducing the incidence of diseases. S deficiency is commonly observed in coarse-textured sandy soils. If soil tests are not available, then apply 30 to 40 kg ha⁻¹ from N source, especially ammonium sulphate (Patra *et al.*, 1995). Bands or rows are the preferred methods of application; application must be split at sowing, flower initiation and pod formation stages. (Singh, 1999). In the case of broadcast application, the fertilizers should be fully incorporated into the soil for improved fertilizer use efficiency.

Calcium (Ca): Ca improves pod filling, shelling percentage and oil contents in groundnut. Application of 250 to 500 kg ha⁻¹ gypsum as top dressing, band, rows application and broadcasting followed by incorporation/mixing in the soil near the pegging zone are the recommended methods of application (Singh *et al.*, 1997).

Magnesium (Mg): Mg is a component of chlorophyll and plays a role in enhancing plant growth and development. Deficiency is commonly observed in sandy and strongly acid soils. The recommended application of Mg is 20 kg of MgSO₄ ha⁻¹ in deficient soils. (Singh *et al.*, 2004).

Iron (Fe): Fe improves nodulation and nitrogen fixation ability in groundnut. Deficiency is commonly reported in calcareous and alkaline soils. Application of 0.5 percent FeSO₄ and 0.02 percent citric acid at a rate of 50, 500 and 1 000-Litre ha⁻¹ as foliar at 30, 50 and 70 DAS is recommended in case of Fe deficiency (Singh and Dayal, 1992; Singh and Joshi, 1997 in Singh *et al.*, 2004).

Manganese (Mn): As a component of chlorophyll, Mg enhances plant growth and development. Application of two percent MnSO₄ at 500 lt at 30, 50 and 70 DAS as foliar application is the recommended method in case of known Mg deficiency (Singh, 1994 & Singh *et al.*, 1993 in Singh *et al.*, 2004)

Zinc (Zn): Zn is an important micronutrient for plant growth and development. When Zn deficiency is detected, apply two percent ZnSO₄ as foliar application at 30, 50 and 70 DAS (Singh *et al.*, 1993 in Singh, *et al.*, 2004).

Copper (Cu): Cu enhances photosynthetic activities and plays an important role in groundnut root development. Deficiency is normally reported in the case of organic and acidic soil. Application of two kg Cu ha⁻¹ as CuSO₄, CuS and Bordeaux mixture in seed dressing, rows or foliar spray 0.1 percent CuSO₄, if Cu deficiency is observed (Singh *et al.*, 2005).

Molybdenum (Mo): Mo plays role in enhancing nitrogen fixation abilities in groundnuts. Application of 0.5 to one kg ha⁻¹ ammonium or sodium molybdate or seed pelleting with Mo at 100 g ha⁻¹ for application is the recommended method of overcoming Mo deficiency (Singh *et al.*, 2005).

Boron (B): Boron facilitates translocation of sugar and fat synthesis in groundnuts. Boron deficiency is becoming more common in groundnut. In B deficient soils, application of 0.5 to one kg ha⁻¹ B as borax or boric acid could revert the deficiency. The boron should be applied prior to blooming stage. Foliar application of 0.05 to 0.1 percent aqueous solution of boric acid is effective in alleviating B deficiency of groundnut in the field (Singh *et al.*, 1993 in Singh, et al 2004).

The fertilizers and soil additives used for GAP crop before and after sowing, soil test results, dose, method and timings of chemical fertilizers application should be recorded as per Annex 3 (Form- 1. Fertilizer Application; 1 to 4 & Form.2; Fertilizers and Soil Additives; 1 to 6).

Figure 10. Pale plants and leaves are typical of low N levels, often associated with poor nodulation or wet soils



Figure 11. Light flecking gradually becoming more yellow until parts of the leaf die indicates P deficiency

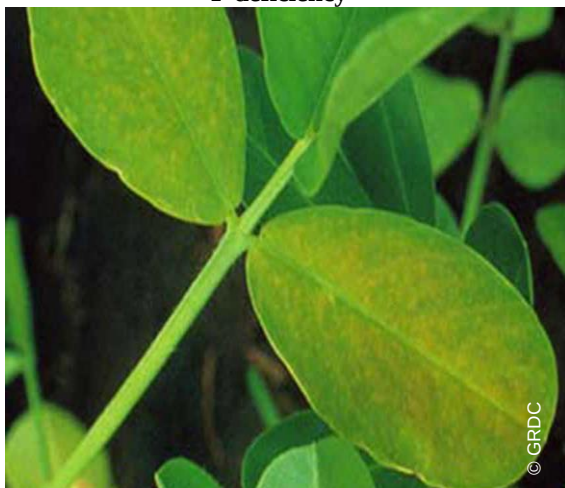


Figure 12. Leaves folded together can also indicate a lack of P



Figure 13. Potassium deficiency typically showing yellowing then browning of the tips and leaf edges



Figure 14. Symptom of Ca deficiency: Younger leaves were affected (poor pod formation)



Figure 15. Localized pitted area



Figure 16. Symptom of Mg deficiency: Growth ceases (darkening of veins)



Figure 17. Symptom of Mg deficiency: Interveneal chlorosis and orange, purple and bright yellow blotches



Figure 18. Symptom of Sulphur deficiency: Papery leaves under severe deficiency



Figure 19. Symptom of Sulphur deficiency: Young leaves showing pale yellow colour with vein white, a typical S deficiency



Note: Younger leaves turn into yellow colour & oil formation will not be there.

Figure 20. Symptom of Zinc deficiency: Leaf becomes chlorotic (stunted growth & leaf lamina will be uneven on both sides)



Figure 21. Groundnut showing manganese deficiency symptoms. Notice the interveinal chlorosis and yellowing of the leaf



Figure 22. Manganese deficiency in peanut in the field



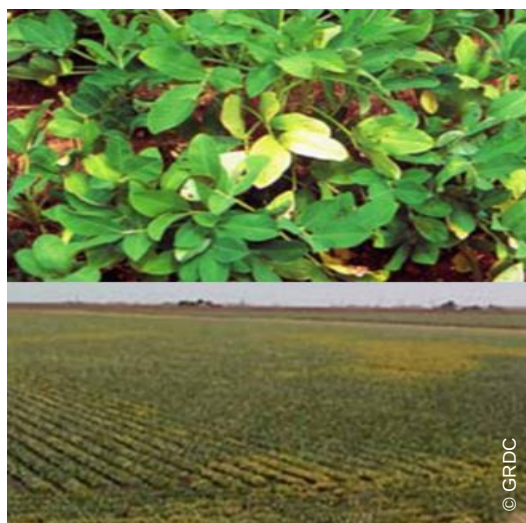
Figure 23. Kernels with ‘hollow heart’ are classic symptoms of low soil B. Hollow hearts will form well before deficiency symptoms on the foliage



Figure 24. Leaf symptoms of low Cu levels—distorted leaf tips. Bottom: Cu deficiency in the field showing yellowing and browning leaf tips



Figure 25. Fe deficiency, showing the pale leaves with the veins staying green and eventually losing most of their colour. Bottom: Fe deficiency at Jandowae on a high pH soil



2.2.6. Organic manuring

Organic manuring is a climate smart approach for safe, sustainable, resource efficient and ecofriendly system of groundnut production and a viable step towards climate smart agriculture. Most farmers are using farmyard manure as a mixture of animal wastes such as cow-dung (solid or slurry form), goat manure, chicken manure, plant residues and kitchen wastes. Using organic and inorganic manures together is known as integrated nutrient management (INM) approach, which is a sustainable and ecofriendly approach of crop nutrition to overcome nutrient deficiency and low nutrient retention capacity in soils.

Organic manuring: A climate smart approach for a safe, sustainable, resource efficient and ecofriendly system of groundnut production and a viable step towards climate smart agriculture

Besides application of inorganic manures, organic manures such as farmyard/animal manure (FYM), mulching, crop residues and green manuring must also be incorporated in the cropping systems in

groundnut-cultivated areas to prevent micro- and macronutrient deficiencies. The main types of organic manures are farm and animal manures, crop residues, green manures, biogas slurry, and biodynamic compost, vermicompost, which if properly prepared and applied, provide the best medium for plant growth and nutrient mobility and uptake by the plant nutrients. Herridge *et al.*, (2019) reported that total nutrient input values (FYM + min fertilizer, nutrient inputs as split applications, i.e. at planting and 20 and 45 days after planting) for 100 baskets acre⁻¹ of monsoon groundnut and 66 basket acre⁻¹ of late monsoon groundnut are four kg N acre⁻¹, 17 kg P₂O₅ acre⁻¹ 14 kg K₂O acre⁻¹ and 12 kg S acre⁻¹.

The types, dose, method and timings of organic fertilizers should be recorded as per Annex 3 (Form 1. Fertilizer Application; 3).

2.2.6.1. Farm yard manures (FYM)

FYM are manures collected and decomposed, consisting of both dung and urine with associated litter and remains in the animal sheds. Composting of farmyard manure increases its value in terms of nutrient recycling capacity, texture, friability and absorptive capacity. Application of fresh farmyard manure should be avoided not only due to low nutrient contents but also due to a source of insects' pests and other potential toxicity to the plants. Animal urine is a valuable part of animal manure and contains appreciable amounts of nutrients. The animal manure mixture (dung and urine) should be collected and trenched in a pit of the size six to 7.5m in length, 1.5 m to 2.0 m in width and 1.0 m deep for decomposition. After filling the pit, the top should be tightly covered with plastering to enhance decomposition and nutrient loss. The manure becomes ready after four to six months for application to the crops at the time of sowing/land preparation. Application of farmyard manures depends on soil fertility status and other crop management practices. Six to 10 tonnes of well-decomposed FYM ha⁻¹ should be applied and fully incorporated into the soil during land preparation (Myanmar GAP guidelines, 2018).

Table 5. Average values for moisture and nutrient content of farm animal manures						
Source	Portion	percent	Moisture content	Nitrogen (percent)	Phosphorus (percent)	Potassium (percent)
Horse	Manure	80	75	0.55 (0.50–0.60)	0.33 (0.25–0.35)	0.40 (0.30–0.50)
	Urine	20	90	1.35 (1.20–1.50)	Trace	1.25 (1.00–1.50)
	Mixture	—	78	0.7	0.25	0.55
Cattle	Manure	70	85	0.40 (0.30–0.45)	0.20 (0.15–0.25)	0.10 (0.05–0.15)
	Urine	30	92	1.00 (0.80–1.20)	Trace	1.35 (1.30–1.40)
	Mixture	—	86	0.6	0.15	0.45
Swine	Manure	60	80	0.55 (0.50–0.60)	0.50 (0.45–0.60)	0.40 (0.35–0.50)
	Urine	40	97	0.40 (0.30–0.50)	0.10 (0.07–0.15)	0.45 (0.20–0.70)
	Mixture	—	87	0.5	0.35	0.4
Sheep	Manure	67	60	0.75 (0.70–0.80)	0.50 (0.45–0.60)	0.45 (0.30–0.60)
	Urine	33	85	1.35 (1.30–1.40)	0.05 (0.02–0.08)	2.10 (2.00–2.25)
	Mixture	—	68	0.95	0.35	1
Poultry	Mixture	—	55	1.00 (0.55–1.40)	0.80 (0.35–1.00)	0.40 (0.25–0.50)
Source: Van Slyke, L. L. 1933. Fertilizers and crop production. <i>Soil Science</i> , 35(2), 171.						

Protection of stored manure (and compost) from rain, and containment of run-off effluent needs to be managed to avoid contamination of adjacent soils, work areas and waterways. It is not always possible to keep a large distance between the area where manure is spread and the neighbours. Another good practice is to dig the manure into the soil as quickly as possible. As with the storage area, natural and manmade barriers between production areas and neighbours can greatly reduce the likelihood of complaints. Apart from the visual effect, barriers can also help to filter and thin out odours.

Figure 26. Well decomposed FYM



2.2.6.2. Bokashi compost

Bokashi is a Japanese word meaning, "fermented organic matter" which was first developed in the early 1980s at the University of Ryukyus, Japan. The method encompasses layering of kitchen scraps (vegetables and fruits, meat and dairy scraps) with a Bokashi inoculant in a specially-made bucket. The inoculant used in Bokashi contains wheatgerm, bran of wheat or sawdust mixed with EM and molasses. The bran is food for the microorganisms similar to those organisms found in the soil. Application of combined application with NPK enhances the quality of sustainable soil fertility management (Lasmini *et al.*, 2018).

Steps in preparing Bokashi compost (OISCA, DoA Myanmar)

1. Place a four to five inches layer of cow-dung and chicken droppings. (Stage -1)
2. Cover cow-dung layer with rice bran. (stage -2)
3. Thoroughly mix Bokashi seed (0.5 kg) with a small amount (3 Pyi = 2.56 litres) of rice bran.
4. Then, spread Bokashi seed on rice bran layer.
5. Then, add sesame oil cake or dry fish powder. (stage 3)
6. Then, add ash or rice husk charcoal. (stage 4)
7. Then, add silt on rice husk charcoal.
8. Mix thoroughly the composting materials and sprinkle water on to it with a rate of 20 litre water/100 kg of composting materials and mix thoroughly again. (stage 5)
9. Take a small handful of the mixture and knead it. If the mixture is equally damp and slightly sticks to itself (it cannot be moulded), it is ready to make a Bokashi compost. (stage 6)
10. The mixture is piled up to (1–2) feet height evenly and slightly covered the top with a layer of straw or dried grass or old tarpaulin (stage 7–8)
 - Turn the compost pile once a day depending on the temperature. If it is needed, stir the compost pile to keep the temperature not to be more than at 50–55 °C until five days after piling.
 - Compost can be harvested and used during 7–10 days after piling.
 - Be careful and keep the compost not to be in direct sunlight for a long time before use.
 - For later use, air-dried compost can be stored in the polyethene bags or containers. Moisture during storage should be controlled to prevent development of mould, nor to allow moisture to decrease enough to leave the compost dry.
 - Compost can be used by mixing with chicken manure/swine manure/cow dung for soil fertility improvement by increasing the number of effective microorganisms.

Bokashi preparation steps

Figure 27. Placing a 4–5 inches layer of cow dung



Figure 28. Covering cow-dung layer with rice bran



Figure 29. Spreading sesame oil cake



Figure 30. Spreading rice husk charcoal



Figure 31. Sprinkle water 80 litres



Figure 32. Mixing all materials thoroughly



Figure 33. Covering with old tarpaulin



2.2.6.3. Biodynamic/aerobic composting

A number of climatic factors affect the quality of compost as the final organic fertilizer. Oxygen for aeration encourages aerobic microbes' activity and thus enhances the decomposition of compost materials. Therefore, good aeration is particularly important for effective composting. Similarly, moisture is also necessary for microbial activity of microorganisms. The materials should have a moisture content of 40 to 65 percent. Temperature is an important factor in determining the composition of compost. The initial temperature can go up to 20 to 45 °C and can further increase up to 50 to 70 °C with the microorganism.

