Food and Agriculture Organization of the United Nations

Good agricultural practices (GAP)

Sesame

(Sesamum Indicum)

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Abbreviations and acronyms

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
FFS	Farmer Field School
FYM	Farmyard manure
GAP	Good agricultural practices
ICM	Integrated crop management
ICT	Information and communications technology
ISO	International Organization for Standardization
IFDC	International Fertilizer Development Center
IPM	Integrated pest management
ISBN	International Standard Book Number
MAP	Ammonium acid phosphate
MOP	Muriate of potash
NPK fertilizer	Nitrogen phosphate potash fertilizer
PHI	Pre-harvest interval
PPE	Personal protective equipment
QC	Quality control
SSP	Single superphosphate
TSP	Triple superphosphate
USDA	United States Department of Agriculture
WOCAT	World Overview of Conservation Approaches and Technologies

Executive summary

Myanmar has a rich history of sesame production, with this oilseed crop holding a comparative advantage in high-end markets like Japan, yielding significant foreign exchange. To further leverage sesame production and diversify exports, strengthening good agricultural practices (GAP) are vital at pre- and post-harvest level for enhancing food safety, produce quality, collective marketing, and promoting sesame value chain among small farmers and market actors/systems. GAP standards are easily adoptable by resource-poor farmers, leveraging natural agroecosystems, indigenous knowledge, organic methods, integrated pest management (IPM), stress-resistant local varieties, and traditional crop rotations. Efficient use of limited resources, including quality and environmentally-safe inputs, can be effectively managed.

The upgraded version of sesame GAP complements prior achievements in target regions. In an era of increased consumer awareness and market competition, safe food production, increased farm efficiency, and resource conservation are highly important. Organizing and capacitating sesame farmers, alongside project-sponsored marketing, are pivotal for sustained productivity, income food safety, and resource sustainability.

Under the FAO-GAFSP-CFAVC program, GAP dissemination for five crops, including sesame, necessitates upgrading existing standards based on Myanmar and Association of South East Asian Nations (ASEAN) criteria, covering pre- and post-harvest practices. The enhanced sesame GAP focuses food safety, produce quality, worker health and safety, and environmental management. Field implementation will significantly enhance food safety, produce quality, and ecological sustainability in sesame production areas.

Thorough reviews of Myanmar GAP guidelines 2018 and ASEAN GAP standards were conducted. Collaborative GAP situational analysis identified gaps in knowledge, access, and efficiency in inputs and service provision. Extensive secondary research, farmer discussions, and stakeholder insights provided a strong basis for sesame GAP upgrade.

GAP promotion aims for systematic, field-based, impact-oriented rollout with stakeholder involvement. Capacity-building encompasses, local practitioners, lead farmer organizations, public-private partners, and value chain actors. The GAP framework includes concise key messages for agronomic success in each crop practice. Capacity-building through improved demonstrations, market linkages, and input suppliers, along with support for practitioners and extension agents, is central to successful GAP rollout. Farmer field schools, IPM training, exposure visits, and information and communications technology (ICT) tools will further supplement GAP promotion.

User-friendly IPM handbooks and Farmer Field School (FFS) curriculum will add value to participatory implementation, experience sharing, guided capacity-building for farmers and stakeholders, complementing existing initiatives, and supporting sustainable GAP dissemination and adoption.

Glossary of GAP terms

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

Term/Terminology	Definition
Accreditation	The formal recognition by an independent body, generally known as an accreditation body, which is a 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 *Aspergillus flavus* and *Aspergillus parasiticus*. 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 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 GLOBALG.A.P. certification).
Compliance Criteria (CC)	Information 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 requested by a standard (or GLOBALG.A.P. standards) to implement good agricultural practices. Within the GLOBALG.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.
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 (GAP)	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 GAP)	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	A substance or any articles including chemicals, microorganisms or microbial toxins which may be harmful to human, animal, plant, property or environment.
Internal controls	The various engineered and managerial means-both formal and informal established within an organization to help the organization direct and regulate its activities in order to achieve desired results; they also refers to the general methodology by which specific management processes are carried out within an organization.
Pesticide	A hazardous substance used in agriculture regulated by the Department of Agriculture 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 I 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 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 evaluation may be applied depending on the quality factors to be inspected. Additional tools such as a magnifying glass could also be used. Inspection of working procedure and process are also included.
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: Thomas Edmund. 2017. GAP Audit Training Manual.

CHAPTER (1)

1. Scope of good agricultural practices sesame (*Sesamum Indicium*)

The current GAP framework covers good agricultural practices for food safety, environmental safety, produce quality, workers health and safety in line with Myanmar GAP guidelines 2018 and ASEAN GAP guidelines for sesame production during pre-harvest and post-harvest crop management stages. The objective is to produce good quality, safe and suitable sesame for consumption in raw and processed form taking into account inclusive good agriculture production and processing standards.

2. Sesame origin and history

Sesame is one of the oldest oil seed crops and is known as the king of oil seeds due to the high oil content 50-60 percent (Pham *et al.*, 2010). The name "sesame" comes from the Arabic word "simsim". India is considered the origin of sesame, but a belief also exists that the actual origin was Africa, where many wild species of the crop still exist. However, it is generally accepted that sesame originated in the Ethiopian region; others, though, think that the center of origin was the Afghan-Persian region (Mehra, 1967). Identification of sesame seed in excavations in Harappa (Pakistan) shows that it was cultivated in 2000 B.C. (Vast, 1940). As the crop has a long history dating back to prehistoric times, many countries or regions are claimed to be the center of origin.

Figure 1. Sesame cake after extraction of oil

Figure 2. Extracting sesame oil by a bullock driven wooden pressing in Myanmar

3. Nutritional, medicinal and industrial uses

Sesame is a rich source of protein and its seeds contain two unique substances: sesamin and sesamolin known to have a cholesterol lowering effect in humans and to prevent high blood pressure (Anilakumar *et al.*, 2010). Sesame oil is also used as food cooking and salad, medicine and soap manufacturing. Oil cake is used as feed for poultry, goat, sheep, fish and cattle and is fed to lactating animals for increasing milk yield. Its non-culinary use includes ingredient in soap, cosmetics, lubricants and medicines. The seeds and fresh leaves may be used as a poultice.

Sesame is mainly used in confectionery products. Its use as an oilseed crop has not been explored fully yet. Sesame produces high-quality edible oil, which is used for cooking and salad. Unlike other edible

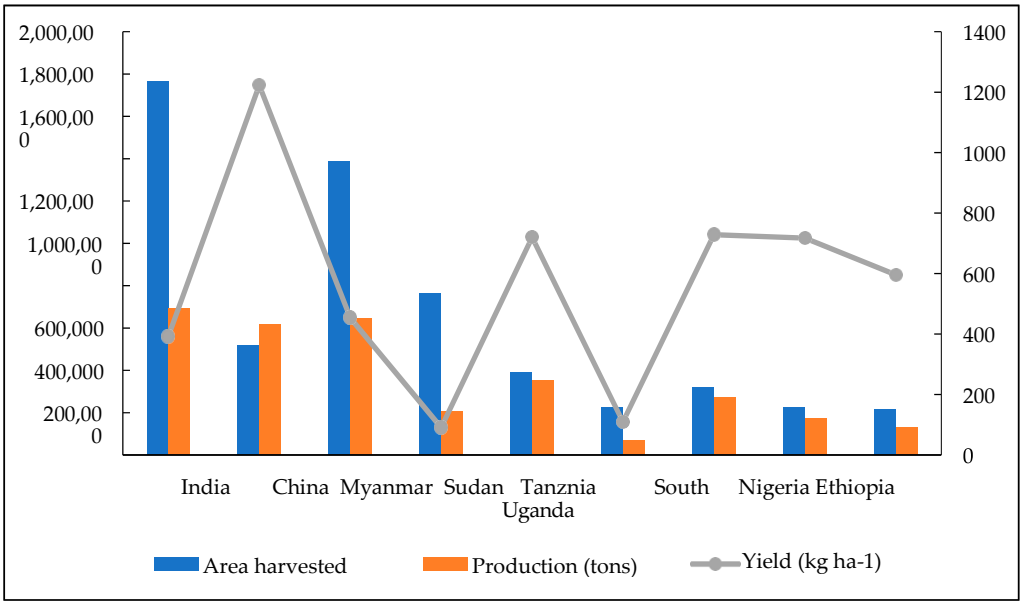
oils, sesame oil does not turn rancid1. This desirable characteristic is due to the sesamolin in the oil, which on hydrolysis produces a strong antioxidant called sesamol. The oil is used in improving the quality of vegetable oils. It is also used in medicines and the preparation of high-quality soaps.

Please see annex 4 for nutritional facts of sesame, based on USDA sample based analysis of 100 g samples, the values of which are based on an average of 2,000-calorie diet, which may vary from person to person.

4. Economic importance

India, Myanmar, and China are the highest producers among the countries of the world producing sesame. Average sesame yield is found to be the highest in China (1 223 kg ha^{-1}) followed by Nigeria (729 kg ha^{-1} and Tanzania (720 kg ha^{-1}) (FAOSTAT, 2020). In 2018, 6 016 000 MT were produced worldwide on 11 743 000 hectares with an average yield of 512 kg ha^{-1} (**see table 1**). Asia and Africa produce nearly 97 percent of the world's supply of sesame. Sudan devotes the greatest acreage but has one of the lowest records for yield ha^{-1}. Tanzania produces nearly 14.6 percent of the world's sesame crop, followed by Myanmar at 12.78 percent and India at 12.4 percent. Myanmar was one of the top five exporters of sesame in the global market in 2017, along with Tanzania, Ethiopia, Sudan, and India (Proximity Design, 2019).