Store manure disposal areas away from the productions site, regularly monitor manures for odour and cover manure heaps with soil to minimize odour and reduce the risk of disease transmission, and pest build-up.

To regulate the temperature, the turning of compost is especially important. Compost can be ready for application to the crops in six to eight months. To prepare quality biodynamic compost, ensure ventilation into the compost heap by punching a hole in the pile at many places or inserting a bamboo and withdrawing it after some days. Keep on turning the compost to improve aeration three to four times during the maturation time. To further improve the quality of compost and enhance its fertility aspect and decomposition, inoculation with cost-effective EM such as fungi such as *Trichoderma sp* and *Pleurotus sp.* is important (*Composting process and techniques, aerobic composting process-FAO*).

Figure 34. Biodynamic compost making in Myanmar



2.2.6.4. Vermicomposting

Vermicompost, which is also called worm compost, and worm manure, is decomposed materials broken down by some earthworms. The compost prepared with worms is rich in nutrients, improves soil fertility and acts as soil conditioner. The compost is a rich source of nutrients, improves soil microbial activities and also contains beneficial growth hormones. The application of vermicompost to chickpeas gives beneficial results in terms of increased production and improved nutrient use efficiency. Due to the declining soil fertility and nutrient losses, the use of organic manures is becoming popular. Organic manures, especially vermicompost application to the groundnut, improve its productivity and growth attributes. As reported by Bekele *et al.*, 2019), the combined application of 46:46 kg N: P₂O₅ ha⁻¹ and 2.5 t vermicompost ha⁻¹ increased the pod yield in groundnut. It is therefore highly important that the application of mineral fertilizers should be combined with organic manures, such as vermicompost, for increased groundnut productivity and improved farmer's income and livelihood.

Steps in preparation of vermicompost

Vermicompost can be prepared from biodegradable materials such as crop residues, weeds biomass, vegetable wastes, leaf litter, hotel and kitchen refuse, and waste from agroindustries and biodegradable waste of rural and urban wastes. The following steps are involved in the preparation of vermicompost (Kaur, 2020).

Step 1	→	Collect wastes, shred, mechanically separate the metals, glass and ceramics and store the organic wastes
Step 2	→	Predigest organic wastes using dry cattle dung and slurry to make it suitable for earthworm feeding
Step 3	→	Prepare the bed for earthworms, for which a concrete base is required for the placement of waste for vermicompost preparation
Step 4	→	Loosen the soil to allow the worms to enter it, as well as all the dissolvable nutrients (while watering)
Step 5	→	Collect the earthworms after vermicompost collection
Step 6	→	Sieve the partially composted material to separate the fully composted material
Step 7	→	Put the partially composted material into a vermicompost bed
Step 8	→	Store the vermicompost in a proper place to maintain moisture and allow the beneficial microorganisms to grow

The common earthworms suitable for vermicomposting of India, Malaysia and Myanmar origin are the Malaysian Blue worm (*Perionyx excavatus*), also known as the Indian Blue worm, and the African Nightcrawler (*Eudrilus eugeniae*), as shown in the pictures below.

Figure 35. Sorting through a tray of Malaysian Blue (*Perionyx excavatus*) earthworms, also known as Indian Blues



Figure 36. African Nightcrawler (*Eudrilus eugeniae*) earthworms, note the distinctive blue sheen



2.2.6.5. Green manuring

Green manuring is the process of incorporating fresh, green crops into the soil by ploughing down, with the objectives to add organic matter to the soil, improve soil texture, structure and friability, besides adding nitrogen and other micronutrients to increase soil productivity. The incorporation of green manure crops into the soil also increases soil microbial activities for increased decomposition and thus improves the soil environment and biodiversity. The organic crop residues from green manure crops also stabilize soil structure, increase its water holding capacity and water infiltration, thus contributing to reduction of runoff in unlevelled and sloppy lands. The best time for incorporation of crop residues into the soil is at the beginning of the flowering stage when the plants attain maximum biomass and are highly succulent.

Green manure crops have the best ability for increasing soil fertility through nitrogen accumulation up to 80 to 100 kg N ha⁻¹ in 45 to 60 days of growth, of which almost 80 percent comes from biological N₂ fixation (Becker *et al.*, 1995). Groundnut is responsive to green manuring as reported by Bheemaiah et al, (1999), whereby its pod yield of increased with different green leaf manuring crops. In particular, green leaf manuring of Subabul (*Leucaena leucocephala*) resulted in groundnut pod yields of 1931 kg ha⁻¹ over other green leaf manuring.

Crops for green manuring should be multipurpose, fast-growing and of short duration with a high nutrition accumulation ability. For the crops to be readily decomposed in the soil after incorporation, they should be herbaceous in nature and have the ability to be successfully cultivated as green manure crops under shaded, low moisture, and widely adapted to various ecological conditions. More importantly, the green manuring crops should not be an (alternate) host to any known insect pest. The suitable crops for green manuring in the project areas (CDZ) are cowpea, mungbean and *Sesbania aculeata* (FAO, 2019).

Process of green manuring

- The seeds of green manuring crops should be cultivated either in rows or broadcasted and chopped at the flowering stage when the crops have maximum nutrients stored and are highly succulent.
- The plants should be incorporated 25cm (10 inches) deep from the soil surface and be left for two weeks to decompose.

Figure 37. Green manure crops



Figure 38. Incorporation of green manure crops into the soil using tractor

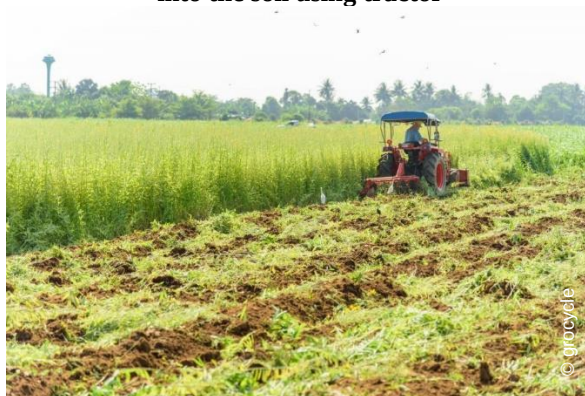


Figure 39. Green manuring (*Crotalaria juncea*) for paddy cultivation, Myanmar



Figure 40. Incorporation of green manures into the soil



2.2.7. Soil additives and amendments

To improve soil biological, chemical and physical environment for increased rice production and produce quality, soil additives should be applied, especially in acidic, alkaline, clayey, loose, rocky, sandy, and waterlogged soils susceptible to erosion and sloppy soils. Addition of sand to heavy clayey soils improves soil aeration, drainage and root growth, resulting in high yield and quality produce. In the case of soils with low pH (acidic), application of lime, and soils with high pH (alkaline), application of sulphur are recommended to neutralize soil pH. Application of organic manures such as compost application, green manuring, stubble mulching and peat mass addition also improves soil texture, aeration, water retention, and absorption of nutrients, especially locked up soil nutrients, and mitigates drought in arid and semi-arid areas.

2.2.7.1. Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

The application of gypsum in groundnut production is useful for many reasons. Gypsum should be applied based on soil tests and identification of conditions for the recommended dose. If soil tests are not available, a blanket application of 500 to 1 000 kg ha⁻¹ gypsum should be executed, especially at flowering and peg formation stages for monsoon and winter groundnut crops (Singh & Basu, 2005). Gypsum also adds Ca and S, besides preventing crust formation (crusting), improving seedling emergence and increasing water-holding capacity.

Figure 41. Gypsum application to the crop rows makes Ca available to the crop and reduces injury of the crop due to salts accumulation in the root zone



The types, dose, method and timings of micronutrient fertilizers and soil additives applied should be recorded as per Annex 3 (Form.1. Fertilizer Application; 1 to 4, Form.2. Fertilizers and Soil Additives; 1 to 6)

2.2.8. Crop rotation and intercropping

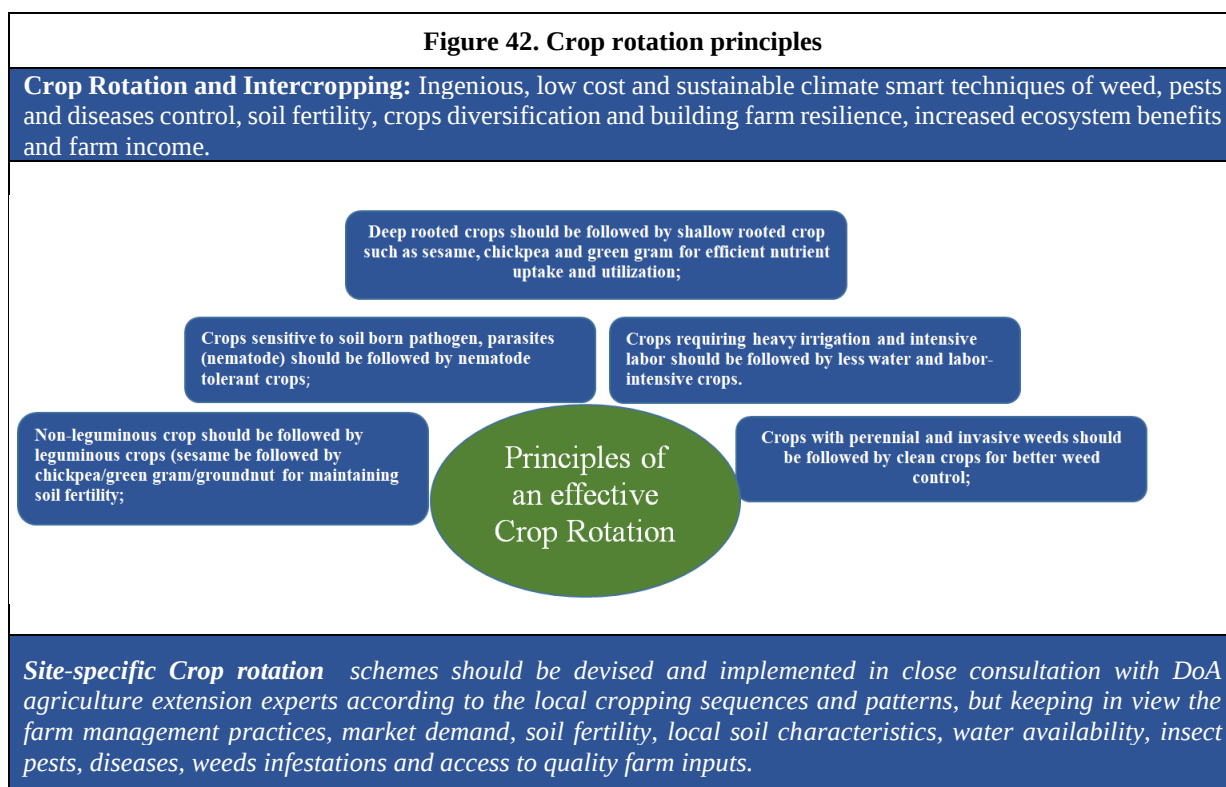
Crop rotation and intercropping are ingenious, low cost and sustainable climate-smart techniques of weed, pests and diseases control, soil fertility, crop diversification and building farm resilience, increased ecosystem benefits and farm income. The techniques, especially intercropping, are a climate-smart way of building farm resilience, optimization of farm resources, increasing productivity, complementing income and minimizing risks.

2.2.8.1. Crop rotations

Crop rotation is a common and beneficial farming practice that promotes soil health by switching the crops grown on a plot of land every season or every few seasons. Farmers in CDZ decide for specific crop rotation because of certain considerations, such as:

- 1) Growing the same crop year after year due to market stability, high market price, high yield, climatic adaptability, availability of sufficient seed stock from the last season, water availability, familiarity with farming practices, easy and affordable farm inputs;
- 2) Using the same crop by changing the long duration varieties to short duration to avoid the risks of crop losses and market variety preference;
- 3) Switching to another crop, i.e. from groundnut to sesame to other crops under circumstances such as high market demand, yield, and government incentives for certain crops;
- 4) Scaling up of farm size due to high resources to buy more land, renting more acreage for cultivation, inheriting more land and scaling down of farm size due to labour shortage, diverting expenditure to other priorities, high debt and loss of farming income (Proximity, 2019);
- 5) Some samples of crop rotation in chickpea-growing areas of CDZ are as follows:

- a) sesame – groundnut
- b) groundnut – pigeon pea (or) groundnut – green gram
- c) green gram – sesame – groundnut.



2.2.8.2. Intercropping and mixed cropping

Cultivation of two or more crops on the same field in close proximity with or without an improved planting geometrical layout (rows, beds, strips, mixed) for increasing production, efficient utilization of environmental and physical resources, insects pests and diseases control, increased soil fertility, yield stability and crop risk minimization (Mousavi & Eskandari, 2011). Based on the nature of crops in terms of growing cycle, purpose of production and utilization and seasonality potentials, the intercropping schemes should follow intercropping annual crops with annual crops, annual crops with biennial crops and perennial crops with perennial crops.

Types of intercropping

Intercropping or mixed cropping is the cultivation of two or more crops on the same field in close proximity with or without an improved planting geometrical layout (beds, rows, strips/mixed) for increasing production, efficient utilization of environmental and physical resources, insects pests and diseases control, increased soil fertility, yield stability and crop risk minimization (Mousavi and Eskandari, 2011). Based on the nature of crops in terms of growing cycle, purpose of production and utilization and seasonality potentials, the intercropping schemes should follow intercropping annual crops with annual crops, annual crops with biennial crops and perennial crops with perennial crops.

Types of intercropping

- Row intercropping, where one or more crops are simultaneously cultivated in rows with variation in number of rows based on demand and local preferences. The ratio of rows of the crops may vary from 1:1, 1:2 and 1:3, etc.
- Mixed intercropping, where one or more crops are simultaneously cultivated with no fixed row or geometrical layout arrangements;

- Strip cropping, where one or more crops are simultaneously cultivated in stripes wide enough to allow independent cultivation;
- Relay cropping, where one or more crops are cultivated during the life cycle of each of the crop. Normally, a second crop is planted when the first crop has attained the reproductive stage but before the first crop is ready for harvest.
- Some samples of intercropping with green gram in CDZ are as follows:
 - groundnut and pigeon pea/green gram/lablab bean/other pulses
 - groundnut and sunflower
 - groundnut and cotton
 - groundnut and maize.

Benefits of intercropping

- Higher production with lower levels of external farm inputs, especially for small farmers where the growing cycle is short.
- Efficient use of farm resources as intercrops components are not in competition for the same niche (ecological nest) due to differences in morphological and growth characteristics but symbiotic in terms of legumes and non-legumes, shallow and deep rooted crops.
- Reduced pests, diseases and weeds, due to the crops species diversity in agricultural ecosystem because of which pathogen spreading is limited. Similarly, weeds also compete with main crops for water, light, nutrients, and space and sometimes cause allelopathic⁵ effects on the main crop. Due to efficient utilization of farm spaces with useful and economic crops, weeds are controlled thanks to less availability of light, water, space, and nutrients being diverted to useful crops in intercropping.

Pursuing Biodiversity on farm: Intercropping, an ecological engineering and climate-smart way of building farm resilience, optimization of farm resources, increasing productivity, complementing income and minimizing risks

- Stability and uniformity yield in case of small farmers having limited sources, income and stability yield. It is therefore important, that in case of failure of one crop, the second compensates for income and production, thus mitigating the risk of crop failure.
- Improved soil fertility and increase in nitrogen due to conservation of soil fertility in intercropping, as in crop rotation. Rhizobium⁶ bacteria are able to have a symbiotic relationship with plants of the legume family and can thereby fix atmospheric nitrogen into available nitrogen for plant uptake; as a result, nitrogen (as an essential element for soil fertility and plant growth) is added to the soil.

Site-specific intercropping and mixed cropping schemes should be devised and implemented in close consultation with DoA agriculture extension experts according to the local cropping sequences and patterns, but keeping in view the farm management practices, market demand, soil fertility, local soil characteristics, water availability, insect pests, diseases, weeds infestations and access to quality farm inputs.

2.2.9. Irrigation and water management

It is important to note that both irrigation and water quality are important for safe and quality groundnut production, according to GAP standards. The water used for irrigation and other crop treatments should be tested for any pathogenic, chemical and biological contamination. The water flowing down from livestock farms, hospitals, industries, wastewater and any sources that may cause environmental harm are not used for irrigation purposes. (If the treated sewage water is used, it needs to comply with WHO

⁵ Allelopathy is a biological phenomenon by which an organism produces one or more biochemical that influence the germination, growth, survival, and reproduction of other organisms. ... Allelo-chemicals with negative allelopathic effects are an important part of plant defense against herbivory.

⁶ *Rhizobium* are present in the soil in two different forms: if the host plant exists in the soil, they establish a symbiotic association with their host plant and fix the atmospheric nitrogen, and if not, they act as free-living saprophytic heterotrophs.

Guidelines). Where the risk of chemical and biological contamination of produce is significant, either a safe alternative water source is used, or the water is treated and monitored, and a record is kept of the treatment method and monitoring results.

An efficient irrigation system be used to minimize wastage and the risk of environmental harm on and off-site.

Soil moisture is an important limiting factor for groundnut production. Groundnut is comparatively drought tolerant but like other legume crops, it needs water at the critical stages of crop growth, especially at germination, flowering, peg formation and pod filling stages. Irrigation at the time of pegging is important for ensuring effective peg penetration in the soil. Reduced soil moisture, besides drastic yield reduction, also causes infection of pods by *Aspergillus flavus*.

The critical stages for groundnut irrigation -plant indicators- and relative susceptibility to moisture stress are indicated below as high, moderate and low, depending on crop growth and development stages (Okello *et al.*, 2013). Lack of irrigation during these critical stages in the growth cycle of groundnut drastically reduces the yield and lowers the quality of the plant.

Groundnut is **highly susceptible** to drought during germination (one to two weeks) at the growth stage, from planting to emergence, and has **low susceptibility** during early vegetative growth (five to six weeks), from emergence to pegging; moreover, it is **highly susceptible** to drought during nut development/fruiting (eight to nine weeks) from flowering/pegging to pod formation, and has **moderate susceptibility** during maturation (five to six weeks) at growth stage, from the plants' pod formation to harvest.

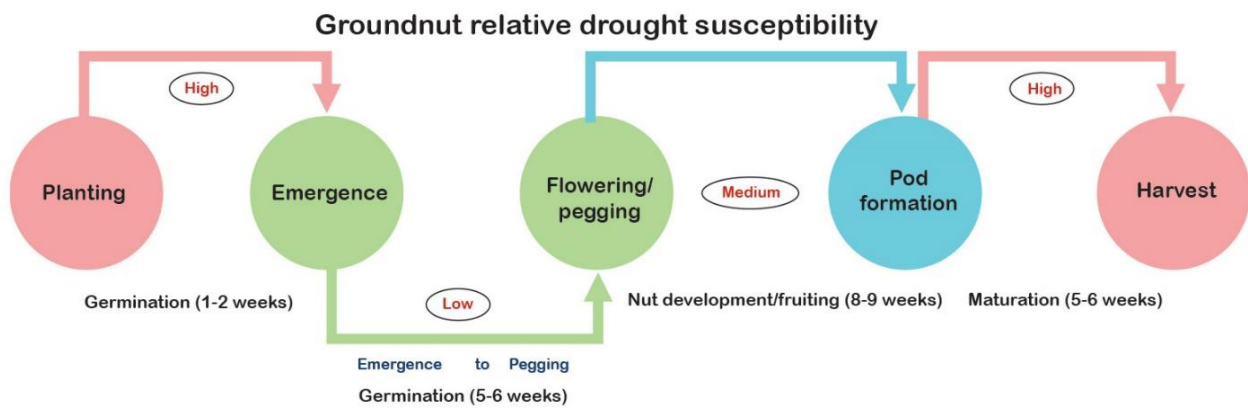
Digging trenches for water harvesting in rainfed areas can retain the moisture content in the soil longer and enhance the yield of groundnut.

Timely irrigation of the groundnut crop, especially at the critical crop growth stages, is important for plant growth, development and productivity. Prolonged drought negatively affects yield and quality as well as increases the susceptibility of the crop to disease and insect pest infestation. If irrigation is missed during the critical growth stages (two weeks after emergence, flowering, pegging, pod formation and pod filling stages), a drastic reduction in yield and quality may result (Boote *et al.*, 1982). Reduced dry matter, poor growth rate, reduced and small flowers and leaves, poor pod filling, quality, low shelling percentage and susceptibility to pests and diseases are the adverse effects of drought at the critical growth stages of groundnut crop.

Water quality should be tested for health and systematically utilized. The water flowing down from livestock farms, hospitals, industries, wastewater and any sources that may cause environmental harm are not used for irrigation purposes. (If the treated sewage water is used, it needs to comply with WHO Guidelines). The irrigation, fertilization and water management of the crop should be recorded as per Annex 3 (15–15.1 to 15.9).

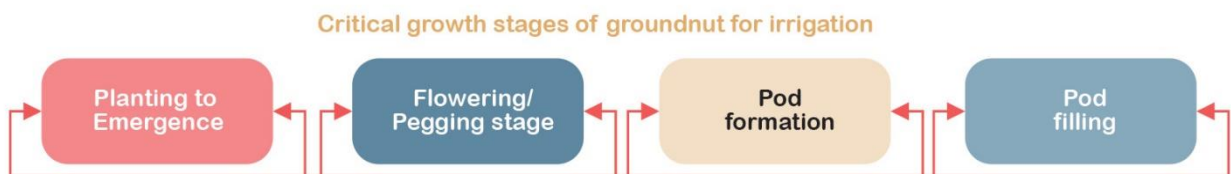
For plantations on irrigated lands, the first irrigation is given for seedbed preparation. The first irrigation should take place three to four weeks after sowing, the second irrigation at the flowering stage, the third at peg formation, the fourth at pod development, and the fifth about one month before digging (if required).

Figure 43. Groundnut relative susceptibility to water shortages



Source: Elaborated by the author

Figure 44. Critical growth stages for groundnut crop irrigation



Source: Elaborated by the author

Figure 45. Water harvesting using dikes, also referred to as tied-ridges



Figure 46. Inter-row mulching in groundnut field for moisture conservation



Irrigation and water management: Refer to Annex 1 practice 1.2, 1.12 of Myanmar GAP guidelines Annex 2.1 practice 2.1.4 Annex 2.2 practice 2.2.4 and Annex 2.3 practice 2.3.5 for further guidance

2.2.10. Harvesting and produce handling

The time of harvesting is of critical importance in the case of groundnut as it affects crop quality and yield. Premature harvesting causes lower yield, oil percentage, flavour and quality of seed while delayed harvesting after physiological maturity can cause *Aspergillus flavus* infection and aflatoxins contamination in pods with many seeds remaining inside the soil, due to weakening of pegs. The pods may germinate in case of delayed harvesting if it rains, thus splitting and allowing moulds to enter. Timely harvesting at the optimum maturity of pods is important. In order to determine the best harvest

time, the field should be regularly observed for indication. The groundnut crop should be harvested when 75 percent of pods are mature. Before harvesting the groundnut crop, the following key considerations in line with Myanmar GAP Guidelines, 2018 and ASEAN GAP standards should be kept in view:

- Harvesting should be carried out safely to avoid damage to the pods and prevent aflatoxin infection.
- Equipment and tools suitable for harvesting should be checked for cleanliness before use or cleaned as required.
- Harvest the crop at the coolest time of the day to avoid quality deterioration in the heat, but avoid harvesting during rain.
- Harvested produce should not be placed in direct contact with soil or the floor of handling, packing or storage areas.

The important indicators for the maturity of groundnuts are when the inside portion of the pod develops brown to black markings, while the immature show a fresh white appearance. When the colour is orange light brown, maturity is near. Counting the days after planting is another way to estimate or assess crop maturity as each variety has a specific number of days until maturity (days after planting [DAP]). However, maturity depends on biotic and abiotic factors, such as irrigation, weed control, fertilization, temperature, insect pests and diseases, rainfall and soil structure/texture, and the organic matter content of the soil.

Figure 47. Mature groundnut saddle area

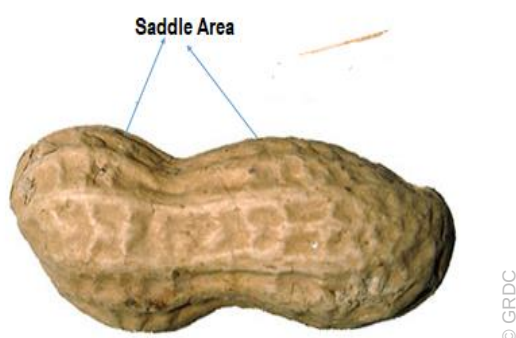


Figure 48. Mature groundnut with dark brown pericarp



Figure 49. Immature to underdeveloped pods



Figure 50. Aflatoxins affected pods



Figure 51. Aflatoxins affected pods



Figure 52. Safely harvested groundnut



Time and method of crop harvesting should be recorded as per Annex 3 (Form.2. Harvesting and Handling Produce; 1 to 6).

The crop should be harvested using manual methods of hand hoe or ox-drawn plough, but extreme care should be taken not to injure the pods seeds¹. Hand pulling/hand harvesting is suitable in well-drained, sandy and loam soils. This method should be used during the rainy season when the soil is moist and soft. While pulling the plants, care should be taken that the plants are held firmly and uprooted entirely.

Figure 53. Groundnut harvesting through hand pulling



Figure 54. Groundnut harvesting using toothed hoe



Figure 55. Delayed harvesting result in sprouting of nuts in the ground



Harvesting with Hoe/Ox drawn plough is also used on heavy soils and during dry conditions, but care should be taken to avoid losses to the pods. The method is efficient in lifting the entire crop from the soil with reduced pod losses. Care should be taken that the blades pass away from the pods so that they are not crushed, as injury to the pods results in mould and aflatoxin infection. The use of forked hoes instead of blades minimizes damage to the pods.

Harvesting and produce handling: Refer to Annex 1 practice 1.5, 1.7, 1.8 and 1.9 of Myanmar GAP guidelines 2018 for groundnut, Annex 2.1 practice 2.1.6 Annex 2.2 practice 2.2.6 and Annex 2.3 practice 2.3.7 of ASEAN GAP guidelines for further guidance.

2.3. Post-harvest management

2.3.1. Cleaning, sorting and drying

The two most important post-harvest management practices of groundnut are cleaning, sorting and drying to maintain groundnut quality. Damaged, broken, rotted, and other foreign matter should be removed from pods after harvest. Shaking of the harvested plants should be done to remove soil clinging to the plants and promote faster drying, as well as to prevent fungal infection causing aflatoxin. The harvested plants should be left in a row for final rouging/sorting and removal of off-types. To maintain desirable quality, flavour, texture and aroma, groundnut should be appropriately cured/dried. Drying is done twice within the cycle of postharvest operations: initial drying prior to threshing, and final drying before pod shelling.

Use clean tarpaulin sheets, polythene sheets or tarpaulin, or mats made of papyrus, cemented grounds or raised structures for drying the pods to avoid contact with the soil. Mixing the diseased or infected pods with healthy ones should be avoided as it degrades quality and spoils the sound groundnuts. Moisture reduction is the most important factor in groundnut curing which should be maintained through drying in the sun or mechanically, in a controlled environment. Groundnut pods have moisture of 35 to 60 percent at the harvest. Open window drying for five to seven days is enough under good conditions to attain the desirable moisture content if the prevailing humidity is low. For seed purposes, direct sun drying should be avoided in case of very high temperatures, which may cause overdrying and deterioration of quality. In the case of high temperatures, the plant should be put in heaps with pods facing inside. Regular observation of the drying process should be ensured for appropriate drying. Once harvested, the pods are picked, and sun-drying is carried out to reduce the seed moisture by up to six to nine percent (Myanmar GAP guidelines, 2018).

Figure 56. Drying in heaps (Mandela Cock) in case of high temperature instead of windrow drying



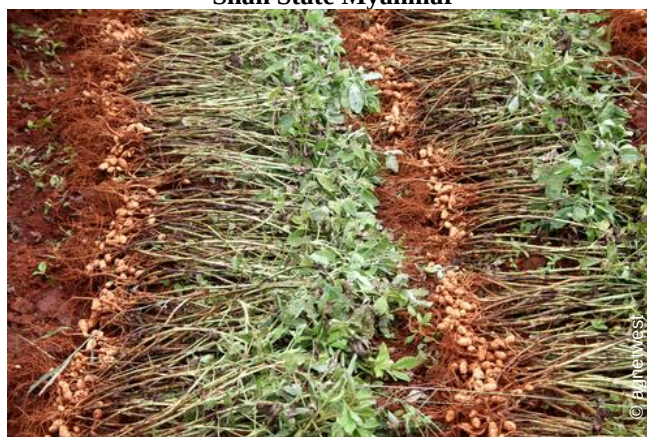
Figure 57. Drying groundnut in windrow



Figure 58. Groundnut drying after harvesting using Mandela Cock method



Figure 59. Drying of groundnut plants in the field in Shan State Myanmar



2.3.2. Threshing and winnowing

When the plants are sufficiently dry, the bundles should be threshed on a concrete floor/canvases/tarpaulin spread on the ground to be free from soil, gravel, dust and other inert materials. The plants are beaten gently with sticks and seeds are collected and winnowed. Clean by repeated winnowing until the seeds are separated from the chaff and other inert matters. Threshing and winnowing are done without further contact with soil or any other source of humidity to avoid contaminations. (Ajeigbe *et al.*, 2014).