Figure 3. Trend of sesame production values in top producing countries during the last twenty years (Average 1999–2018)



Source: FAO. 2023. Food and Agriculture Organization Statistical Databases (FAOSTAT). http://faostat.fao.org/

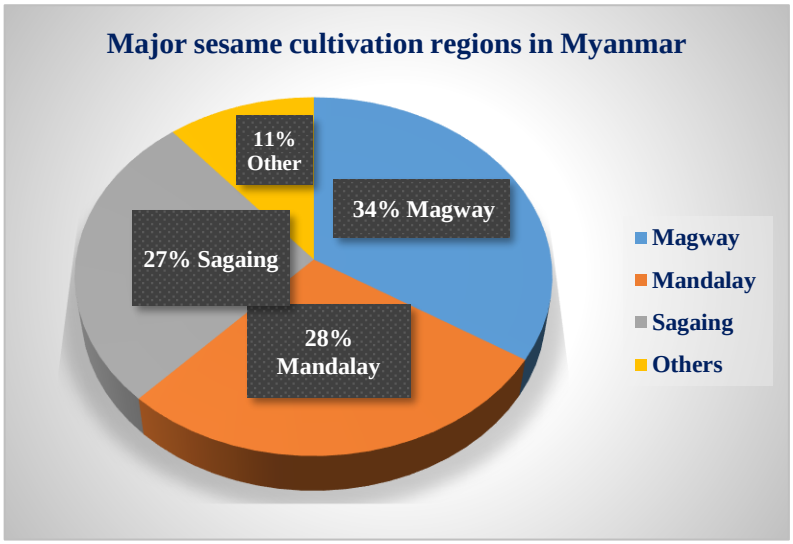
[1] Rancidity or Rancidification is the process of complete or incomplete oxidation or hydrolysis of fats and oils when exposed to air, light, or moisture or by bacterial action, resulting in unpleasant taste and odor.

Table 1. Area, production, and yield of sesame in the selected countries and the world in 2018				
Top producing countries	Area (000 ha)	Yield (kg ha^{-1})	Production ('000 MT ha^{-1})	percent of world production
India	1 730	431	746	12.4
China	311	139 3	433	7.2
Myanmar	1 463	525	769	12.78
Sudan	3 480	282	981	9.33
Tanzania	800	701	561	14.56
South Sudan	618	334	207	3.43
Nigeria	539	106 3	573	9.52
Ethiopia	415	726	301	5.01
Uganda	210	667	140	2.33
Regions				
Asia	3 906	578	2 257	37.52
Africa	7 549	474	3 575	59.42
America	288	636	183	3.04
Europe	1	975	1	0.02
World	11 743	512	6 016	-
Source: FAO. 2023. Food and Agriculture Organization Statistical Databases (FAOSTAT). http://faostat.fao.org/				

The major producing regions/area in Myanmar is central dry zone. Over 500 000 farming households now cultivate the seed over the course of three annual harvests, giving it a crucial role in Myanmar's rural economy. Three regions, viz., Magway Mandalay, and Sagaing are producing about 90 percent of sesame in Myanmar (Extension Division, DOA Myanmar).

Sesame is an economically important crop not only for producing edible oil but also for domestic and international markets in Myanmar. It is also an essential component for Myanmar traditional food. It also serves as cooking oil, a garnish, a snack, and a flavoring agent in some foods. Recent production statistics indicate a steady increase in sesame production, but it is still mostly traditional. Compared to other sesame producing countries, the sesame yield is meager, and local oil sufficiency is still not enough (Myint *et al.*, 2020).

Figure 4. Major Sesame cultivated regions in Myanmar



Source: MOALI. 2018. Myanmar GAP Guideline. Department of Agriculture. Ministry of Agriculture, Livestock and Irrigation: Nay Pyi Taw, Myanmar, 2018.

5. Morphological characters

Sesame (*Sesamun indicum* L.) belongs to the family Pedaliaceae. A broadleaf plant grows to a height of 1 to 1.5 m depending on the variety and growing conditions. It considerably differs in size, form/shape, growth habit, color of flowers, seed size and color and composition. It is erect, branched, mostly annual, or long season plant with well-developed root system.

The stem is erect, variously shaped, and branched. In sandy soils, the roots develop more profusely than in clay soils, which impart drought resistance to sesame. Flowers on short peduncles are borne singly in the axils of leaves of the upper portion of the stem and branches. The fruit, a capsule, varies from 2.5 to 8.0 cm in length and 0.5 to 2.0 cm in diameter. Capsules mature from bottom to top, allowing shattering of the lower ones by the time the uppermost capsules are mature. The seeds are small and ovate, weighing 2–4 grams per thousand seeds. Cultivars with different coloured seeds are available. Seeds are present in hairy capsules, each with 4–8 locules. The plant has indeterminate growth habit; therefore, the capsules do not mature uniformly. Because of this characteristic, shattering is one of the main constraints in sesame cultivation.

Figure 5. Sesame flower

Figure 6. Sesame plant with leaves and flowers

Figure 7. Sesame seed capsule

Figure 8. White sesame seeds

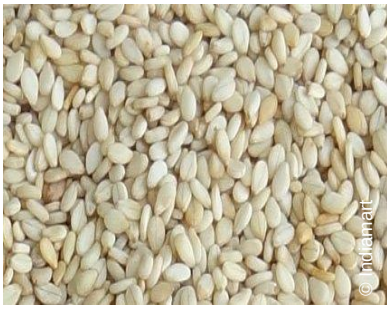


Figure 9. Black sesame seeds

Figure 10. Sesame taproot system

CHAPTER (2)

6. Sesame production status in Myanmar

As mentioned earlier, sesame is a crop of multi-dimensional importance for Myanmar. Besides, a crop of religion, cultural and ceremonial importance, and significant foreign exchange is earned from the crop export. In terms of total area cultivated and total production of Myanmar sesame, **table 2** indicates a decreasing trend in cultivated total area and production from 2014–15 to 2018–19 (1 572 000 ha to 1 505 000 ha) and decreasing production from 930 000 MT to 745 000 MT, while the yield remained stagnant (avg. 0.5 MT per ha). The total volume of export and export value progressively increased over the years 2014–15 to 2018–19.

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

Year	Area harvested (000 ha)	Total production (000 MT)	Yield (MT/ha)	Export	
				Volume (000 MT)	Value (million USD)
2014–15	1 572	930	0.59	91.81	181.96
2015–16	1 611	943	0.59	96.62	130.90
2016–17	1 610	927	0.58	107.81	145.70
2017–18	1 539	829	0.54	120.95	147.06
2018–19	1 505	745	0.495	116.84	193.81

Source: MOALI. 2019. Myanmar Agriculture at a Glance. Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, 209 pp.

7. Constraints and prospects of sesame in Myanmar

Inspite of certain comparative advantages of Myanmar in sesame production, the crop yield, productivity and cultivated areas could not maximized upto the full potentials due to some constraints, which if overcome, sesame competiveness as oil seed and cash crop can further be increased at regional and national and at export horizon. The key strength for further productivity enhancement of sesame are favourable climatic conditions, farmers experience in sesame production, easy transportation and transport infrastructure, availability of farm based machinery, technical knowhow, crop differentiation, government interest and commitment in productivity and quality enhancement of sesame and rising demand in domestic and international market. Sesame productivity, quality and marketability can be enhanced by overcoming some of the weaknesses especially improving the quality and timeliness of service provision to the sesame growers for GAP implementation, methods and technologies of reducing cost of crop production. Facilitation of small farmers for better access to machinery for farm operation (pre-harvest) and post-harvest management such as strengthening linkages with markets through establishment of an organized system of market information, improved access to markets and capacity building in reduction of post-harvest losses, are the important considerations for overcoming the yield gap and improving the competitiveness of sesame at domestic and export level.

Sesame farmers need to be supported in availing the available opportunities such as crops diversification, crop rotation, intercropping for increased soil fertility, climate smartness of crops production and farm profit maximization from sesame. Some ICT technologies can also be effectively used for efficient production and postharvest management of sesame, which is already initiated by some progressive farmers in Magway (Phyu, 2019). Private sector engagement can also create a favourable

environment for increasing farmer's access to quality inputs (seeds, fertilizers, farm machinery, marketing support and price stabilization etc). Sustainable production of the crop in view of changing climate, increased environmental hazards, marketing and pricing risks, less availability of quality seed, low interest in traditional crops cultivation, biotic and abiotic stress factors are some of threats which can adversely affect sesame productivity and quality (Myint *et al.*, 2017).