Groundnut curing refers to the process during which its moisture content is reduced to a safe level for preservation of quality. Along with the removal of moisture, many physiochemical changes take place during the curing process, influencing the flavour and quality of groundnuts. Once groundnut is dug, the produce is cured by sun-drying for about six to eight days to maintain the desired flavour and quality. At the time of digging, pods contain 40 to 50 percent moisture, which should be reduced to eight to ten percent by curing for safe storage. Well-dried, clean pods should be stored. Excessive humidity in the store favours the aflatoxin growth on the pods, which damages the quality of the seed.

Hand shelling is preferred over mechanical shelling to avoid damaging the seeds/grains. Hand shelling is only possible on small farms. For larger farms, various kinds of machines are available in the market. These can easily be manufactured in local markets as well. Shelling should be done carefully to separate damaged, diseased, aflatoxins affected, small size, shrivelled grains for maintaining better quality and marketability. Groundnut should not be shelled by beating or trampling.

Figure 60. Megakonnnect hand operated Groundnut Decorticator is small machine for shelling



Figure 61. Motorized groundnut shelling machine



2.3.3. Packing and packaging

Packaging is an important post-harvest management in value chain development practices determining the quality of the groundnut seeds. The cleaned and well-dried groundnut seeds should be packed and packaged in polythene-lined gunny bags indicating the name of the variety, year of production, farm brand name /location, moisture when packed, weight and GAP certification tags. Various packages can be used depending on the market demand and quality assurance for the end market. Vacuum packaging for export markets is desirable as it preserves the produce for longer periods and protects it from damage during transportation and storage. As a climate-smart GAP, it is recommended to use biodegradable material for packaging groundnut.

Figure 62. Hermetic (airtight) storage containers prevent aflatoxin-producing molds in groundnut



Figure 63. Gunny bags to use for better air circulation and prevention of condensation



2.3.4. Storage and transport

Produce should not be stored in the containers previously used for chemicals and other dangerous substances and materials. If there is no permanent silo, the super bags, tin boxes and pots (a kind of traditional container made of bamboo) are used. For export purposes, prevention measures for storage pests are practised during the storage period to meet the requirements of the different exporting countries.

Transport vehicles should be checked before use for cleanliness, availability of proper tarpaulins to cover the cargo, foreign objects and other materials, chemical contamination or pest infestation, and must also be checked to ascertain dryness, without any moisture in the vehicles. Produce is stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.

2.3.4.1. Storage

- All facilities where groundnut is stored in bulk need to have a detailed sanitation plan and designated persons be trained in maintaining the hygiene and safety of the premises and the produce stored therein;
- All good management practices must be documented, and the workforce must understand to comply and adopt the guidelines;
- In order to ensure safe storage, the storage building should be rodent proof and in case there is risk of rodent infestation, take preventive/protective measures, such as closing all the holders at the roof of the door, etc., where pests can enter, and also repair cracks in walls where pests can hide;
- The infested residue, which can contaminate the newly introduced produce in the store, should be removed;

- In order to maximize the use of space, ensure hygienic conditions and facilitate effective management, bags should be put in stacks;
- Sanitation of the storage place is highly important and can be attained by not mixing the old produce with new produce. Old, infested materials should either be removed or thoroughly fumigated. The storage structure, including machinery, packing bags and baskets, should be disinfected with fumigants or exposed to sun heat. Hermetic storage is also an effective way of safe storage as the airtight conditions cause reduced oxygen supply and increased carbon dioxide, reducing the chances of insects infestation and mould development. Some special plants acting as natural fumigants can also be used;
- Before storage of the groundnut, it should be ensured that all the damaged, diseased, shrunk /shrivelled nuts, discoloured, rotten, immature, germinated, other inert materials and soil are removed. It is suggested to store the groundnut in pod form instead of seeds for long-term storage and quality maintenance. All inlets to the storage should be closed to stave off rodents, especially mice damaging the crop.
- The stores should be well-ventilated to prevent water condensation or dampness. The filled bags should be disinfected through exposure to sun for one to two days to destroy any remnants of insect pests (eggs, larvae). Bags' stacking should not be more than 10 bags per stage, keeping inter-stage space for air circulation.
- Pellets should be used for each stack and regular turning over of the stacks performed to avoid the buildup of moisture and fungus in the underneath bags. Storage at locations with a temperature of more than 300 °C should be avoided. As organic practices, the leaves of Neem (*Azadirachta indica*) can be used in stores to avoid stored grain pests and insects.

Storage handling and transportation: Refer to Annex 1 practice 1.5, 1.7, 1.8, 1.10, 1.11, 1.12 and 1.17 of Myanmar GAP Guidelines and Annex 2.1 practice 2.1.5, 2.1.6, 2.1.7, 2.1.9 Annex 2.2 practice 2.2.7, 2.2.8, 2.2.9, 2.2.10, 2.2.11 and 2.2.13 Annex 2.4 practice 2.4.1, 2.4.2, 2.4.3, 2.2.4 for further guidance.

Details of storage & transport conditions should be recorded as per Annex 3 (Form 1. Postharvest Practices; 1 to 3, Form 2. Storage and Transport; 1 to 3

2.3.4.2. Transportation

Transport vehicles should be checked before use for cleanliness, availability of proper tarpaulins to cover the cargo, foreign objects and other materials, chemical contamination or pest infestation, and must also checked to ascertain dryness, without any moisture in the vehicles. Produce is stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.

The groundnut should be transported in a well-aerated transported vehicle, avoiding exposure to extreme heat and rain. Overloading should be avoided as it impairs the quality of the nuts during transportation. Produce should be stored and transported separately from goods that are potential sources of chemical, biological or physical contamination. Overloading in trucks should be avoided and produce should be covered to reduce moisture loss during transportation. Bags/containers filled with produce should not be placed in direct contact with soil, where there is a significant risk of produce contamination.

Storage and transportation: Refer to Annex 1 practice 1.7, 1.8, 1.10 of Myanmar GAP guidelines 2018, Annex 2.1 practice 2.1.7, 2.1.8 Annex 2.2 practice 2.2.7, 2.2.8, 2.2.9, 2.2.10, 2.2.11, 2.2.12 for further guidance

2.3.5. Aflatoxins in groundnut a major food safety concern

Besides other factors, adversely affecting the quality and food safety of groundnuts are aflatoxins, which are caused by *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxins deleteriously affect human and

animal health. Aflatoxins are toxic and cause tumors, liver damage (cirrhosis) with associated carcinogenic, estrogenic, teratogenic, and immunosuppressive effects. Groundnut being a popular and multipurpose crop is contaminated with aflatoxins at the pre- and post-harvest stages if proper agronomic and postharvest management are not administered (Bediako *et al.*, 2019). Groundnut plants become more susceptible to infection by *Aspergillus* on account of prolonged exposure to high humidity conditions or other abiotic stresses such as drought, which lowers the plant's defences. The fungi thus establish a colony and contaminate at any point of the crop's value chain. Groundnuts are affected with aflatoxins at pre-harvest entry of fungus (during plant growth), during harvest and postharvest entry of fungus, after harvest and during processing.

2.3.5.1. Pre-harvest predisposition to aflatoxins

The infection during the pre-harvest is mainly caused by farming practices which expose the groundnut crop to infection (*A. flavus* and *A. parasiticus*), mainly by:

Repeated cultivation of host plants and lack of crop rotation: Repeated cultivation of the same crop or susceptible crop species on the same piece of land supports rapid buildup of *A. flavus* populations leading eventually to pre-harvest contamination of crops in the field. The insect infestation associated with the same crops damage the developing seed/pod leading to aflatoxin infection.

Late planting and adverse effect of drought: If the crop is planted late, the crop quality is impaired by the end season drought and high soil temperatures, as well as insect pests or attacks, especially termites damaging the pods, creating entry points for the fungus. The drought also causes pod cracking, which also facilitates entry and growth of *Aspergillus*. Groundnut fields infested with weeds result in termite attacks on the pods increasing the susceptibility to *Aspergillus* infection.

Inappropriate plant population and poor water management: In erosion prone fields -due to sloppy conditions and loose soil composition- the cultivations become exposed to water erosion, loss of soil moisture and deterioration of soil structure, which further exacerbate the effects of droughts and predisposes the land to increased chances of *A. flavus* buildup.

2.3.5.2. Contamination at harvest

Defective method of harvesting: Harvesting at the right time and in the right manner significantly affect the quality as well as exposure to aflatoxin contamination. Poor harvesting methods, especially the use of hand hoes and other pointed digging tools, cause damage to the nuts, making the entry of fungus possible within the pods. The crop can be infected with *Aspergillus*, if harvested with the soil sticking to the pods.

Drying on bare ground and exposure to atmospheric humidity: Similarly, crop dried on bare ground/soil is also infected with fungi and increases the chances of aflatoxins' contamination.

Premature harvesting: During early harvesting, at a time when the crop is still immature, the crop has a high moisture content, which exposes it to fungal infestation. Harvesting immature nuts increases the opportunity for infection by fungi.

2.3.5.3. Post-harvest contamination

Groundnuts are infected with aflatoxins at the post-harvest stages due to mishandling and defective post-harvest management.

Improper drying: Drying on roofs or on the floor exposes the grains to moisture leading to growth of fungus. Drying on bare floors also causes insect pest infestation, which in turn paves the way for aflatoxins through fungal growth.

Improper shelling: Some practices are very undesirable and encourage fungal infestation and growth. Sprinkling/spraying water on pods to facilitate the removal of shells and improve the weight of the nuts for high market prices result in *Aspergillus flavus* infection and aflatoxin contamination. Sometimes,

groundnuts are threshed inside the bags, which also causes damage to the pods/kernels and exposure to aflatoxins contamination.

Poor curing techniques: Some farmers dry the pods without having the knowledge about the adverse effects on the quality of peanuts. The practice of overdrying causes cracking of the pods and seed coat, thus exposing the nuts to further infection.

Inappropriate/ poor stripping: Groundnut farmers strip off the groundnuts hastily and improperly with soil sticking to the pods, inducing soil-borne fungal infection in the storage and other processing stages. Pods contaminated with soil provide a harboring place for fungal infection and aflatoxins contamination.

Poor sorting and grading: Poor grading, especially non-removal of the damaged nuts before storage, cause contamination. Damaged, broken, shrivelled and cracked kernels need to be separated from healthy ones to avoid contamination during storage.

Inappropriate/Poor storage conditions: Storing groundnuts with high moisture content and poor storage (at household level, market/shops) that exposes grains to winter rains, high humidity during the night and poor air circulation that enhances high temperatures, leads to fungus growth.

Use of airtight containers: Using non-porous nylon bags and other airtight storage materials decreases insect pest attack and subsequently infection by fungus. Vacuum machines can be used for packaging in cellophane bags/sheets.

Defective transportation: Transporting the grains in vehicles with open roofs can expose the grain to sudden rain, strong humid winds and moisture, prompting fungus growth.

Methods to reduce and prevent aflatoxin contamination

The etiology of fungal growth and aflatoxins is multifaceted and various factors influence the contamination. Of these factors, some are external/environmental, beyond the control of the farmers, while others pertain to management practices during crop production. Adoption of appropriate and good agriculture practices can significantly reduce fungal infection, growth and aflatoxins production in groundnuts.

2.3.5.4. Crop management practices that reduce infection in the field

Some management practices at the pre-harvest stage may minimize exposure to infection by fungi and reduced infestation by insects, drought and ultimately infection by the aflatoxin fungi, *A. flavus*. These approaches aim at providing crops with the best possible growth environment to avoid infestation by insects, drought and subsequent infection by fungi.

Planting early, especially in rainfed areas, enables the crop to escape from severe droughts and high temperatures, as the exposure of the crop to extreme heat causes pods to crack.

Maintaining field hygiene through timely weeding to retain soil moisture needed for proper plant growth and avoiding dry conditions that predispose developing pods to cracking. Termite control is also very important to prevent damage to developing pods, especially as the crop matures.

Retaining/harvesting water in the field at the time of harvest during drought and when the crop is growing, causes fungal contamination and subsequent aflatoxin contamination. The water should be retained in the field to avoid drought and provide residual moisture to the growing pods. The use of **tied ridges (box ridges)** can improve water penetration into the soil, thereby reducing exposure of the developing crop to *A. flavus* infestation. Box ridges should be put in place early in the cropping season to capture enough rainwater and reduce the effects of end-of-season drought. Mulching also helps to retain water in the field.

Using soil additives as strong defense, i.e. applying lime to the crop, supports the development of strong shells (pod resistance). Strong shells provide the first line of defence against pests and fungal

attacks. Application of balanced fertilizers, including the application of micronutrients, creates resistance against diseases and insect pest infestation.

2.3.5.5. Crop management practices that reduce infection during harvesting

Some important techniques which are helpful in reducing the contamination of pods/kernels and exposure to fungi are mentioned below:

Timely harvesting is the key farm operation in groundnut, which determines the quality and shelf life of peanuts. The crop should be harvested at an appropriate maturity time. Immature harvesting encourages infection, growth and aflatoxin contamination. Timely harvesting when the crop matures physiologically and physically is the best strategy to minimize exposure of the crop to extreme heat, sudden rain or drought, which affects the infection and aflatoxins contamination.

Avoiding injuries to pods, as pods are injured during digging (especially using hand hoes). Proper care should be taken to focus the hoe on the root zone to avoid injury to the kernel.

Removing soil from the pods and keeping them clean is an important phytosanitary measure for preventing the fungus from being carried into stores and processing facilities.

2.3.5.6. Crop management practices that reduce contamination at post-harvest

Postharvest handling and management is an important phase for preventing or avoiding fungal infection and aflatoxin contamination. The two important aspects of post-harvest management are drying, shelling, grading, sorting and storage.

Drying appropriately, as improper drying of peanuts results in absorption of ambient moisture and aflatoxin contamination. Drying on bare ground, such as root top or bare soil, is not a standard practice of drying. It is recommended to detach the pods immediately after uprooting to reduce aflatoxin contamination. To do so during monsoon season, the use of dryers like Solar Bubble Dryer is also recommended rather than sun-drying (DAR, 2019). The use of Mandela Corks (ventilated stacking) is one of the best methods for curing groundnuts and is specifically preferred for its ability to minimize the direct exposure of groundnuts to the sun. Mandela Corks should be stacked on a raised platform, leaving a hollow space in the middle to allow air circulation inside the structure. The stacks should be put on the waterproof tarpaulin to prevent moisture absorption.

Shell safely, as sometimes sprinkling water on pods to shell the groundnut leads to fungal accumulation and aflatoxin production. It is therefore always better to avoid wetting pods during shelling. The use of mechanical shellers can also reduce labour cost and increase shelling efficiency.

Practice improved grading and sorting as fungi readily invade kernels with cracked or damaged pods or seed coats. Removal of such damaged, discoloured, small and shrivelled pods reduces the amounts of infected produce in the lot.

Store under optimum conditions as entry of insects and moisture into storage lots also allows the entry of fungus and eventually aflatoxin contamination. Grains should be stored in a dry and secure place where the entry of insects and moisture is improbable. DAR, 2019, also advised to use cold storage facilities at 20 to 22 °C for medium enterprises that can afford to reduce aflatoxin contamination.

Observe care at the processors' level, as it is highly important to sort out the loose, shelled kernels, shrivelled, damaged or discoloured pods from the healthy ones, as such pods are at a higher risk of fungal growth and aflatoxins contamination compared to large, mature and well-filled pods. Sorting alone can reduce contamination and keep it within acceptable levels. Such pods should be sorted before shelling, while kernels must be sorted in various grades or categories based on size, colouration and shape. The off-grades should not be used by humans nor be fed to animals due to high levels of aflatoxin which may lead to sudden death.

Figure 64. Aflatoxins contaminated groundnut kernels



Figure 65. Groundnut infected with *Aspergillus flavus*



Figure 66. Pods infected by *Aspergillus flavus*

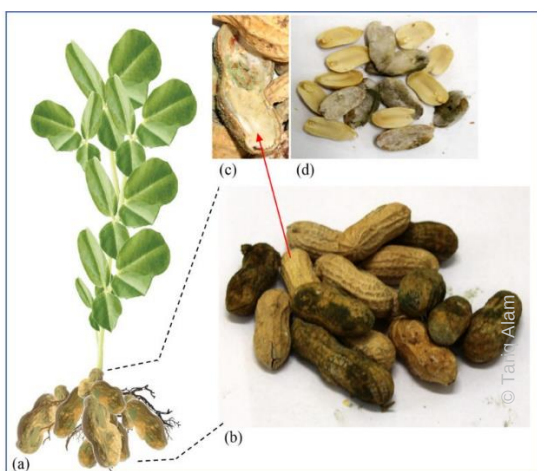


Figure 67. Aflatoxins infected kernel and shell of peanuts



Figure 68. Termite nest in the field



Figure 69. Groundnut pods damaged during harvesting



Figure 70. Other common ways of drying peanuts include Mandela Cork, also known as stalked pole, inverted, and on tarpaulin



Figure 71. Aspergillus Flavus colonized kernel which must be removed from the bulk



CHAPTER 3 – OTHER GAP AND QUALITY ASSURANCE STANDARDS

3.1. Produce quality production plan

In order to produce quality food, a quality production plan should be developed, implemented and kept on record. Quality plans should encompass practices that are critical to managing produce quality during production, harvesting and post-harvest handling, expected losses, causes, control measure, and monitoring activities. Proper record of all the crop management practices should complement the quality plan (ASEAN GAP–produce quality module).

3.2. Buildings and structures

Buildings and structures are constructed in separate places from farm animals, animal feed and compost-making venues. The floor of the building is checked before use for cleanliness, foreign objects, chemical contamination, pest infestation and other materials. The bamboo/timber is placed on the floor of the building with the intent of not being in direct contact with the floor. The building is structured and managed to have good ventilation and prevention of birds, rats and pest. Produce is not stored in direct contact with fuels, pesticides, fertilizers, including farm implements and other materials (Myanmar GAP Guidelines, 2018).

3.3. Animals and pest control

The produce, packaging materials, other goods, traps, rodenticides and stimulating foods are stored in targeted places to minimize the risk of contamination (Myanmar GAP Guidelines, 2018).

3.4. Agro-chemicals and other chemicals

Only registered products are purchased from licensed suppliers and used for crop production. Banned pesticides are not used. In the case of groundnut production for export purposes, the banned pesticides by the importing countries are not used. IPM should be practised minimizing pesticide use. Use of physical and biological control measures is better than using pesticides, fungicides and herbicides to minimize the risks of contaminating the environment (Myanmar GAP Guidelines, 2018). **Pre-harvest intervals (PHI) are observed and followed exactly.** The chemicals obtained, stored, and application of chemicals are systematically handled and recorded. Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating produce. (Myanmar GAP Guidelines, 2018).

The chemicals obtained, stored, used, application and disposals of chemicals are systematically handled and recorded as per Annex 3 (Form.1. Pesticides/Fungicides Application; 1 to 4 & Form.2. Agro-Chemicals and Other Chemicals; 1 to 12).

3.5. Agriculture and other related materials

Farm machineries, threshing, grading machines and processing complex are placed in cleaning areas. Equipment, materials and storage containers that come in contact with produce are cleaned to avoid contamination. Waste, chemicals, dangerous substances and other hazardous materials are not used for storage or for holding produce (Myanmar GAP guidelines, 2018).

3.6. Traceability and recall

To ensure a systematic record for product/produce traceability and recall, each production site should be identified and coded. Packed containers should be marked with an identification code and record showing the date of supply, quantity, year of production, and destination of each consignment. In case

of any contamination, the cause should be investigated, and relevant preventive measures taken should be recorded.

3.7. Documents and records

Documentation and record-keeping in an important steps. Records of good agricultural practices should be kept for a minimum period of at least two years. Out-of-date documents must be discarded, and only current versions are to be kept. The documents should provide GAP practices implemented over the pre- and post-harvest stages, standards maintained for worker health, safety and welfare, workers training and review of GAP practices.

3.8. Training and awareness

Training and awareness raising of GAP actors such as DoA extension staff, farmers, consumers, merchants, brokers and exporters is important to increase their knowledge in their respective areas of responsibilities, building trust and mutual cooperation for GAP promotional activities. Capacity building of farmers and DoA extension staff in Integrated Crop Management (ICM) and IPM, and record-keeping is integral to GAP production and post-production activities. The workers should be specifically trained on hazard identification and their safe management up to GAP compliance standards.

3.9. Review of practices

All practices are reviewed at least once a year to ensure they are properly applied. Actions are taken to resolve the complaints related to production quality, and a record is kept of the complaints and actions taken (Myanmar GAP Guidelines, 2018).

3.10. Personal hygiene and worker welfare

Personal hygiene is of immense importance for food safety and workers' health. Key instructions and guidance should be displayed at prominent locations on and off the farm and should be reinforced for compliance. Visible and potential sources jeopardizing the hygiene of workers and produce, such as sewage, should be identified and remedial measures taken should be recorded. Regular demonstrations and role-plays should be practised for the implementation of personal hygiene practices. Appropriate hygiene facilities should be provided in the bathrooms and handwashing places as well as cleaning of equipment.

3.11. Cleaning and sanitation plan

A plan to prevent or minimize the risk of food contamination through the application of approved standards should be maintained. Packing, handling and storage areas and equipment, tools, containers, and materials that may be a source of contamination for the produce are identified, and instructions are prepared and followed for cleaning and sanitation. Moreover, appropriate cleaning and sanitation chemicals need to be selected to minimize the risk of these chemicals causing contamination of produce.

3.12. Conservation of biodiversity

To conserve and protect local biodiversity and ensure resource sustainability of the local ecosystem, local legislation and regulations should be followed. Production and processing activities should not damage the environmental quality, especially if a safe, efficient, and approved management of farm operations is applied. Employers and workers should have appropriate knowledge and training in their area of responsibility, relevant to GAP for environmental management. Burning of crop residues and packaging materials has tremendous deleterious effects on air quality; therefore, safe disposal of waste is paramount. A safe disposal plan should be available for verification and compliance. Complaints

related to environmental management and actions taken to resolve them should be documented and available for consultation.

**Refer to part II as ICM handbook on
Integrated Pest, Disease and Weed
Management for oils seed crops
(Sesame and Groundnut)**

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Annexes

Annex 1. Myanmar GAP guidelines for groundnut

S.No	GAP parameters	Recommended GAP practices
1.1	Site selection	Saline soil and soils with a pH of less than 5.5 are unsuitable for groundnuts. The soil for groundnut should be well-drained. According to the site history, the previous use of selected site must not be the area of hospital, livestock farm, industry and waste disposal areas. Groundnut is mostly grown in the areas of temperate, sub-temperate. The optimum temperature for vegetative growth is at (27–30) degree centigrade, (24–27) degree centigrade for reproductive growth and (30–34) degree centigrade for pod formation. The annual rainfall range for groundnut production is (23–26) inches and it can be grown at 3500 ft above sea level. Soil is prepared for deep ploughing and very fine tillage.
1.2	Water	Water quality should be tested for health and systematically utilized. The water flowing down from livestock farms, hospitals, industries, waste water and any sources that may cause environmental harm are not used for irrigation purpose.
1.3	Seed	Local adaptable varieties with a germination of over 80 percent and certified seeds should be selected and used for production. Existing seed law must also be complied with. Groundnut pods used for seeds are placed in sun-shade for air drying and it is used for one week. It must be free from seed borne disease. Pest and disease resistant and climate resilient varieties are selected and used. (e.g. Sinn Pa Dae Ther-6, Sinn -12 and Magway-11) A record is kept of the source of supply, amount of supply and the date of supply, name of variety for seeds.
1.4	Fertilizers and soil additives	Fertilizers and soil additives are systematically applied based on the result of soil testing. The registered products are only purchased from licensed suppliers and used for crop production. The application of fertilizers and soil additives are recorded. The (3 – 6) kg of Furadan insecticide is applied in the rows to prevent soil born pests and stem borders. The cow-dung and other animal feces are used during land preparation after making thorough compost. About 3–5 tons/acre of natural fertilizer and green manure are annually applied for improving the physical and chemical properties of the soil. The plant residues free from pest and diseases are used for compost. Seed treatment blending rhizobium and fungicide is avoided. Fungicide is applied to prevent seed-borne disease and rhizobium is applied as seed treatment at sowing time. Based on the calcium content of different gypsum fertilizer, about (10–15) lbs of Calcium is applied. If the soil type is below pH 5.5, liming is done for good seed formation three months before sowing time.
1.5	Agro-chemicals and other chemicals	Integrated Pest Management should be practised minimizing the pesticide use. The registered plant-extract and bio pesticides are only purchased from licensed suppliers and used. It is careful to minimize the risks of contaminating the environment and harmfulness to the people's health according to the Pesticide/Fertilizer Laws and Regulations. The registered products are only purchased from licensed suppliers and used for crop production. Pre-harvest intervals (PHIs) are observed and followed exactly. The chemicals obtained, stored, and application of chemicals are systematically handled and recorded. Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating produce.
1.6	Care and management	The following measures should be practised for producing good quality groundnut; - The optimum seed rate is (6 – 8) baskets/acre (about 150 –200 lb/acre). - Row to row and plant to plant spacing should be 15 × 4 inches for erect type with a plant population of at least 100 000 while 18 × 4 inches for branching type with plant population of at least 890 00. - Sowing time should be (May – June) for monsoon season and August for mid-monsoon season while October-November for post-monsoon season.

S.No	GAP parameters	Recommended GAP practices
		- Seed treatment with appropriate fungicide should be done to prevent soil-borne disease. - Seed treatment with recommended dose of rhizobium is done. - Liming is done 8 inches or 20 centimetres deep in the soil, 3 months ahead before sowing, if necessary. - Contour farming and terrace farming should be used in slopping areas. Prevention measures is necessary to prevent the flood. - Seed depth should be within 1 – 1.5 inches with enough moisture content for good germination. - Inter-cultivation weeding and hand weeding should be done within 1 month after sowing. - Weeding should be done before fertilizer application. - Split dose of Potash and Nitrogen fertilizers in rows with enough soil moisture and earthing up is more beneficial to minimize fertilizer losses. - All natural fertilizers, Phosphate and Potassium fertilizers are applied as basal and Urea and remaining Potassium are applied during vegetative growth with enough soil moisture. - Mono-cropping of groundnut is avoided. - Erect type is recommended for irrigation areas. - Soil moisture should be enough nearby plant (4–6 inches) from peg initiation stage to 1 month ahead before harvesting. If necessary, foliar spray is used. IPM should be practised.
1.7	Prevention measures for aflatoxin free	- Prevention and control measures are managed/ prepared before harvesting. - The plants affected by root-rot are not harvested and not mixed with other plants. - Once harvesting, the pods are picked, and sun drying is done up to 13 percent of seed moisture
1.8	Agriculture and other related materials	Farm machineries, threshing, grading machines and processing complex are placed in cleaning areas. Equipment, materials that contact produce and containers used for storage and other materials are cleaned not to contaminate the produce. Chemicals used for cleaning are identified and properly selected not to contaminate the produce.
1.9	Harvesting and handling produce	The proper harvesting time is 75 percent of groundnut pods matured. Irrigation before harvesting is avoided for seed-purpose production. Avoid harvesting before or after the maturity stage. When sun drying, the pods are placed in tarpaulin sheet, mats or concrete floors. Once harvesting, the pods should be immediately picked and placed outside for sun drying for about 2–3 days to get (6–7) percent of seed moisture content. Removal of unfilled grains, dust, sands and small gravel is done by machine or manually.
1.10	Storage and transport	Produce is not stored in the containers previously used for chemicals and other dangerous subsistence and materials. If there is no permanent silo, the super bags, tin boxes and potes (a kind of traditional container made of bamboo) are used. For export purpose, the prevention measures for storage pests/disease are practised during the storage period to meet the requirements of the different exporting countries. Transport vehicles are checked before being used for cleanliness, foreign objects and other materials, chemical contamination, pest infestation and are also checked to make sure to be dry without any moisture in the vehicles. Produce is stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.

S.No	GAP parameters	Recommended GAP practices
1.11	Building and structure	Building and structure are constructed in separate places from farm animals, animal feed and compost making exist. The floor of the building is checked before being used for cleanliness, foreign objects, chemical contamination, pest infestation and other materials. The bamboo/timber are placed on the floor of the building with purpose of not being direct contact with the floor. The building is structured and managed to have good ventilation and prevention of birds, rats and pest. Produce is not stored in direct contact with fuels, pesticides, fertilizers including farm implements and other materials. Recommended pesticides are used during the storage period according to the recommended dosage to prevent the storage pest.
1.12	Animals and pest control	The traps and stimulating foods are put in targeted places and carefully monitored to minimize the risk of contaminating produce. A record is kept of places where the traps and stimulating foods are placed.
1.13	Documents and records	Records of good agricultural practices are kept for a minimum period of at least two years. A record is kept of current practices taken in the format form.
1.14	Traceability and recall	Packed containers are clearly marked with an identification and registration number to enable traceability of the produce to the farm or site where the produce is grown. A record is kept of the date of supply and destination for each consignment of produce.
1.15	Training	Government staff, farmers, consumers, merchants, brokers and exporters are trained to have the knowledge in their area of responsibilities relevant to good agricultural practices. They should attend the trainings about Integrated Pest Management and Crop Management Practices. A record is kept of the training attendance.
1.16	Review of practices	All practices are reviewed at least once each year to ensure that they are done correctly by the Technical Advisory Team organizing with SMSs. Actions are taken to resolve the complaints related to produce quality, and a record is kept of the complaint and actions taken.
1.17	Personal hygiene and worker welfare	Written instructions on personal hygiene practices are also displayed in prominent locations and also distributed to them and encourage them to practice. Sewage is carefully disposed of in a manner that minimizes the risk of contamination of workers. All actions taken are emphasized on personal hygiene and worker welfare. For personal hygiene and workers welfare, teamwork activities and educational meetings are conducted.