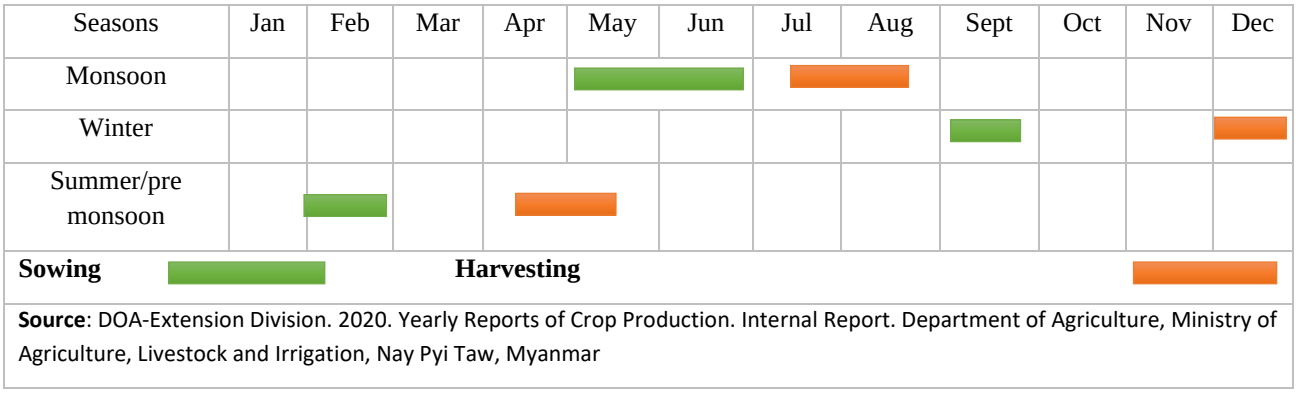
8. Planting seasons and crop calendar

Sesame is cultivated in three different seasons in Myanmar as summer/pre monsoon, monsoon and winter sesame of which monsoon season is the main cultivation season.

Summer or pre monsoon sesame: The crop is sown in Feb in areas where irrigation water is available. The yield potential is the highest in pre-monsoon.

Monsoon Sesame: The main crop is sown from May/June. Drought or heavy rains sometime cause damage to the crop in terms of delayed sowing, flower fall and deterioration of seed quality due to excessive rainfall.

Winter sesame: The crop is also common among the farmers in rain-fed areas. The crop is cultivated in September at the end of rains or residual moisture from monsoon rains.



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 (3)

9. Crop production requirements

9.1. Climatic requirements

9.1.1. Temperature

The overall temperature range for sesame production is 25°C to 37°C. Favorable temperature for rapid germination, initial growth and flower formation is 25°C to 27°C while temperature below 20°C for any length of time inhibits or delay germination. A temperature of less than 18°C after emergence severely retards growth of seedlings. Low temperature at flowering can result in the production of sterile pollen, or premature flower fall whereas high temperatures, 40°C or over, at flowering will also seriously affect fertilization and the number of capsule/fruit set will be low. (Terefe *et al.,* 2012). Sesame being an herbaceous plant is also prone to wind storms and frost. Therefore, windbreaks with appropriate hedge plants on the boundaries of farms are beneficial. This is one of the climate smart intervention for agriculture and reckoned as a Good Agriculture Practice for farm management.

9.1.2. Moisture/rainfall

An overall rainfall requirement of the crop is 300 to 800 mm over the entire growing season. However, a rainfall of 500 to 650 mm evenly distributed over the 3–4 months growing period is appropriate for optimum yield. Heavy rain at flowering drastically reduces crop yield, and if cloudy weather persists for any period at this time, sever bacterial and/or fungal infection will occur resulting in yield losses. Excessive rainfall above 1 100 mm and low rainfall below 300 negatively affect the crop yield performance. (Terefe *et al.,* 2012).

Figure 11. Use of organic mulch CDZ Myanmar

Figure 12. Mulching with residues from maize stubbles

9.1.3. Soil requirements

Sesame can be successfully cultivated on a variety of soils but for high productivity; well-drained, medium textured fertile soils with a pH of five to eight are suitable soils. Heavy clay, salty and waterlogged soils are not suitable for sesame cultivation. The crops is extremely susceptible to water logging even for a shorter spell at any stage of growth (Terefe *et al.,* 2012, p. 9, 10).

CHAPTER (4)

10. Crop production technology

10.1. Site selection

It is highly important to carefully select site for safe and quality sesame production. The sites should be assessed for prevention or minimization of chemical and biological hazards. The site history must show that the sites is not used previously for disposal of hospital waste, industrial waste, and livestock farm (Myanmar GAP Guideline, 2018). Sites with low-lying soils having current or potential risk of inundation and defective drainage during rainy seasons should be avoided. Sustained availability of irrigation water should be kept under consideration especially in case of summer/pre-monsoon crop. Freedom from shading effects and exposure to maximum sunlight are the important considerations to be envisaged while selecting site for sesame production.

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).

While producing sesame for seed purpose, an isolation distance of 100 meters from the field of other varieties should be maintained to prevent mixing with other varieties (Jawahar *et al.*, 2015). A site map denoting crop production site, environmentally sensitive areas, highly degraded areas, areas for chemical storage, mixing, chemical treatment and spaces used for cleaning of equipment as well as areas or facilities used for storage, mixing for composting, fertilizers and soil additives should be kept on record. The site map should also delineate, watercourses, sewage and drainage lines near and around the production site.

Water courses, sewage and drainage lines, areas of active run off, erosion, water discharge points, farm buildings, farm structures and roads should be shown on the map. In case of existing or potential risks, causing chemical and biological contamination should have remedial measures in place, documented and kept on record. The sites of production, and post-harvest management should comply with Myanmar Legislation and National Plans related to protect /prevent air, water, noise, soil, biodiversity and other environmental issues.

Site selection and site management

1. 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
2. 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 & Surrounding Areas; 1 to 3).

10.2. Land preparation

Land preparation is an important crop management practice for better crop germination, root growth and development, suppression of weeds, insect's & pest's control (especially nematodes) and moisture conservation ultimately leading to high crop yield and quality. The land should be cleared from all types of weeds before plowing. Weeds and weed residues should be disposed of to avoid weed and pest infestation during the crop growth. Sun drying of weeds until complete desiccation of propagules (vegetative propagation

Organic mulching
Organic mulching can compensate for effects of low rainfall, organic manuring, weed control, moisture conservation, and improved soil stability and erosion control on slopes with mild slope gradient

materials) should be ensured. The dried weeds should be used for compost/*Bokashi* compost making instead of burning which negatively affect the environment through carbon emission.

The field should be plowed before the onset of monsoon rains for rain moisture conservation. One deep plowing (six inches deep), followed by two light harrowing for better soil tilth[2] and seed bed preparation, improved germination and root growth should be carried out. The land should be properly leveled for uniform irrigation water distribution, avoiding water inundation, controlling weeds and increasing water and fertilizers use efficiency. Well-decomposed FYM @6–8 cartload should be applied and be fully mixed with the soil through light ploughing.

"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."

The use of organic manures is highly beneficial as it improves soil structure and texture, increase its friability. The use of organic mulching using wheat or paddy straws or any other available organic materials should be used for covering the beds to control weeds as well as to reduce loss moisture through evapotranspiration. In case of summer sesame, the seed should be cultivated on raised beds (3–6 ft.) wide and 6–8 inches above the ground according to the soil structure, soil type and slope gradient (*Farmers Improved Practices Magway Region*). The seeds should be sown at the edges of the ridges.

Figure 13. Sesame farmers plows sesame fields in Yesagyo township of Magway region

Figure 14. Inter-cultivation weeding in monsoon sesame in Yesagyo township of Magway Region

[2] Tilth generally refers to the physical condition of the soil as it relates to plant growth.
Favorable tilth implies good conditions for seed germination and root proliferation, allowing crops to thrive (Source: SARI-Sustainable Agriculture Research Institute, USA)

Figure 15. Mid bloom stage of monsoon sesame in Yesagyo township

Figure 16. Mid bloom stage of summer sesame in Kyauksae township of Mandalay region

10.3. Recommended varieties, seed and seed quality

10.3.1. Seed selection

According FAO-GAFSP project GAP situational analysis, 63 percent interviewed farmers' identified access to quality seed of improved varieties as one of the main issues. Sesame varieties recommended by the DoA as good quality, locally adaptable and with high market demand should be obtained for sesame production (**see table. 3 for recommended varieties**). The seed should be free from physical impurities, resistant to diseases, tolerant to drought. Fresh seed not older than two years and certified by DoA will give best results. Seed germination should not be less 80 percent, with physical and analytical purity of 98 percent.

10.3.2. Recommended varieties

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

Table 3. Recommended sesame varieties

Type	Variety name	Cultivation season	Growth cycle (seed to seed)	Yield potential (kg ha^{-1})	Oil Content (percent)
Black sesame	Black Theitpan	All season	85–90	605–907	48–50
	Black Samone	All season	100–105	605–907	48
	Sin Yadanar 2	All season	85–90	907–1 210	42–44
	Sin Yadanar 3	All season	90–100	605–907	42–45
	Sin Yadanar 14	All season	80–85	726–907	42–44
White sesame	White Sesame	All season	90–95	605–907	45–48
	Sin Yadanar 4	All season	80–85	605–907	45–46
	Sin Yadanar 12	All season	80–85	726–907	44–46
Red Sesame	Red sesame (25/160)	Monsoon, Winter	90–95	605–907	55

Source: DAR. 2018. Released New Varieties. Department of Agricultural Research, Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, Myanmar, 168 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 the Annex 3 (Form-1. Seed selection; 1 to 3, Form-2. Seed/Seedling; 1).

10.3.3. Seed rate

Using optimum seed rate is an important prerequisite for high yield and quality sesame production. The project GAP situational analysis revealed that 22 percent of the sesame growers are not using recommended seed rate of sesame. The seed rate should be adjusted according to the seed quality, germination, and variety, time of sowing, soil condition, and availability of labor, preferred crop management practices, and crop utilization. The recommended seed rate for row planting is 5–7 ha^{-1} kg while for broadcast is 7–10 kg ha^{-1}. Seed rate can be increased in case of delayed sowing, deep planting, conditions of limited soil moisture, low soil temperature, compacted, cloddy or trashy soils and in case of high risk of seeds losses due to insects pests.

***Seed and planting materials**:* Refer to Annex 3, practice 1.3, 1.6 of Myanmar GAP sesame 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

10.3.4. Seed treatment

Seed treatment before sowing is important for control of soil and seed borne diseases of sesame. As per the project GAP situational analysis, 62 percent of farmers are not practicing seed treatment with DoA recommended fungicides/pesticides. Sesame seed should be treated according to the technical recommendation of DoA for compliance with GAP standards to ensure food safety and produce quality.

Maintain the record of seed treatment with details of chemicals used for seeds, seedlings and plant propagations as per the details given in Annex 1 (Form-2, Seed/Seedling; 2).

10.4. Method of sowing

Row planting is the recommended method of sowing as it facilitates control of weeds, efficient water utilization and other farm operations. Sowing of seed should be done manually or through drills by maintaining planting geometry of row-to-row distance of 12 inches for single type & 15 inches for branching type varieties/types and plant-to-plant distance of 4 inches. The plant population of (250 000 – 320 000) plants ha^{-1} is recommended to get maximum yield. The seeding depth should be maintained maximum up to 1.5 to 2.0 inches for better germination.

Table 4. Planting geometry for sesame

Variety Types	Plant x Plant Distance (inches)	Row x Row Distance (inches)	Plants population per hectare	Seeding depth (inches)
Single Type	4	12	320 000	1.5–2
Branching type	4	15	250 000	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

Sowing method and planting geometry should be recorded as per Annex 1 (Form- 1. Cultivation Method; 1 to 3).

10.5. Thinning

In order to maintain desired plant population, facilitate exposure to the sunlight and avoid shading effects, adequate nutrients and moisture availability, sesame plants should be thinned out at 6 leaves stage of the crop. While thinning, weak and diseased plants should be removed. (Myanmar GAP Guideline, 2018).

10.6. Manures and fertilizers

Type, dose, method and time of fertilizers application depend on many factors such as existing soil physical properties such as soil texture (clay, silt, loam) and soil structure, soil moisture and relative humidity, existing nutrients (N, P, K and necessary micronutrients), soil pH and organic matter. Moreover, type of fertilizers applied to the previous crop, previous crop grown (leguminous or non-leguminous/deep rooted, shallow rooted), risk of nutrient losses due to fertilizers application, soil erosion and irrigation practices should also be considered while deciding about fertilizers application. Fertilizers should be applied according to DoA recommendations based on site specific soil testing.

The project GAP situational analysis explored that 49 percent of sesame farmers are unable to apply fertilizers according to DoA recommendation of approved nutrient regimes. Fertilizers are applied only at sowing time and about @ 62–185 kg ha^{-1}/25–75 kg $acre^{-1}$) of compound fertilizers such as 15:15:15 or 10:10:5 are used as basal application.

Only the registered and DoA recommended fertilizers and soil additives available with DoA licensed suppliers should be purchased for application. Soil conservation measures and good soil management practices should be take care of as they significantly reduce the risk of environmental pollution, improved food quality, food safety and minimum soil contamination as well as increased fertilizer use efficiency.

For the effective use of fertilizers, the split dose application, especially on sandy soil at different stages; land preparation, vegetative stage, flowering time and initial fruiting stage is more beneficial. Herridge *et al.*, (2019) reported that the grain yield of sesame was increased by 73 percent by the fertilizer applied at planting and by a further 25 percent when the fertilizer was applied (split) two or three times. Soil moisture should be enough at the time of fertilizer application, apply irrigation after fertilizers application if the soil has not enough moisture, or is dry. To ensure food safety, equipment/tools used for fertilizers and soil additives should be efficiently maintained, kept clean and functional for safe application.

Areas and facilities for composting of organic materials should be located at safe distance to prevent or minimize risks of food contamination. The application of fertilizers and soil additives should be properly recorded, detailing the name of the product or material, date, treatment location, application rate and method, and operator name. The risk of chemical (heavy metals) and biological contamination of produce from the use of fertilizers or soil additives need to be documented for preventing or minimization of contamination. It is also important to obtain information about product safety and quality from the suppliers and kept on record.

Fertilizers and soil additives: Refer to **Myanmar GAP Guidelines** annex 1 for practices at S.No. 1.4, **ASEAN GAP guidelines** annex 3.1 for practices at S.No. 3.1.3, annex 3.2 for practices at S.No. 3.2.3 and annex 3 for practices at S.No. 3.3.4

10.6.1. Chemical fertilizers

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

Role and importance of nitrogen: Nitrogen is the most vital nutrient and building block of all plant structures and required for protein synthesis, due to which its application for sesame production is critically important. Growth and yield of sesame is significantly influenced by N application. Adequate application of N also enhances the uptake of other essential plant nutrients particularly, P, and K and some other micronutrients. Application of N has positive interactions with P, K, S, Ca, Mg, Zn, Cu, Mn, and Fe (Fageria and Baligar, 2005).

Nitrogenous fertilizers: Commonly available source of nitrogen as chemical fertilizers are[3], 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*).

[3] Fertilizers and their use, Agriculture extension services, University of Tennessee. https://extension.tennessee.edu/publications/documents/pb1637.pdf

Rate of nitrogen application: Application of nitrogen should be applied on the basis of site specific testing and DoA recommendations. The rate of N application depends on soil fertility, previous crops cultivated, organic manure application, and availability of water, crop management and soil chemical and physical properties. However, if soil tests are not available, 75 kg N ha^{-1} can be applied for optimum seed yield (Shehu *et al.,* 2009). Another research conducted by Zenawi & Mizan, (2019) reported optimum sesame yield with application of 46–100 kg N ha^{-1}.

Method and time of application: Nitrogen is highly mobile nutrient and significant losses can occur through leaching, and volatilization, denitrification. In order to ensure safe and efficient use of nitrogen, plant growth stage, available soil nitrogen supply, and level of pest infestation, climatic variation and soil moisture should be kept in view. Sesame has low demand during seedling and pre-harvest stages while the demand for N is high during vegetative and flower initiation stage (Watson *et al.,* 1994). Higher seed yield can be obtained with three-spilt application of nitrogen; 25 percent at planting, 50 percent at 8-leaf stage, and 25 percent at flower initiation. (Amin & Ali Reza, 2015). Nitrogen fertilizers should be applied in furrows as narrow band 5-8 cm to the side of the plants and 3-5 cm deeper than the seed. Placement too close to the seeds can damage the young seedling. In case of broadcast, the fertilizers should be fully incorporated in the soil to reduce losses through volatilization (Langham *et al.,* 2008). Band application or side dressing 5 cm deep on both sides of the row no more than 20 cm from the plants is also recommended (Stevenson & Baldwin 1969).

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

Role and importance of phosphorous*:* Phosphorous plays a vital role in sesame plant such as stimulating root growth, enhancing better root development, increasing stalk and stem strength, uniform crop maturity, increasing the ability of nitrogen fixation in leguminous crops and disease resistance as well as synergizing the uptake of other nutrients especially nitrogen (Cope and Hunter 1967).

Phosphate fertilizers: Commonly available phosphate fertilizers are DAP (Diammonium Phosphate with 18 percent N and 46 percent P available in granular form, Triple Super Phosphate (TSP) with 46 percent P available in solid granular form and Single Super Phosphate (SSP) with 20 percent O available in sold granular form[4]. Phosphate fertilizers, however, should be applied on site-specific basis for ensuring its 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 and in consultation of DoA technical recommendations. The application also depends on soil structure, losses of phosphorous due to erosion, flooding and other abiotic stress factors. Sesame responds significantly to phosphorous fertilization when the soil test indicates that phosphorous is below optimum—very low or low. As report by Jan et al, (2014), application of 100 kg P ha-1 produced maximum seed yield of 770 kg ha^{-1}. Supply of Phosphorus improves root density and proliferation, resulting in increased growth and yield traits, thereby ensuring more seed and dry matter yield (Shehu *et al.,* 2010 in Jan *et al.,* 2014). Application of 90 kg P ha^{-1} significantly increased growth, yield and yield attributes of sesame (Olowe and Busari, 2000, in Jan *et al.,* 2014).

Method and time of phosphorous application: Phosphorous fertilizers should can be applied as broadcast as well as banded application. In case of broadcast, the fertilizers should be fully

[4] Fertilizers and their use, Agriculture extension services, University of Tennessee. https://extension.tennessee.edu/publications/documents/pb1637.pdf

incorporated in the soil to reduce the risk of P loss through runoff and leaching below the root zone. Placement of P in a concentrated band near the seed row increases P uptake efficiency and yield (Grant & Flaten, 2019). Phosphorus should be applied as basal dose during land preparation in rain-fed areas while in irrigated areas; the application can be split in two doses with 50 percent to be applied at the time of sowing and remaining 50 percent at the time of flower initiations.

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

Role and importance of potash: Potassium (K) is one of the key nutrients required for sesame productivity and quality. Potassium (K) is an integral element in activation of enzymes for plant metabolism, inducing resistance to biotic (diseases) and abiotic (cold, water stress/drought, heat, high light intensity and frost) stresses. The oil and protein content of sesames increase with increased K application and maximum oil and protein context in sesame seed were recorded with the application of 50 kg K_2O ha^{-1} (Jat *et al.,* 2017). Potassium (K) nutrition also increased growth of sesame plant especially in case of continuous mono-cropping system.