Annex 2. Relevant ASEAN guidelines

Annex 2.1. Module for produce quality–GAP requirements

S.No	GAP requirement	Objectives	Required practice (s)
2.1.1	Quality production plan	To manage produce quality ⁷	1. Practices that are critical to managing produce quality during production, harvesting and postharvest handling are identified in a quality plan for the crop grown.
2.1.2	Planting material (seed, variety, types)	To improve quality and optimize market return	1. Crop varieties are selected to satisfy market requirements; 2. Good quality of planting materials is evidenced from certified sources
2.1.3	Fertilizers and soil additives	To ensure application of quality, safe, ecofriendly, sites specific, fertilizers and soil additives for improved produce quality	1. Nutrient application is based on recommendations from a competent authority or on soil or leaf or sap testing and the nutritional requirements for the crop grown. 2. Equipment used to apply fertilizers and soil additives is maintained in working condition and checked for effective operation at least annually by a technically competent person. 3. Areas and facilities for composting organic materials are located, constructed and maintained to prevent contamination of crops by diseases. 4. The application of fertilizers and soil additives is recorded, detailing the name of the product or material, date, treatment location, application rate and method, and operator name.
2.1.4	Irrigation and water management	To ensure efficient fulfillment of crop irrigation water requirement in a site and crop specific for increased yield, quality and water use efficiency	1. Irrigation use is based on crop water requirements, water availability, and soil moisture levels. 2. A record of irrigation use is kept, detailing the crop, date, location, and volume of water applied or duration of irrigation.

⁷ The quality plan encompasses steps in growing, harvesting and postharvest handling of the crop, expected losses in quality, causes and control measures, monitoring activities and record keeping to be practised to prevent or minimize the risk of the hazard affecting the quality.

S.No	GAP requirement	Objectives	Required practice (s)
2.1.5	Chemical (Agrochemicals)	To prevent quality losses of the produce by using safe, approved and integrated methods of agrochemicals applications	1. Employers and workers have been trained to a level appropriate to their area of responsibility for chemical application. 2. Crop protection measures are appropriate for the control of pests. 3. Integrated pest management systems are used where possible. 4. Chemicals are only obtained from licensed suppliers. 5. Chemicals used on crops are approved by a competent authority in the country where the crop is grown and intended to be traded, and documentation is available to confirm approval. 6. Chemicals are applied according to label directions, or a permit issued by a competent authority. 7. A chemical rotation strategy and other crop protection measures are used to avoid pest resistance. 8. Equipment used to apply chemicals is maintained in working condition and checked for effective operation at least annually by a technically competent person 9. The application of chemicals is recorded for each crop, detailing the chemical used, reason for application, treatment location, date, rate and method of application, weather conditions, and operator name.
2.1.6	Harvesting and handling produce	To prevent and minimize quality loss through safe and efficient harvest and postharvest handling	1. An appropriate maturity index is used to determine when to harvest produce. 2. An appropriate technique is used for harvesting produce. 3. Equipment and tools are suitable for harvesting and are checked for cleanliness before use and cleaned as required. 4. Containers are suitable for harvesting produce and are not overfilled. 5. Liners are used to protect produce if containers have rough surfaces. 6. Containers are covered to reduce moisture loss and exposure to the sun. 7. Containers are checked for soundness and cleanliness before use and cleaned or discarded as required. 8. Produce is harvested at the coolest time of the day and harvesting in the rain is avoided if possible. 9. Produce is removed from the field as quickly as possible. 10. Harvested produce is placed in the shade if long delays occur before transport. 11. Packed containers are not stacked on top of each other unless they are designed to support the container and minimize mechanical damage. 12. Containers are secured during transport to minimize mechanical damage. 13. Equipment is constructed to minimize excessive drops and impacts.

S.No	GAP requirement	Objectives	Required practice (s)
			14. Equipment, containers and materials that come into contact with produce are regularly cleaned and maintained to minimize mechanical damage. 15. Measures are taken to prevent the presence of pests in and around handling, packing and storage areas. 16. Where required, produce is treated to minimize disease development and loss of quality. 17. Water used after harvest for handling, washing, and produce treatment is treated or changed regularly to minimize contamination from spoilage organism. 18. Produce is packed and stored in covered areas. 19. Produce is not placed in direct contact with soil or the floor of handling, packing or storage areas. 20. Produce is graded and packed according to customer or market requirements. 21. Protective materials are used where required to protect produce from rough surfaces of containers and excessive moisture loss. 22. Field heat is removed using appropriate cooling methods.
2.1.7	Storage and transport	To prevent or minimize quality loss through safe, product specific and approved storage and transportation of produce	1. For long delays before transport, produce is held at the lowest suitable temperature available 2. Transport vehicles are covered, and appropriate temperature conditions are used to minimize quality loss. 3. Transport vehicles are checked before use for cleanliness, foreign objects, and pest infestation, and cleaned if there is a significant risk of mechanical damage and contamination from spoilage organisms. 4. Mixing of non-compatible produce during transport is avoided. 5. Produce is transported quickly to the destination.
2.1.8	Traceability and recall	To implement an effective system ⁸ for identifying and tracing produce is needed to investigate causes of quality loss when it occurs and to prevent re-occurrence of the problem	1. Each separate production site is identified by a name or code. The name or code is placed on the site and recorded on a property map. The site name or code is recorded on all documents and records that refer to the site. 2. Packed containers are clearly marked with an identification to enable traceability of the produce to the farm or site where the produce is grown. 3. A record is kept of the date of supply, quantity of produce and destination for each consignment of produce.
2.1.9	Employees and workers training	To improve knowledge and skills of employees and workers for safe and approved handling of farm produce	1. Employers and workers have appropriate knowledge or are trained in their area of responsibility relevant to good agricultural practice and a record of training is kept.

⁸ The production site be identified by a name or code and each packed container is clearly marked with an identification code including record of the batch identification, date of supply, source, destination and records of farm operation.

S.No	GAP requirement	Objectives	Required practice (s)
2.1.10	Documents and records	To ensure effective record keeping for easy, evidence based and timely investigation of quality loss of the produce	1. Records of good agricultural practices are kept for a minimum period of at least two years or for a longer period if required by government legislation or customers. 2. Out of date documents are discarded and only current versions are used.
2.1.11	Review of practices	To confirm and reinforce the implementation of practices and improvement as necessary	1. All practices are reviewed at least once each year to ensure that they are done correctly, and actions are taken to correct any deficiencies identified. 2. Record is kept of practices reviewed and corrective actions taken. 3. Actions are taken to resolve complaints related to produce quality, and a record is kept of the complaint and actions taken.

A2.1. Compost and crop residues should be stored away from production sites to avoid produce contamination



A2.2. Compost and crop residues should be stored away from production sites to avoid produce contamination



A2.3. Chemicals should be applied according to label directions, or a permit issued by a competent authority



Annex 2.2. Module for food safety—GAP requirements

S.No	GAP requirement	Objectives	Required practice (s)
2.2.1	Site history and management	To document and manage sites of production for prevention/control of chemical, biological and physical contamination for improved food safety	1. The risk of contaminating produce with chemical and biological hazards from the previous use of the site or from adjoining sites is assessed for each crop grown and a record is kept of any significant risks identified. 2. Where a significant risk of chemical or biological contamination of produce has been identified, either the site is not used for the production of fresh produce or remedial action is taken to manage the risk. 3. If remedial action is required to manage the risk, the actions are monitored to check that contamination of the produce does not occur, and a record is kept of the actions taken and monitoring results. 4. The location of any contaminated sites on the property, which are unsuitable for the production of fresh produce, is recorded.
2.2.2	Planting material	To prevent and minimize contamination by using safe and approved planting materials	1. If planting material is produced on the farm, a record is kept of any chemical treatment used and the reason for use. 2. If planting material is obtained from another farm or nursery, a record is kept of the name of the supplier and the date of supply. 3. Varieties known to be toxic for human consumption are not grown.
2.2.3	Fertilizers and soil additives	To prevent or minimize the risk of chemical and biological contamination through safe, appropriate and approved organic/inorganic fertilizers and soil additives for better food safety	1. The risk of chemical and biological contamination of produce from the use of fertilizers or soil additives is assessed for each crop grown and a record is kept of any significant hazards identified. 2. If a significant hazard from the use of fertilizers or soil additives is identified, measures are taken to minimize the risk of contamination of produce. 3. Fertilizers and soil additives are selected to minimize the risk of contamination of produce with 'heavy metals. 4. Untreated organic materials are not applied in situations where there is a significant risk of contaminating the produce. 5. Where an organic material is treated on the farm before application, the method, date and duration of the treatment are recorded. 6. If a product containing organic materials is obtained from off the farm and there is a significant risk of contaminating the produce, documentation is available from the supplier to show that the material has been treated to minimize the risk of contaminating the produce. 7. Human sewage is not used for production of any fresh produce destined for human consumption. 8. Equipment used to apply fertilizers and soil additives is maintained in working condition and checked for effective operation at least annually by a technically competent person. 9. Areas or facilities for storage, mixing and loading of fertilizers and soil additives and for composting of organic materials are located, constructed and maintained to minimize the risk of contamination of production sites and water sources.

S.No	GAP requirement	Objectives	Required practice (s)
			10. A record of fertilizers and soil additives obtained is kept, detailing the source, product name, and date and quantity obtained. 11. The application of fertilizers and soil additives is recorded, detailing the date, name of the product or material used, treatment location, application rate, application method, and operator name.
2.2.4	Irrigation and water management	To prevent or minimize the risk of chemical and biological food contamination during irrigation/fertigation or other water treatments through assessed, safe and documented water sources	1. The risk of chemical and biological contamination of produce is assessed for water used before harvest for irrigation, fertigation, and applying chemicals, and after harvest for handling, washing, produce treatment, and cleaning and sanitation. A record is kept of any significant hazards identified. 2. Where water testing is required to assess the risk of contamination, tests are conducted at a frequency appropriate to the conditions affecting the water supply, and a record of test results is kept. 3. Where the risk of chemical and biological contamination of produce is significant, either a safe alternative water source is used, or the water is treated and monitored, and a record is kept of the treatment method and monitoring results. 4. Untreated sewage water is not used during production and postharvest handling of produce. In countries where the use of treated water is permitted, the water quality must comply with the relevant regulations.
2.2.5	Chemicals (Agrochemicals)	To prevent or reduce the risk of chemical food contamination through the use of known, approved, and safe use of agrochemical for better food safety	1. Employers and workers have been trained to a level appropriate to their area of responsibility for chemical use. 2. If the choice of chemical products is made by advisers, proof of their technical competence is available. 3. Integrated pest management systems are used where possible to minimize the use of synthetic chemicals. 4. Chemicals and biopesticides used on crops are approved by a competent authority in the country where the crop is grown and intended to be traded, and documentation is available to confirm approval. 5. Up to date information on chemical MRL standards for the country where produce is intended to be traded is obtained from a competent authority. 6. Chemicals are applied according to label directions, or a permit issued by a competent authority. 7. To check that chemicals are applied correctly, produce is tested for chemical residues at a frequency required by customers or a competent authority in the country where produce is intended to be traded. The laboratory used is accredited by a competent authority. 8. The mixing of more than two chemicals is avoided, unless recommended by a competent authority. 9. Withholding periods for the interval between chemical application and harvest are observed. 10. Equipment used to apply chemicals is maintained in working condition and checked for effective operation at least annually by a technically competent person. 11. Equipment is washed after each use and washing waste is disposed of in a manner that does not present a risk of contaminating the produce.

S.No	GAP requirement	Objectives	Required practice (s)
			12. Surplus application mixes are disposed of in a manner that does not present a risk of contaminating the produce. 13. Chemicals are stored in a well-lit, sound and secure structure, with only authorized people allowed access. The structure is located and constructed to minimize the risk of contaminating produce and equipped with emergency facilities in the event of a chemical spill. 14. Liquid formulations of chemicals are not stored on shelves above powders. 15. Chemicals are stored in the original container with a legible label and according to label directions or instructions from a competent authority. If a chemical is transferred to another container, the new container is clearly marked with the brand name, rate of use and withholding period. 16. Empty chemical containers are not re-used and are kept secure until disposal. 17. Empty chemical containers are disposed of according to relevant country regulations and in a manner that minimizes the risk of contaminating produce. Official collection and disposal systems are used where available. 18. Obsolete chemicals that are unusable or no longer approved are clearly identified and kept secure until disposal. 19. Obsolete chemicals are disposed of through official collection systems or in legal off-site areas. 20. The application of chemicals is recorded for each crop, detailing the chemical used, reason for application, treatment location, date, rate and method of application, withholding period, and operator name. 21. A record of chemicals obtained is kept, detailing chemical name, supplier of chemical, date and quantity obtained, and expiry or manufacture date. 22. Where applicable, a record of chemicals held in storage is kept, detailing chemical name, date and quantity obtained and date when completely used or disposed of. 23. If chemical residues in excess of the MRL are detected in the country where produce is traded, marketing of the produce is ceased. The cause of the contamination is investigated, corrective actions are taken to prevent re-occurrence, and a record is kept of the incident and actions taken. 24. Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating produce.
2.2.6	Harvesting and handling produce	To prevent or reduce the risk of physical, chemical, biological contamination during postharvest handling	1. Equipment, containers and materials that contact produce are made of materials that will not contaminate produce. 2. Containers used for storage of waste, chemicals, and other dangerous substances are clearly identified and are not used for holding produce. 3. Equipment and containers are regularly maintained to minimize contamination of produce. 4. Equipment, containers and materials are stored in areas separated from chemicals, fertilizers and soil additives and measures are taken to minimize contamination from pests.