Potash fertilizers: Commonly available potash fertilizers are potassium chloride with 60 percent potassium and available in solid granular form, 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: Application rate of potassium should be decided based on soil test, previous crop cultivated and soil physical and chemical properties. Recommendation of DoA should be followed for efficient fertilization application. Application of 30 kg K ha^{-1} increases seed yield and yield attributes (Singh and Prakash 2012). Maximum sesame yield of 673 kg ha^{-1} was reported with the application of 50 kg ha^{-1} (Ahmad *et al.,* 2018).

Method and time of potassium application: Various methods can be used for application of K in sesame depending upon the climatic, soil physical and chemical characteristics and crop growth stage. Potassium can be applied, as band or as side dressing away from the plant so that the salt content may not negatively affect seed germination or seedling growth. If broadcasted, K fertilizers should be subsequently incorporated into the soil to facilitate roots to fertilizer contact for effective uptake. As K uptake is more active during the early growth phases, therefore full dose should be applied before or during the sowing time, except in coarse textured (sandy) soil due to high rate of leaching due to which K application is also recommended at the early growth stages of the crop (Ravichandran &Sriramachandrasekharan, 2011).

10.6.1.4. Compound fertilizers (NPK)

Application of NPK fertilizers should be administered based on the results of soil test and in line with DoA recommendations. Application of NPK fertilizers should be applied based on the results of soil test. However, if soil tests are not available, the fertilizers should be applied as per the recommendation of DoA and DAR. Herridge et al. (2019b) 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 16 baskets $acre^{-1}$ of sesame is 24 kg N $acre^{-1}$, 16 kg P_2O_5 $acre^{-1}$ 12 kg K_2O $acre^{-1}$ and 10 kg S $acre^{-1}$.

However, if tests are not available then use NPK at the rate of 23:13:13 kg per hectare, for rain-fed areas and 35:23:23 NPK kg per hectare, respectively for irrigated areas. For obtaining 23:13:13 NPK kg ha^{-1} for rain fed areas, the farmers should apply one (1) bag urea, one (1) bag SSP (in soils with pH >7) or half (½) bag DAP (in soils with pH <7), and half bag MoP ha^{-1}, respectively. For getting 35:23:23 NPK ha^{-1} for irrigated areas, the farmers should apply 1 ½ bag urea, 1.75 bags SSP

(in soils with pH >7) or 1 bag DAP (in soils with pH <7) and about 1 bag MOP, respectively. (TNAU 2016)[5]

10.6.1.5. Other essential & micronutrients

In case of oil seed crops such as sesame, the oil contents are influenced by micronutrients. Micronutrients not only enhance the plant growth, development and yield but also improve the quality of the produce as well increasing resistance to biotic and abiotic stresses. (Cakmak, 2008). Various research studies have reported significant positive effects of certain micronutrients especially Zn, Mn and Boron with resultant increase of seeds per pod, 1000 seed weight (seed index, number of capsules and seed yield of sesame (Shirazy *et al.*, 2015) as influenced by micronutrients. Research studies have shown that integrated use of N P K, along with S, B, Mo, Zn and *Azospirillum*[6] in various combinations or alone performed better about seed yield of sesame. It is interesting to note that application of either B, or Mo or Zn along with NPK boosted the yield of sesame significantly (Sahu *et al.*, 2017). Micronutrients can be applied on the basis of soil test, crop requirement and uptake as well as previous crop cultivated, other fertilizers used, soil physical and chemical characteristics. The following are the important essential and micronutrients for sesame crop.

Sulphur: Sulphur (S) is an important plant nutrient after NPK and plays a vital role due to the fact that S is the key element of amino acids (Jamal *et al.*, 2010). According to the research findings of Shah et al, (2013) S significantly increased sesame yield and yield characteristics capsules per plant, 1000-seed weight, and biological and grain yields @ 45 kg ha^{-1}. The available source of S in Myanmar are Ammonium sulfate (21 percent N, 24 percent S), Sulfate of potash (SOP - 50 percent K2O, 18 percent S), Magnesium sulphate (26.63 percent S), N-P-K + with 18–4–5–15–S[7] (Soil Fertility and Fertilizer Management Strategy for Myanmar, 2018, IFDC).

Magnesium: Mg is a component of chlorophyll and plays role in enhancing plant growth and development. Deficiency is commonly observed in sandy and strongly acidic soils. The recommended application 20 kg of MgSO4 ha^{-1} in deficient soils gives best results. Mg based fertilizers should be applied as basal dose in rows or as broadcast followed by mixing in the soil (Singh et al 2004). The available source of magnesium is Magnesium sulphate (26.63 percent S).

Calcium: Ca^{2+} has an important role in the growth and developmental of plants especially in areas with probability of heavy metal causing stress in sesame plants. Ca helps in heavy metal detoxification especially increasing tolerance to Cd (Cadmium) stress (Suzuki 2005). As reported by Abd Allah et al. (2017), Ca supplementation led to improved root and shoot length in sesame. The available source of Ca are calcium chloride $CaCl_2$ and potassium chloride KCl.

Boron: Among the micronutrients, boron deficiency is one of the widest spread micronutrient deficiency but not commonly observed. Boron has an important role in pollen germination and viability. Both B deficiency and toxicity result in lower chlorophyll content (Mamatha *et al.*, 2017). Boron plays role in enhancing other nutrient absorption, improve root metabolism and development and oil synthesis. (Sahu *et al.*, 2017). The available sources for boron are Borax ($Na_2B_4O_710H_2O$) with 11 percent B content, Boric acid (H_3BO_3) with 16 percent B, Soluble ($Na_2B_4O_7.4H_2O$ + $Na_2B_{10}O_{16}$.$10H_2O$ with 20 percent B.

[5] TNAU Agritech.portal, Agriculture 2016 (https://agritech.tnau.ac.in/agriculture/agri_index.html)

[6] The genus *Azospirillum* comprises plant-growth-promoting bacteria (PGPB) being important to induce tolerance in plants to abiotic and biotic stresses, which may be mediated by phyto-hormones acting as signaling molecules.

[7] Soil Fertility and Fertilizer Management Strategy for Myanmar, 2018, IFDC

Zinc: Zinc is an important micronutrient but has gained high importance due to its deficiency in soils and vital role in many plant metabolic enzymatic reactions as well as creating resistance to insect pests and disease pathogen (Alloway 2008). Application of zinc is important for optimum plant growth and seed yield in sesame. According to Jahan et al (2019), highest seed yield of sesame (1 619 kg ha^{-1}) was recorded with application of 2.5 percent ZnO.

Manganese: Manganese is an important component and activator of enzymes during protein synthesis, lipid metabolism and photosynthesis besides its importance in N metabolism and in CO assimilation (Tisdale *et al.*, 1990). Application of Manganese at the rate of 5 kg ha^{-1} of MnSO4 caused an increase in sesame seed yield, oil content and nutritional qualities of sesame crop (Krishnasamy *et al.*, 1994; CPG, 20). Habimana et al. (2016) also reported high sesame yield (740 kg ha^{-1}) higher oil content and oil yield (49.17 percent and 369 kg ha^{-1} respectively) with application of 3 kg ha^{-1} as $MnSO_4$. The available sources of Mn are Manganese oxide MnO with 53 percent Mn, Manganese Sulphate ($MnSO_4$) soluble with 24 percent Mn.

Iron: Iron is important for biochemical and physiological process in plants. Iron deficiency is not due to adequate Fe in the soil but deficiency in plants occurs in case of high soil pH, low soil oxygen levels caused by either soil compactions or water- logging, prolonged periods of excessive soil moisture, high temperatures, high soil phosphorus, copper, manganese, and zinc[8]. The available sources of iron are Ferrous ammonium phosphate (Fe (NH_4) PO_4H_2O) with 29 percent Fe, Ferrous ammonium sulfate ($NH_4SO_4.FeSO_4.6H_2O$) with 14 percent Fe.

The fertilizers and soil additives used for GAP crop before & after sowing, soil test result, 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 17. Boron deficiency in Sesame

Figure 18. Symptoms of Zn Deficiency in Sesame

[8] https://www.clemson.edu/public/regulatory/ag-srvc-lab/soil-testing/pdf/micronutrients.pdf

Figure 19. Magnesium deficiency

Figure 20. Sulphur deficiency in Sesame (smaller new leaflets with yellow and erect petioles than the normal

Figure 21. Iron deficiency

10.7. Organic manuring

Organic manuring is a climate smart approach for safe, sustainable, resource efficient and ecofriendly system of sesame 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. To maintain soil productivity, health, sustainability and biodiversity, Integrated Soil Fertility Management (ISFM) approach should be followed to overcome nutrient deficiency and low nutrient retention capacity in soils. It is therefore important that besides application of inorganic manures, organic manures such as farmyard/animal manure, mulching, crop residues and green manuring must also be incorporated in the cropping systems in sesame-cultivated areas to prevent both micro and macronutrient deficiencies.

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

In case of rainfed agriculture and water scarce areas, application of organic manures increases the water holding capacity of the soil and conserve soil biodiversity (Chandra, 2005). The nutrients which are

locked up with other soil or nutrient particles or available below the rooting zone becomes available with the application of organic manures. The main types of organic manures are farm and animal manures, crop residues, green manures, biogas slurry, and biodynamic compost, vermi-compost, which if properly prepared and applied, provide the best medium for plant growth, nutrient mobility and uptake by the plant nutrients.

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

10.7.1. Farmyard manures (FYM)

The well rotten/full decomposed farmyard manures should be used after making compost. About 7–12 tons ha^{-1} (3–5 tons $acre^{-1}$) of farmyard manure or green manure are annually applied for improving the physical and chemical properties of the soil. The sesame straws that are free from diseases can be used as farmyard manures after making compost (Myanmar GAP Guideline 2018). FYM consists of all the decomposed mixture of animal dung and urine along with litter and leftover materials in animal sheds/farm. 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 due to not only low nutrient contents but also a source of insects' pests and other potential toxicity to the plants. Animal urine is a valuable part of animal manure and contains appreciable amount of nutrients. The animal manure mixture (dung+urine) should be collected and trenched in a pit of the size 6 m to 7.5 m length, 1.5 m to 2.0 m width and 1.0 m deep for decomposition. After filling the pit, the top should be tightly covered through plastering to enhance decomposition and nutrient loss. The manure becomes ready after 4–6 months for application to the crops at the time of sowing/land preparation[9] (Misra *et al.*, 2003).

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

[9] FAO small scale composting. http://www.fao.org/3/y5104e/y5104e06.htm

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. 1932. Fertilizers and crop production. Orange Judd Publ. Co. Inc., New York.						

Significant sesame yield improvement has been reported with application of FYM either alone or in combination of other mineral nutrients. Teshome, 2016 reported highest sesame seed yield of 750.4 kg ha^{-1} with combined application of 60–30 NP kg ha^{-1} and 5t ha^{-1} FYM. FYM should be applied during land preparation and should be uniformly incorporated into the soil.

10.7.2. Bokashi compost

DOA-OISCA Training Center in Yesagyo Township, Magway Region, has been producing "*Bokashi* Compost" – a nutrient rich organic composted fertilizer that act as both a long-term and short-term soil fertilizer and improves the soil as well. Using effective microorganisms to accelerate decomposition/fermentation and subdue other organisms that are harmful, cow-dung and other organic materials mixed together can be made into *Bokashi* compost. Since the process involves the intense heat of biological decomposition, the seeds of weeds are also destroyed.

Bokashi is an organic fertilizer, but unlike other composts, it acts quickly with long lasting residual effects in the soil and can be safely used as substitute of chemical fertilizers. Farmer can buy effective microorganisms, oilcake and rice bran, and can prepare their own other materials as needed such as cow-dung, ashes, charcoals and soil from the woods.

Inputs/materials for Bokashi preparation

The following are materials and their cost of the organic fertilizer are needed for preparing *Bokashi* for 1-acre field;

Table-6. List of inputs and materials for *Bokashi* preparation

Sr.	Item	Unit	Unit Price (MMK)	Quantity	Cost (MMK)
1	Bokashi"Seed" (effective microorganisms)	pack	1 000	1	1 000
2	Cow-dung	kg	15	100	1 500
3	Chicken Droppings	kg	20	100	2 000
4	Rice bran	kg	307	39	11 973
5	Sesame oilcake	kg	333	15	4 995
6	Ash	kg	5	66	330
7	Soil	kg	5	80	400
	Total	**kg**	**-**	**400**	**22 198**
Source: OISCA Training Center, DoA					

Bokashi Compost *is an effective, low cost, safe and sustainable organic fertilizer for better plant growth, productivity and environment*

Step in preparing Bokashi compost[10]

1. Place a 4–5 inches layer of cow-dung and chicken droppings. (stage-1)
2. Cover on cow-dung layer with rice bran. (stage-2)
3. Thoroughly mix Bokashi seed (0.5 Kgs) 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 kgs of composting materials & mix thoroughly again. (stage-5)
9. Take a small handful of the mixture and knead it. If the mixture is equally damp and slightly stick 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 5 days after piling.
    - Compost can be harvested and used during 7–10 days after piling.
    - Be careful & 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 polyethylene bags or containers. But it needs to control the moisture levels during compost storage, as it may become moldy when soggy, but it should not dry out completely either.
    - Compost can be used by mixing with chicken manure/swine manure/cow dung for soil fertility improvement by increasing the number of effective microorganisms.

[10] OISCA (Myanmar)

Figure 22. Bokashi preparation-placing a 4-5 inches layer of cow-dung

Figure 23. Bokashi preparation-covering cow-dung layer with rice bran

Figure 24. Bokashi preparation-spreading sesame oil cake

Figure 25. Bokashi preparation -spreading rice husk charcoal

Figure 26. Bokashi preparation- sprinkle water on Bokashi

Figure 27-Bokashi preparation- mixing thoroughly the composting materials

Figure 28. Bokashi preparation -covering with tarpaulin

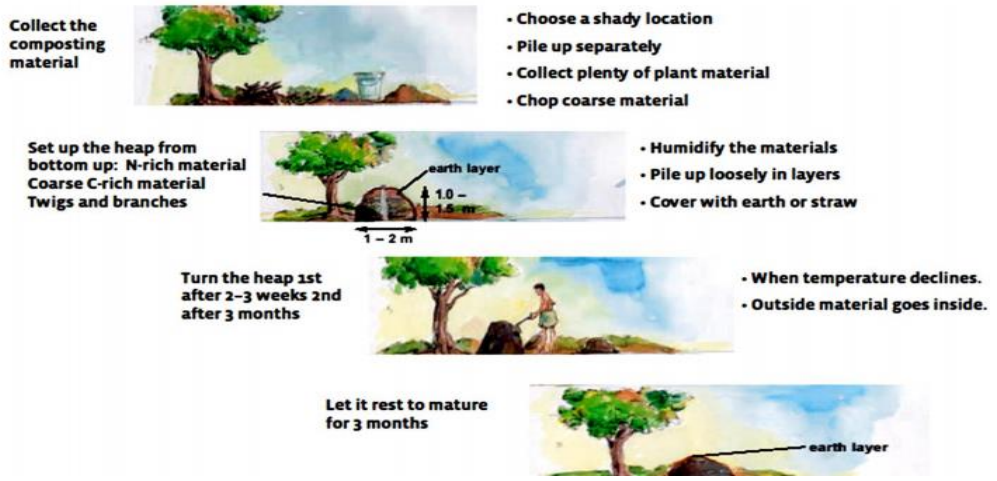
10.7.3. Biodynamic composting

Composting is the process of natural decomposition of organic matter by certain microorganism under controlled condition. The raw materials for composting consist of crop residues, animal wastes, food garbage, kitchen waste and cut grasses. Compost is a rich source of organic matter and improved physical and chemical condition of soil as well as creating resistance in soil to biotic stresses such as drought, disease and toxicity. Application of compost also improves nutrient uptake because of an active nutrient recycling capacity due to microbial activities and ultimately contributes to higher and quality crop yield. Both the quality and quantity of compost is affected by temperature, aeration (for microbial activity) and moisture content. To create conducive factors for better compost preparation, the compost heap should be turned, for hastening its maturity (*Composting process and techniques, aerobic composting process-FAO*). Aerobic compost can be prepared by following the steps below.

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

- Ensure ventilation into the compost heap through punching a hole in the pile at many places or inserting a bamboos and withdrawing them a day later.
- Turn the compost to improve aeration 3–4 times during the maturation time.
- Inoculate the compost with cost effective EM (Effective Microorganisms) such as fungi such as *Trichoderma sp* and *Pleurotus sp*.
- Chop/cut the materials to increase the surface and facilitate decomposition through microbial action especially for woody twigs and branches.

Figure 29. Steps in compost making



Source: FAO. 2015. FAO Training manual for Organic Agriculture, Edited by Nadia SCIALABBA Climate, Energy and Tenure Division (NRC) of the Food and Agriculture Organization of the United Nation (FAO). 2015. Pp 53

One of the many challenges in sesame production in CDZ is poor soil fertility status due to clay and sandy composition resulting in high exposure to water shortages and erosion (JAICAF 2018)[11]. Application of compost can enable to sustain soil fertility and increase sesame production. Compost should be applied to sesame cultivated sites 14 days before planting and should be fully incorporated in the soil upto 30 cm depth. Quantity of compost to be applied can be determined based on current soil fertility, previous crops cultivated and crop management practices. Ganjineh et al. (2019) have reported sesame yield upto 1478 kg ha^{-1} with the application of compost.

10.7.4. Vermi-composting

Vermicomposting, which is also, called worm compost, vermicast and worm manure is decomposed materials broken down by some earthworms. The compost prepared with worms is rich in nutrients, improve soil fertility and act as soil conditioner. Some researchers have reported that sesame responds significantly in terms of improved seed yield and other yield attributes. Combined application of nitrogen and vermicompost gave seed yield of 1 352 kg ha with 10 t ha^{-1} vermicompost (Sajadi and Yadavi 2013).

Steps in preparation of vermi-compost

Vermi-compost can be prepared from biodegradable materials such as crop residues, weeds biomass, vegetables waster, leaf litter, hotel and kitchen refuse, and waste from agro-industries and biodegradable waste of rural and urban wastes. The following steps are involved in the preparation of vermi-compost (Kaur, 2020).

Collect wastes, shred, mechanically separate the metals, glass and ceramics and store the organic wastes→Predigest organic wastes using cattle dry dung and slurry for making it suitable for earthworm feeding→Prepare the bed for earthworm for which a concrete base is required to put the waste for vermi-compost preparation→Make the soil loose for allowing the worms to go into soil and also while watering, all the dissolvable nutrients go into the soil along with water →Collect the earthworm after

[11] Japan Association for International Collaboration of Agriculture and Forestry (JAICAF). Technical Cooperation Project for Agricultural Productivity and Quality Improvement in Myanmar; Project Report; JAICAF: Akasaka, Japan, 2018.

vermi-compost collection→Sieve the composted material to separate fully composted material→Put the partially composted material into vermi-compost bed→Store the vermi-compost in proper place to maintain moisture and allow the beneficial microorganisms to grow. The common earthworms suitable for vermicomposing of Myanmar, India and Malaysia origin are Malaysian Blue worm (Perionyx excavatus) also called the Indian Blue worm and African Nightcrawler (*Eudrilus eugeniae*).