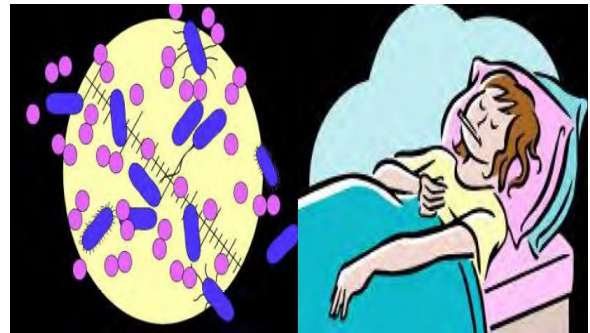
S.No	GAP requirement	Objectives	Required practice (s)
			5. Equipment, containers and materials are checked for soundness and cleanliness before use and cleaned, repaired or discarded as required. 6. Harvested produce is not placed in direct contact with soil or the floor of handling, packing or storage areas.
2.2.7	Buildings and structures	To prevent or reduce the risk of physical, chemical, biological contamination during handling and storage	1. Buildings and structures used for growing, handling and storage of produce are constructed and maintained to minimize the risk of contaminating produce. 2. Grease, oil, fuel and farm machinery are segregated from handling, packing and storage areas to prevent contamination of produce. 3. Sewage, waste disposal and drainage systems are constructed to minimize the risk of contaminating the production site and water supply. 4. Lights above areas where produce and packing containers and materials are exposed, are either shatter proof or protected with shatter proof covers. In the event of a light breaking, exposed produce is rejected and equipment and packing containers and materials are cleaned. 5. Where equipment and tools that may be a source of physical hazards are located in the same building as produce handling, packing and storage areas, the equipment and tools are screened with a physical barrier or are not operated during packing, handling, and storage of produce.
2.2.8	Cleaning and sanitation	To prevent and reduce the risk of food contamination through application of approved standards of cleaning and sanitation	1. Packing, handling and storage areas and equipment, tools, containers and materials that may be a source of contaminating the produce are identified, and instructions are prepared and followed for cleaning and sanitation. 2. Appropriate cleaning and sanitation chemicals are selected to minimize the risk of these chemicals causing contamination of produce.
2.2.9	Animals and pest control	To prevent or reduce the risk of biological contamination through animals such as rodents, insects and feral animals and birds	1. Domestic and farm animals are excluded from the production site, particularly for crops grown in or close to the ground, and from areas where produce is harvested, packed and stored 2. Measures are taken to prevent the presence of pests in and around handling, packing and storage areas. 3. Baits and traps used for pest control are located and maintained to minimize the risk of contaminating the produce and packing containers and materials. The location of baits and traps is recorded.
2.2.10	Personal hygiene	To prevent or reduce the risk of physical and biological contamination by following hygiene standards	1. Workers have appropriate knowledge or are trained in personal hygiene practices and a record of training is kept. 2. Written instructions on personal hygiene practices are provided to workers or displayed in prominent locations. 3. Toilets and hand washing facilities are readily available to workers and are maintained in a hygienic condition. 4. Sewage is disposed of in a manner that minimizes the risk of direct or indirect contamination of produce.

S.No	GAP requirement	Objectives	Required practice (s)
2.2.11	Storage and transport	To prevent or minimize food contamination through safe storage and transportation of produce	1. Containers filled with produce are not placed in direct contact with soil where there is a significant risk of contaminating produce from soil on the bottom of containers. 2. Pallets are checked before use for cleanliness, chemical spills, foreign objects and pest infestation, and are cleaned, covered with protective material or rejected if there is a significant risk of contaminating produce. 3. Transport vehicles are checked before use for cleanliness, chemical spills, foreign objects, and pest infestation, and cleaned if there is a significant risk of contaminating produce. 4. Produce is stored and transported separate from goods that are a potential source of chemical, biological and physical contamination.
2.2.12	Traceability and recall	To ensure an effective system for identifying, tracing and recalling unsafe produce and removal from sale as well as to identify the cause of contamination and prevent re-occurrence.	1. Each separate production site is identified by a name or code. The name or code is placed on the site and recorded on a property map. The site name or code is recorded on all documents and records that refer to the site. 2. Packed containers are clearly marked with an identification to enable traceability of the produce to the farm or site where the produce is grown. 3. A record is kept of the date of supply, quantity of produce and destination for each consignment of produce. 4. When produce is identified as being contaminated or potentially contaminated, the produce is isolated and distribution prevented or if sold, the buyer is immediately notified. 5. The cause of any contamination is investigated, and corrective actions are taken to prevent reoccurrence and a record is kept of the incident and actions taken.
2.2.13	Training of workers and actors in supply chain	Workers, employers and supply chain actors are trained in GAP and record keeping	1. Employers and workers have appropriate knowledge or are trained in their area of responsibility relevant to good agricultural practice and a record of training is kept.
2.2.14	Documents and records	To ensure GAP record keeping and management	1. Records of good agricultural practices are kept for a minimum period of at least two years or for a longer period if required by government legislation or customers. 2. Out of date documents are discarded and only current versions are used.
2.2.15	Review of practices	To review the GAP practices on yearly basis or when needed, keep record of the corrective actions taken	1. All practices are reviewed at least once each year to ensure that they are done correctly, and actions are taken to correct any deficiencies identified. A record is kept of practices reviewed and corrective actions taken. 2. Actions are taken to resolve complaints related to food safety, and a record is kept of the complaint and actions taken.

A2.4. The use of pesticides that are not approved for the crop and the continued use of fertilizers with high levels of heavy metals are common sources of chemical hazards



A2.5. The types of microorganisms that cause illness are bacteria, parasites and viruses



A2.6. Physical hazards are foreign objects that become embedded in produce or fall into packages



A2.7. The risk of chemical and biological contamination of produce from previous use of the site and from adjoining sites must be assessed



A2.8. For side-dressing produce grown close to the ground, use only fully composted materials or treated proprietary organic products, and do not apply them within 2 weeks of harvest



A2.9. The location of organic materials beside waterways used to irrigate or wash produce can lead to biological contamination of produce



A2.11. Chemicals and bio-pesticides used on crops must be approved by a competent authority in the country where the crop is grown and intended to be traded



A2.12. Chemicals must be stored in a well-lit, sound and secure structure, with only authorized people allowed access



A2.13. Empty chemical containers are not re-used and are kept secure until disposal



A2.14. Domestic and farm animals must be excluded from the production site, particularly for crops grown in or close to the ground, and from areas where produce is harvested, packed and stored



A2.15. Toilets and hand washing facilities must be readily available to workers and maintained in a hygienic condition



Annex 2.3. Module for environmental management ASEAN GAP

S.No	GAP requirement	Objectives	Required practice (s)
2.3.1	Sites history and management	To prevent or minimize the risk of hazards causing environmental harm while selecting site for production and postharvest handling	1. Sites used for production comply with country regulations that restrict production at high altitudes or on steep slopes. 2. For new sites, the risk of causing environmental harm on and off the site is assessed for the proposed use and a record is kept of all potential hazards identified. The risk assessment shall consider: - the prior use of the site, - potential impacts of crop production and postharvest handling on and off the site, and - potential impacts of adjacent sites on the new site. 3. Where a significant risk is identified, either the site is not used for crop production and postharvest handling, or measures are taken to prevent or minimize the potential hazards. 4. property layout map is available showing the location of: a. crop production sites, b. environmentally sensitive areas and highly degraded areas, c. chemical storage and mixing areas, chemical application equipment cleaning areas, and postharvest chemical treatment areas, d. areas or facilities for storage, mixing and composting of fertilizers and soil additives e. water courses, storage sites, and significant drainage lines, run-off areas and discharge points, and f. property buildings, structures and roads. 5. Highly degraded areas are managed to minimize further degradation. 6. Management of site activities conforms to country environmental legislation covering air, water, noise, soil, biodiversity and other environmental issues.
2.3.2	Planting material	To minimize or prevent the risk of chemical contamination by selecting disease resistant and environmentally compatible planting materials for reduced use of fertilizers and pesticides	1. To minimize chemical usage and nutrient runoff, planting material is selected for disease resistance and compatibility with site properties such as soil type and nutrient levels.
2.3.3	Soil and substrates	To minimize or prevent soil degradation through soil erosion, salinity, alkalinity, sodicity and acidity land through improved land, irrigation and crop management practices	1. The intended production practices are suitable to the soil type and do not increase the risk of environmental degradation. 2. Where available, soil maps are used to plan rotation and production programs 3. Cultivation practices that improve or maintain soil structure and minimize soil compaction and erosion are used. 4. The use of chemical fumigants to sterilize soils and substrates is justified and a record is kept of the location, date, product, application rate and method, and operator name.

S.No	GAP requirement	Objectives	Required practice (s)
2.3.4	Fertilizers and soil additives	To prevent or minimize environmental harm through chemical contamination using improved and sites/location specific fertilizers and soil additives management	1. Nutrient application is based on recommendations from a competent authority or on soil, leaf or sap testing to minimize nutrient runoff and leaching. 2. Areas or facilities for storage, mixing and loading of fertilizers and soil additives and for composting of organic matter are located, constructed and maintained to minimize the risk of environmental harm on and off the site. 3. Equipment used to apply fertilizers and soil additives is maintained in working condition and checked for effective operation at least annually by a technically competent person 4. The application of fertilizers and soil additives is recorded, detailing the name of the product or material, date, treatment location, application rate and method, and operator name.
2.3.5	Irrigation and water management	To prevent or minimize environmental harm through use of safe irrigation water and efficient of drainage and run off water	1. Irrigation use is based on crop water requirements, water availability, soil moisture levels, and consideration of environmental impact on and off the site 2. An efficient irrigation system is used to minimize wastage of water and the risk of environmental harm on and off the site. 3. The irrigation system is checked for operational efficiency during each use, according to manufacturer's instructions or other appropriate methods, and maintained to ensure efficient delivery. 4. A record is kept of irrigation use, detailing crop, date, location, volume of water applied or duration of irrigation, and name of person who managed the irrigation activity. 5. Water collection, storage, and use is managed to comply with country regulatory requirements. 6. Water used from sources that may cause environmental harm to land and soil, waterways and sensitive areas is managed or treated to minimize the risk of environmental harm. 7. Water from toilets and drainage systems are disposed of in a manner that minimizes the risk of environmental harm on and off the site. 8. Water discharged from the property, including waste water from harvesting, cleaning and handling operations, is managed or treated to minimize off site environmental harm.
2.3.6	Chemical (Agrochemicals)	To prevent or minimize loss /damages to the local ecosystem through safe and approved use of agrochemicals	1. Employers and workers have been trained to a level appropriate to their area of responsibility for chemical application. 2. If the choice of chemical products is made by advisers, proof of their technical competence is available. 3. Crop protection measures are appropriate for the control of pests and based on recommendations from a competent authority or monitoring of crop pests. 4. Integrated pest management systems are used where possible to minimize the use of chemicals. 5. Chemicals are only obtained from licensed suppliers. 6. Chemicals used are approved for the targeted crop by a competent authority in the country of application, and up to date documentation is available to demonstrate the current approval status.

S.No	GAP requirement	Objectives	Required practice (s)
			7. Chemicals are applied according to label directions, or a permit issued by a competent authority. 8. A rotation strategy for chemical application and other crop protection measures are used to avoid pest resistance. 9. The application of chemicals (ground and aerial) is managed to minimize the risk of spray drift to neighbouring properties and environmentally sensitive areas. 10. Appropriate volumes of chemicals are mixed to minimize the amount of surplus chemical remaining after application. 11. Surplus chemical mixes and tank washings are disposed of in a manner that minimizes the risk of environmental harm on and off the site. 12. Equipment used to apply chemicals is maintained in working condition and checked for effective operation at least annually by a technically competent person. 13. Chemicals are stored in a well-lit, sound and secure structure, with only authorized people allowed access. The structure is located and constructed to minimize the risk of contaminating the environment and equipped with emergency facilities in the event of a chemical spill. 14. Chemicals are stored in the original container with a legible label and according to label directions or instructions from a competent authority. If a chemical is transferred to another container, the new container is clearly marked with the brand name, rate of use and withholding period. 15. Empty chemical containers are not re-used and are kept secure until disposal. 16. Empty chemical containers are disposed of according to relevant country regulations and in a manner that minimizes the risk of causing environmental harm on and off the site. Official collection and disposal systems are used where available. 17. Obsolete chemicals, which are unusable or no longer approved, are clearly identified and kept secure until disposal. 18. Obsolete chemicals are disposed of through official collection systems or in legal off-site areas. 19. The application of chemicals is recorded for each crop, detailing the chemical used, reason for application, application date, treatment location, application rate and method, weather conditions, and operator name. 20. Where applicable, a record of chemicals held in storage is kept, detailing chemical name, date and quantity obtained and date when completely used or disposed of. 21. Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating the environment. 22. The application, storage, and disposal of chemicals used after harvest, such as pesticides and waxes, follow the same practices as described in the Chemicals section. 23. A waste management plan is documented and followed, including identifying types of waste

S.No	GAP requirement	Objectives	Required practice (s)
			products generated by property activities and using practices to minimize waste generation, reuse or recycle waste and store and dispose of waste.
2.3.7	Harvesting and handling produce	To prevent or minimize damage to the environment through safe and approved use of chemicals used for application such as pesticides, fungicides, insecticides, weedicides, fumigants and wax used for surface coating	All the procedures and safety protocols given in S.No. 6 for chemicals and agrochemicals are followed.
2.3.8	Waste and energy efficiency	To prevent or minimize environmental harm through safe, efficient and improved waste water and emergency use efficiency	1. Consumption of electricity and fuel is reviewed, and efficient operating practices are identified and used. 2. Machinery and equipment are serviced to maintain operational efficiency or are replaced. 3. Property activities comply with country regulations covering the protection of endangered plant and animal species. 4. To conserve native plant and animal species, access and activity is managed in significant remnant native vegetation areas, wildlife corridors, and vegetation areas on and near the banks of waterways. 5. Measures are used to control feral animals and environmental pests. 6. The generation of offensive odour, smoke, dust, and noise is managed to minimize the impact on neighbouring properties.
2.3.9	Biodiversity	To preserve and protect local biodiversity through safe crop management practices	1. Local legislations and laws are followed for preservation and protection of local biodiversity for improved ecosystems
2.3.10	Air	To prevent or minimize environmental pollution through safe, efficient and approved management of the farm operations	1. Employers and workers have appropriate knowledge or are trained in their area of responsibility relevant to good agricultural practices and a record of training is kept. 2. Records of good agricultural practices are kept for a minimum period of at least two years or for a longer period if required by legislation or customers 3. Out of date documents are discarded and only current versions of documents relevant to good agricultural practice are used. 4. All practices are reviewed at least once each year to ensure that they are done correctly, and actions are taken to correct any deficiencies identified or if changes occur to environmental regulations. 5. A record is kept showing that all practices have been reviewed and any corrective actions taken are documented. 6. Actions are taken to resolve complaints related to environmental management, and a record is kept of the complaint and actions taken.