Figure 30. Sorting through a tray of Malaysian Blue (Perionyx excavatus) earthworms, also known as Indian Blues

Figure 31. African Nightcrawler (*Eudrilus eugeniae*) earthworms, note the distinctive blue sheen

Fertilizers and soil additives: Refer to **Myanmar GAP Guidelines** annex 1 for practices at S.No. 1.4, **ASEAN GAP guidelines** annex 3.1 for practices at S.No. 3.1.3, annex 3.2 for practices at S.No. 3.2.3 and annex 3 for practices at S.No. 3.3.3 & 3.3.4

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

10.7.5. Green manuring

Green manuring is the process of incorporating fresh and green crops into the soil by ploughing down with the objectives to add organic matter to the soil, improve soil texture and structure and friability besides adding N and other micronutrient to the soil for increasing its 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 stabilizes soil structure, increases its water holding capacity, and water infiltration and thus contributes in reduction of runoff in unlevelled and sloppy lands. The best time for incorporation of crop residues into the soil is beginning of the flowering stage when the plants attain maximum biomass and are highly succulent. Green manure crops has the best ability for increasing soil fertility through nitrogen accumulation upto 80–100 kg N ha^{-1} in 45–60 days of growth of which almost 80 percent comes from biological N_2 fixation (Becker, 1995).

Crops for green manuring should be multipurpose, fast growing, short duration with high nutrition accumulation ability. For the crops to be readily decomposed in the soil after incorporation, should be herbaceous in nature and should have the ability to be successfully cultivated as green manure crops under shaded conditions, low moisture conditions and widely adapted to various ecological conditions. More importantly, the green manuring crops should not be a host/alternate host to any

known insect pest. The suitable crops for green manuring crops in the project areas (CDZ) are *Sesbania aculeata*, mungbean and cowpea[12].

Process of green manuring

- The seeds of the 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 25 cm (10 inches) deep from the soil surface and be left for two weeks to decompose.

Figure 32. Green manure crops

Figure 33. Incorporation of green manure crops into the soil using tractor

Figure 34. Green manuring (Crotalaria juncea) for paddy cultivation, Myanmar

Figure 35. Slashing green manure crop using a hedge trimmer

10.8. Soil additives and amendments

No soil is inherently perfect for sustained crop production but soil fertility and biodiversity needs to be maintained through the application of certain organic and inorganic materials for maintaining nutrient build up, aeration, drainage, physical, chemical and biological environment for commercial production. Problem soils such as rocky, sandy, clayey, acidic, alkaline, and waterlogged, loose, susceptible to erosion and sloppy soils need amendments and additives for sustained productivity of crops. In case of heavy clayey soils, sand should be added to improve soil aeration and drainage. Soils having high soil pH (alkalinity) or very low pH (Acidity) can be corrected with the application of lime or sulphur respectively. Use of manures (compost and green manures) improves soil structure and textures and

[12] FAO handbook on climate smart agriculture in Myanmar, Sustainable Cropland and Forest Management in Priority Agroecosystems of Myanmar 2019.

helps in buildup of soil nutrients. Stubble mulching is a useful technique of moisture conservation under drought conditions and rain-fed agriculture.

10.8.1. Gypsum (CaSO4 2H2O)

Gypsum is an important soil amendment for maintaining soils for sustained and quality crops production. Gypsum is used for correction of soil sodicity, improves soil stability, water penetration into soil, and more rapid seed emergence (Wallace, 1994). The target regions of the project (Mandalay, Sagaing and Magway) has salinity as one of the soil problems and is a prominent abiotic stress (Oo *et al.*, 2017). According the to the project GAP situational analysis report 67 percent of the farmers in the target townships are using gypsum for correction of soil salinity but are not aware of the exact dosage and condition under which gypsum application should be administered. Gypsum should therefore be applied on soil analysis basis especially pH level. If the pH is alkaline (>7.5), gypsum should be used as per the DoA recommendations. It is highly important to apply gypsum on soil test basis. As reported by Jain & Nehra (2012), sesame yield increased by 14.3 percent with the application of 250 kg gypsum ha^{-1}.

***Apply Gypsum** and make the roots of sesame grow deeper, enrich soils with nutrients, conserve moisture and ensure sustained soil productivity*

10.9. Crop rotation and intercropping

Crop rotation and intercropping is an ingenious, low cost and sustainable climate smart technique of weed, pests and diseases control, soil fertility, crops diversification and building farm resilience, increased ecosystem benefits and farm income. The techniques especially intercropping is climate smart way of building farm resilience, optimization of farm resources, increasing productivity, complementing income and minimization of risks.

10.9.1. Crop rotations

Crop rotation is a systematic and sequential cultivation of different crops in the same field site unlike continuous cropping in which the same crop is cultivated year after year[13]. Crop rotations should be planned by keeping key considerations in mind that deep rooted crops are followed by shallow rooted crop such as sesame, chickpea and green gram for efficient nutrient uptake and utilization, legumes should be followed by non-legumes crops such as sesame should be cultivated after chickpea/green gram/groundnut for maintaining soil fertility and vice versa. Pathogens/nematode resistant crops and crops requiring heavy irrigation should follow crops sensitive to certain pathogens, parasite (nematode) and less water and labor-intensive crops should follow intensive labor. Crop rotation as climate smart and conservation agriculture production techniques has many benefits such as higher yield without extra investment, improved soil fertility and microbial activities, reduced accumulation of soil toxicity, fixation of atmospheric nitrogen into nitrate. Crop rotation also result in effective utilization of soil nutrients and soil moisture, reduced insects pests and disease problem. Farm income can be effectively diversified and sustained in view of climate change effect on agriculture.

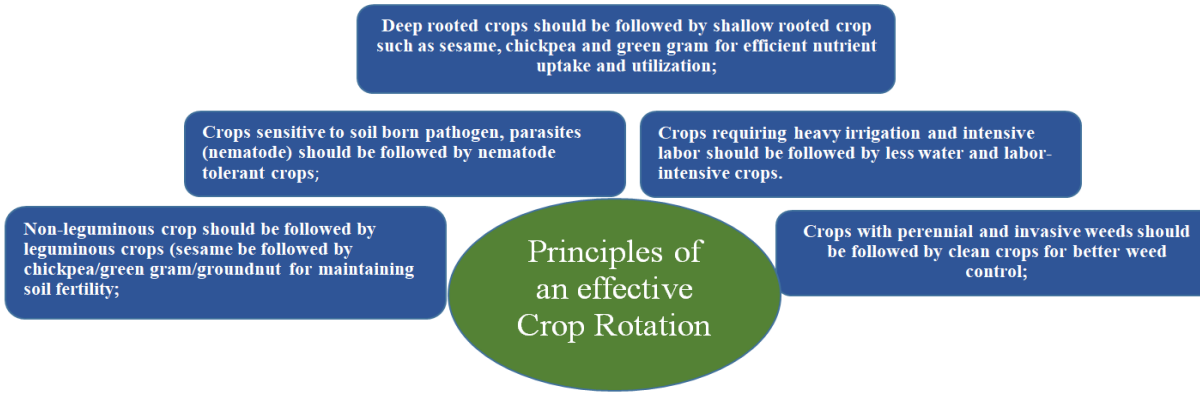
[13] Sustainable settings; harvesting nature's nature intelligence. http://sustainablesettings.org/crop-rotation/

The crop rotations are normally practiced during a year or 2–3 year in the central dry zone of Myanmar. Some samples of crop rotations in sesame growing areas of central dry zone are as follows;

- sesame – green gram
- sesame – pigeon pea
- sesame – groundnut.

Crop Rotation and Intercropping: An ingenious, low cost and sustainable climate smart techniques of weed, pests and diseases control, soil fertility, crops diversification and building farm resilience, increased ecosystem benefits and farm income.

Figure 36. Crop rotation principles



Sites specific Crop rotations schemes should be planned in close consultation with the DoA agriculture extension experts according to the local cropping sequence, cropping pattern 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 considerations.

10.9.2. Intercropping

Intercropping is growing two or more crops simultaneously on the same field. Intercropping is termed as m*ixed intercropping* (*mixed cropping*) when two or more crops are grown simultaneously with no distinct row arrangement. It is called *row intercropping* (*intercropping*) when two or more crops are grown simultaneously where one or more crops are planted in rows. The crop intensification is in both temporal and spatial dimensions. Types of intercropping are: (a) *parallel cropping*, (b) *companion cropping* and (c) *synergistic cropping*.

Some samples of intercropping with sesame in the CDZ are as follows;

- sesame + pigeon pea
- sesame + green gram.

Principles of intercropping

The following key principles should be followed for successful intercropping;

- The associating crop should be complimentary to the main crop.

- The subsidiary crop should be of shorter duration and of faster growing habits, to utilize early slow growing period of main crop.
- The component crops should require similar agronomic practices.
- Erect growing crops should be intercropped with cover crop.
- Erosion permitting crop should be intercropped with erosion resisting crop.
- The component crops should have different rooting pattern and depth of rooting.