S.No	GAP requirement	Objectives	Required practice (s)
2.3.11	Trainings	To prevent or minimize environmental hazards through awareness and skills of employers and workers engaged in farm	1. Workers are trained on hazards and hazards safe management 2. Record of the training and compliances are maintained.
2.3.12	Documents and records	To maintain documents and record as evidence for traceability and implementation of GAP	1. Documents and record for traceability related to environmental safety are maintained at least for two years 2. Evidence for implementation of safety measures and GAP practices are available to the auditors and investigators
2.3.13	Review of practices	To ensure compliance to GAP and corrective actions taken through regular or need based review of practices	1. Record and documents of practices reviewed, and compliances/course correction taken are available 2. Record of the complaints and corresponding correction actions taken are maintained.

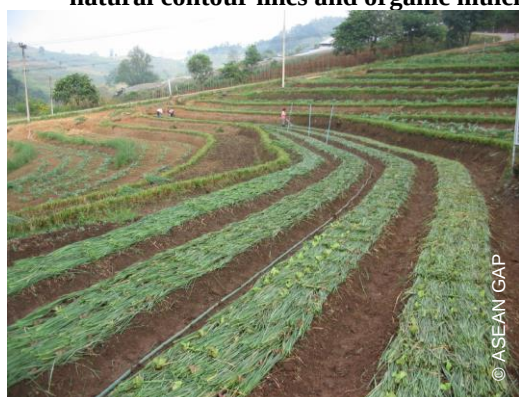
A2.16. For new sites, the risk of causing environmental harm on and off the site is assessed for the proposed use



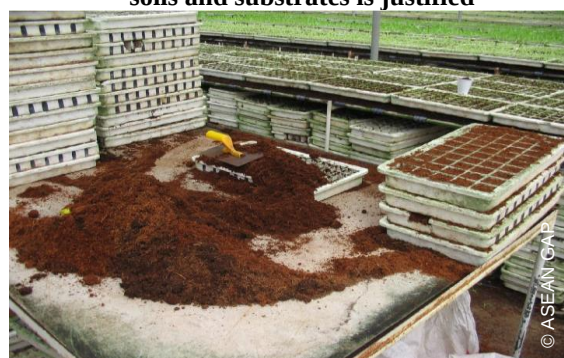
A2.17. Highly degrade areas must be managed to minimize further degradation



A2.18. To minimize the risk of soil erosion, use natural contour lines and organic mulches



A2.19. The use of chemical fumigants to sterilize soils and substrates is justified



A2.20. Storage, mixing and loading areas for fertilizers and soil additives should be positioned to minimize the risk of pollution of waterways and groundwater



A2.21. Chemicals are applied according to the label directions, or a permit issued by a competent authority



A2.22. Waste management and documentation is an important aspect of environmental safety



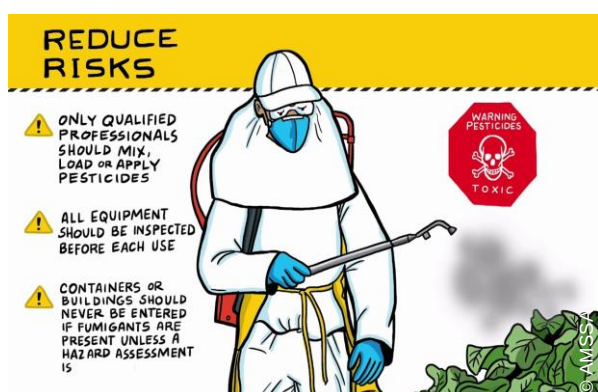
Annex 2.4. Module Worker Health, Safety and Welfare Module—ASEAN GAP

S.No	GAP requirement	Objectives	Required practice (s)
2.4.1	Chemicals	To ensure workers health, safety and welfare through prevention or minimization of exposures to the hazardous effects of chemicals.	1. Chemicals are handled and applied by authorized workers with appropriate knowledge and skills. 2. Chemicals are stored in a well-lit, sound and secure structure, with only authorized people allowed access. The structure is located and constructed to minimize the risk of contaminating workers and equipped with emergency facilities in the event of a chemical spill. 3. Chemicals are stored in the original container with a legible label and according to label directions or instructions from a competent authority. If a chemical is transferred to another container, the new container is clearly marked with the brand name, rate of use and withholding period. 4. Where there is a significant risk of chemical contamination of workers, Material Safety Data Sheets or safety instructions from chemical labels are readily available. 5. Facilities and first aid measures are readily available to treat workers contaminated with chemicals. 6. Accident and emergency instructions are documented and displayed in a prominent location within or close to the chemical storage area. 7. Workers handling and applying chemicals and entering newly sprayed sites are equipped

S.No	GAP requirement	Objectives	Required practice (s)
			with suitable protective clothing and equipment for chemical used. 8. Protected clothing is cleaned and stored separately from crop protection products. 9. Access to sites where chemicals are being applied or newly applied is restricted for an appropriate period relevant to the chemical used. 10. required, chemical application in areas of public access is marked with warning signs.
2.4.2	Working conditions	To provide safe, healthy and conducive work conditions for workers	1. Working conditions are suitable for workers and protective clothing is supplied where conditions are hazardous to workers. 2. All farm vehicles, equipment and tools, including electrical and mechanical devices, are adequately guarded and maintained and inspected on a regular basis for potential hazards to users. 3. Safe manual handling practices are followed to minimize the risk of injury from lifting heavy objects and excessive twisting and reaching movements.
2.4.3	Personal hygiene	To prevent or minimize biological, physical and chemical contamination through implementation of personal hygiene practices by farm family and workers and provision of personal hygiene facilities at the farm	1. Workers have appropriate knowledge or are trained in personal hygiene practices and a record of training is kept. 2. Written instructions on personal hygiene practices are provided to workers or displayed in prominent locations. 3. Toilets and hand washing facilities are readily available to workers and are maintained in a hygienic condition. 4. Sewage is disposed of in a manner that minimizes the risk of contamination of workers. 5. Where employers are required to provide medical and health cover, any serious health issue is reported to the relevant health authority. 6. Where required, foreign workers complete mandatory medical checks and a record is kept. 7. Measures are taken to minimize the presence of animals and pests with infectious disease in production sites and around handling, packing and storage areas.
2.4.4	Worker welfare	To ensure welfare and wellbeing of workers and productivity of the farm or packing shed through prevention of exploitation due to age, gender, race and any other reason	1. Where provided by an employer, living quarters are suitable for human habitation and contain basic services and facilities. 2. The minimum working age shall comply with country regulations. Where regulations are absent, workers shall be older than 15 years of age.
2.4.5	Trainings	New workers should be informed and trained about the risks to their health and safety and safety measures	1. New workers are informed about the risks associated with health and safety when starting at the worksite.
2.4.6	Documents and records	To ensure implementation of GAP for protection of workers health, safety and welfare.	1. Documents and records provide evidence that good agricultural practices have been implemented to protect worker health, safety and welfare. 2. Workers trainings record are available for safety and wellbeing.

S.No	GAP requirement	Objectives	Required practice (s)
			3. Evidence of regular review of practices for workers welfare and safety is available for verification
2.4.7	Review of practices	To ensure workers safety and wellbeing through regular review of practices.	1. Review practices are documented and implemented for workers safety and welfare. 2. Records of compliance standards for workers safety and wellbeing is available for assessment and verification. 3. Record of Complaints related to worker health, safety and welfare investigated and actions taken to resolve the Complaint are maintained.

A2.23. Protection from the hazardous effects of chemical must be complied with



A2.24. Posters and signs in the work area help to reinforce instructions for workers



Annex 3. GAP Check Lists

FORM-1						
CHECK LISTS FOR FARMERS' FIELD						
Site Inspection						
S.No	Parameter	Required Compliance /Record Keeping/Documentation				
1	Name of Crop					
2	Total Sown Area					
3	Area of GAP Registered Crops/Plant Population					
4	Land Preparation before Sowing Time					
5	Land Preparation after Sowing					
Surrounding Areas						
1	Surrounding Areas of GAP field					
2	Are there any other crops cultivated in surrounding areas of GAP field?	☐ Yes ☐ No				
3	Distance between GAP field & Toilet					
Seed Selection						
1	Name of Crop Variety					
2	Any plant parts for plant propagation					
3	Seed/Plant Propagation Source					
Cultivation Method						
1	Row & Plant Spacing					
2	Status of Inter-cropping	☐ Yes ☐ No				
3	Crop Duration					
Fertilizer Application						
S.No.	Parameter	Inspection Record				
		Fertilizer Used	Fertilizer rate (kg acre ⁻¹)	Frequency	Mode of application	Application Date
1	Fertilizer used before sowing					
2	Fertilizer used after sowing					
3	Farmyard Manure used					
4	Soil additives & other supplements used for GAP crop					

FORM-1						
CHECK LISTS FOR FARMERS' FIELD						
Pesticides/Fungicides Application						
S.No.	Parameter	Inspection Record				
		Pesticides/ Fungicides Used	Pesticides/ Fungicides rate (kg acre ⁻¹)	Frequency	Mode of application	Application Date
1	Pesticides/Fungicides used before field inspection					
2	Pesticides/Fungicides currently used					
3	Pesticides/ fungicides storage methods					
4	Warehouse existences					

Irrigation & Source of Irrigation Water				
Sr.No.	Parameter	Inspection Record		
1	Source of irrigation water			
2	Distance between irrigation source & GAP field			
3	Irrigation System			
Postharvest Practices				
1	Packaging & Cleaning			
2	Storage & Transportation			
3	Warehouse existences for harvested crops			
Personal Hygiene and Worker welfare				
1	Total number of workers			
2	Number of workers who received the trainings on "Systematic Pesticide Application Methods"			
3	Number of workers who received other trainings			
4	Compliance of Personal Hygiene			
5	Existences of housing for the workers			
6	Work done for personal hygiene and worker welfare			
FORM-2				
CHECK LISTS FOR FARMERS' FIELD				
C- Compliance		NC- Non Compliance		NA- Nail
1. Site Selection		C	NC	NA
1	The site and its surrounding areas used for production of GAP crops are not contaminating with any chemical and biological hazards.			
2	The layout map of the site and a record are kept of official document of land use permission (Form-7).			
2. Irrigation				
1	The results of the water test are kept. (rain water, water from river, stream, creeks, tube well & ponds, underground water)			
2	The water used for irrigation are not coming from livestock farms, hospitals, industries, waste water and any sources that may cause environmental harm.			
3. Seed/Seedling				
1	A record is kept of source of supply, amount of supply and the date of supply for seeds, seedlings and plant propagations.			
2	A record is kept of chemicals used for seeds, seedlings and plant propagations.			
4. Fertilizers and Soil Additives				
1	The fertilizers and soil additives used for GAP crop production are free from chemical and biological contaminations that may be harmful on and off the site.			
2	The results of soil test are kept.			
3	The farm manure are used after making thoroughly compost and a record is kept.			
4	The registered products (fertilizers & soil additives) are only purchased from licensed suppliers and used for crop production.			

5	Areas or facilities for storage, mixing and loading of fertilizers and soil additives and for composting of organic matter are located, constructed and maintained to minimize the risk of environmental harm on and off the site.			
6	Produce is stored in areas separated from the chemicals.			

FORM-2				
CHECK LISTS FOR FARMERS' FIELD				
C- Compliance		NC- Non Compliance		NA- Nail
5. Agro-Chemicals and Other Chemicals		C	NC	NA
1	Compliance of Integrated Pest Management System –IPM			
2	The registered chemicals are only purchased from licensed suppliers and used for crop production.			
3	Compliance of post-harvest intervals (PHI)			
4	Compliance of recommended dosage & systematic application methods.			
5	Systematic chemical application methods are observed and followed exactly.			
6	Compliance of using PPE by the workers whenever they use pesticides.			
7	Chemicals are carefully disposed in the areas of separate places far away from water sources & a record is kept of all actions taken.			
8	After pesticide application, personal hygiene practices are observed and followed exactly. Pesticide spraying equipment are also cleaned.			
9	Work done for precaution measures for recently pesticide sprayed areas.			
10	Chemicals are stored in the areas separated from other materials and goods.			
11	The chemicals obtained, stored, used, application and disposals of chemicals are systematically handled and recorded. A record is kept of all actions taken.			
12	Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating produce.			
6. Agriculture and Other Related Materials				
1	The farm machinery & farm implements are cleaned.			
2	Equipment, materials that contact produce and containers used for storage and other materials are cleaned not to contaminate the produce.			
3	Waste, chemicals, other dangerous subsistence and materials are clearly identified and are not used for storage and holding produce.			

FORM-2				
CHECK LISTS FOR FARMERS' FIELD				
C- Compliance		NC- Non Compliance		NA- Nail
7. Harvesting and Handling Produce		C	NC	NA
1	Compliance of proper harvesting method at good maturity stage.			
2	Harvested produce is not placed in direct contact with soil or the floor of handling, packing areas.			
3	Packaging materials are cleaned and systematically stored.			
4	Before storage of produce, the warehouses are carefully cleaned.			
5	Water used for cleaning of produce & any parts of produces are clean.			
6	Identification and compliance of recommended places for having meals.			
8. Storage and Transport				

1	Harvested produce is not stored and transported in direct contact with animals, chemicals & fertilizers.			
2	Transport vehicles are checked before used & cleaned.			
3	Transport vehicles are also checked for chemical waste, pest infestation and other materials.			
9. Building and Structure				
1	Building and structure used for packaging, handling and storage of produce are constructed and maintained to minimize the risk of contaminating produce or separate places for those actions are identified and measures are taken.			
10. Animals and Pest Control				
1	Domestic and farm animals are excluded from the production site particularly for the areas where produce is harvested, packed and stored.			
11. Documents and Records				
1	Records of good agricultural practices are kept for a minimum period of at least two years. A record is kept of current practices taken in the format form.			
	Authorized person for chemical use/application Risk assessment record Record of practices taken Seed, seedlings & any plant parts used for plant propagation Chemicals stored/ used for crop production			
CHECK LISTS FOR FARMERS' FIELD				
C- Compliance		NC- Non Compliance		NA- Nail
		C	NC	NA
	Pesticide application Fertilizers & soil additives Record of irrigation Chemicals obtained & used after harvesting Action plan for personal hygiene & Plant Protection Training Attended Review of practices Other records (field maps,.)			
12. Traceability and recall				
1	Packed containers are clearly marked with an identification and registration number to enable traceability of the produce to the farm or site where the produce is grown.			
13. Training				
1	Employers and workers are trained to have appropriate knowledge in their area of responsibilities relevant to good agricultural practices.			
14. Personal Hygiene and Worker welfare				
1	Written instructions on personal hygiene practices are displayed in prominent locations or are provided to workers.			
2	All actions taken are emphasized on personal hygiene of the workers from packaging sites & packaging, washing and produce treatment is clean.			
3	Toilets, water used for washing & cleaning for personal hygiene practices are easily provided to workers.			
4	All actions taken are emphasized on personal hygienic and worker welfare.			

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