Advantages of intercropping

- It offers similar benefits to that from rotational cropping.
- The total biomass production/unit area/unit time is increased because of the fullest use of land as the inter row spaces are utilized which otherwise would have been used for weed growth.
- The fodder value in terms of quantity and quality becomes higher when a non-legume is inter-cropped with legume. e.g., Napier + desmanthus, sorghum + cowpea.
- It provides crop yields in different times, which reduces the marketing risks.
- It offers more employment and better utilization of labourers, machine and power throughout the year.

Sites specific intercropping and mixed cropping schemes should be devised and implemented in close consultation with the DoA agriculture extension experts according to the local cropping sequence, cropping pattern 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 considerations.

10.10. Irrigation and water management

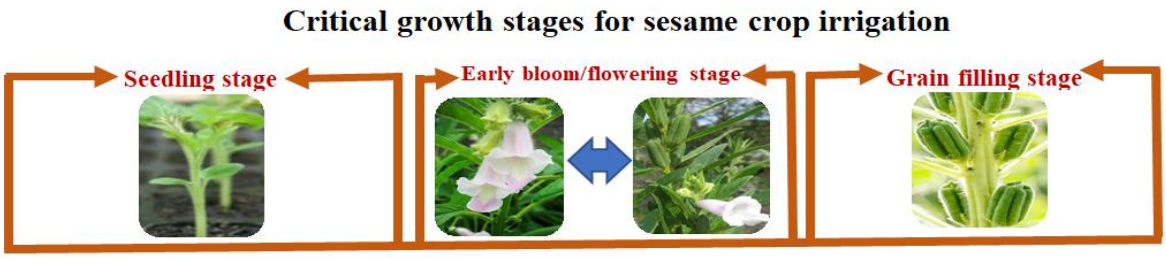
Application of irrigation water is highly important for sesame crop due to its susceptibility to water stresses at critical growth stages. The crop is also sensitive to excess water application or waterlogged conditions as it significantly reduces plant growth and decreases its yield potential. Sesame needs water during the seedling, flowering, and grain filling stages being the most sensitive stages for irrigation during which if irrigation missed, yields can be drastically reduced. Heavy rain at flowering drastically reduce yield, and if cloudy weather persists for long time, severe bacterial blight infection can occur which contribute significantly to yield reduction. In irrigated lowlands where rainfall is erratic and does not support crop growth, irrigation of 75 mm water every 15 days interval until 120 days is advised (Terefe *et al.*, 2012).

As per the findings of GAP situation analysis, 49 percent of respondent farmers were unable to irrigate their crops as required according to recommended crop irrigation regimes. The crops were mostly irrigated once during land preparation/sowing time especially those having less or no access to supplementary irrigation.

Sesame is one of the most drought tolerant crops in the world; however, it prefers frequent but light irrigation. Excessive moisture is not beneficial and extended periods of rainfall and/or high humidity may cause leaf diseases. Watering should be discontinued when the plants complete flowering (70–80 days depending on variety). If a dry period occurs prior to planting, heavy pre-sowing irrigation followed by next irrigation 4 to 5 weeks later may be applied. Two to three additional irrigations may be needed; application should be made every 7 to 12 days as per need of the crop and environmental conditions. When the plants show leaf drooping by mid-day, it is best indicator for the need of irrigation.

It is highly important to test the water quality for heavy metals to ensure safe sesame production. The water testing record should be maintained for any verification. Care must be taken that the water flowing down from livestock farms, hospitals, industries, wastewater and any sources that may cause environmental harm are not used.

Figure 37. Sesame crop critical stages for irrigation



Source (left to right):

Hata, N., Hayashi, Y., Ono, E., Satake, H., Kobayashi, A. & Muranaka, T. 2013. Differences in plant growth and leaf sesamin content of the lignanrich sesame variety "Gomazou" under continuous light of different wavelengths. Plant Biotechnology, 30: 1–8. https://doi.org/10.5511/plantbiotechnology.12.1021a.

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Unitop. The history of sesame: from oilseed to nutritional powerhouse. https://www.unitop.com.pl/en/the-history-of-sesame/.

Figure 38. Irrigation of sesame crop raised on ridges

The water flowing down from livestock farms, hospitals, industries, wastewater and any sources that may cause environmental harm and food contamination should not be used for irrigation and water treatment purposes. Untreated sewage water should not be used during production and postharvest handling of produce. Irrigation water should be applied according to crop water requirements, water availability, and soil moisture levels for increased water used efficiency and water saving.

Irrigation and water management

1. *Refer to **Myanmar GAP Guidelines** annex 1 for practice at S.No. 1.2, **ASEAN GAP guidelines** annex 3.1 for practices at S.No. 3.1.4, annex 3.2 for practices at S.No. 3.2.4 and annex 3 for practices at S.No. 3.3.5*
2. *The irrigation, fertigation and water management of the crop should be recorded as per Annex 3 (15-15.1 to 15.9).*

10.11. Harvesting and handling produce

Timely harvesting and stacking is essential for quality sesame and also decreases shattering losses especially when labor is availability is an issue. When the color of sesame plant turns to a golden hue with capsules gradually turning yellow or the colour of sesame field turns yellow, the crop becomes ready for harvest. This happens 70 to 100 days after seeding, depending on the variety and crop management practices in order to ensure timely harvest. Avoid harvesting before or after the maturity stage.

Stage of sesame physiological maturity and ripening depends on variety, management practices especially soil fertility, irrigation and weed control as well. The crop should be harvested at the right time, with the right manner to minimize losses at harvesting stage to improve the quality of grade. The following are the indicative symptoms for crop maturity and readiness to be harvested;

- The leaves fall from the plant and stems tend to change from green to yellow to red in color;
- The crop should be completely dry before harvesting as sap from green material passing through the header can discolor and taint the seed, creating off flavors in subsequent processed products;
- Harvesting should be started when 75 percent of the capsules are ripened e.g. have turned brown[14].
    - The lowest capsules on the stem are about to split open.
    - Contamination should be avoided during harvesting.
    - The crop should be harvested using sharp tools (sickles) to avoid shaking of the plants.
    - The plants must not be uprooted but should be cut close to the surface of the soil. Uprooting the plants is not an environmental friendly practice as leaving the roots inside the soil improves the soil structure and texture as stubble mulch.

Figure 39. Sesame crop ready for harvest

Figure 40. Over ripening leads to cracking of capsule resulting in shattering losses

[14] Training manual: Farmer's guide for the Production and post-harvest handling of sesame products in Nigeria by STDF Project 172 co-financed by NEPC and STDF, implemented by NEPC and supervised by ITC 2014. https://standardsfacility.org/sites/default/files/PG_172_Annex_I-_Farmers_guide.pdf

CHAPTER (5)

11. Post-harvest management of sesame

11.1. Drying and threshing

Sesame should be harvested in the coolest time of the day to reduce shattering losses and harvesting operation should not be carried out during rain. Equipment and tools are suitable for harvesting and need to be checked for cleanliness before use and cleaned as required. After harvesting, the sesame plants are dried by piling-up in the sun. If it is not possible, those plants are placed in a thin layer. Harvested produce are placed in cleaning floor or container to prevent sesame seed bug. Produce are cleaned at 9 percent of seed moisture content (Myanmar GAP guidelines, 2018). Make sure that the containers are cleaned and dried. For export purpose, the prevention measures for storage pests/disease should be practiced during the storage period to meet the requirements of the different exporting countries (Myanmar GAP Guidelines, 2018).

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 should be beaten gently with sticks and seeds are collected & winnowed. The seeds should be cleaned by repeated winnowing until the seeds are separated from the chaff and other inert matters. Threshing & winnowing should be carried out without further contact with soil and any kind of source of humidity to avoid contaminations.

Harvesting and produce handling: Refer to **Myanmar GAP Guidelines** annex 1 for practices at S.No. 1.8, 1.9, **ASEAN GAP guidelines** annex 3.1 for practices at S.No. 3.1.6, annex 3.2 for practices at S.No. 3.2.6 and annex 3 for practices at S.No. 3.3.7

GAP farmers must maintain a logbook to keep track record of the exact number of days from sowing. Avoid mechanical damage to pods or seeds during weeding, harvesting and storage to control aflatoxin contamination. Seed damage during harvesting affects both the viability of the seed, storage and the quality of the oil. Time and method of crop harvesting should be recorded as per **Annex 3** (Form.2. Harvesting and Handling Produce; 1 to 6).

Figure 41. Threshing by beating sesame dried plants in Myanmar

Figure 42. Proper upright staking of harvested sesame plants bundles for drying in the field

11.2. Storage and transport

Harvested produce should be placed on a clean floor with tarpaulin or container to prevent sesame seed bug. Produce are cleaned at 9 percent of seed moisture content. Cleanliness and dryness are important before storage of sesame seed. For export purpose, the prevention measures for storage pests/disease must be practiced during the storage period to meet the requirements of the different exporting countries. If there is no permanent silo, the super bags, tins boxes and pote (a kind of traditional container made of bamboo) can also be used.

Produce should not be stored in direct contact with fuels, pesticides and fertilizers. Recommended pesticides are to be used during the storage period according to the recommended dosage to prevent the storage pest. Trucks with sesame on board should generally not be transported on a sunny day, since the cover can increase heat build-up. Sesame seeds should be cleaned and dried in sun for about 7 days before bagging and transporting. The bags with or without seed should not be loaded on pesticide or oil contaminated trucks or put in a damp place or any place where it may be exposed to contamination. Transport vehicles are checked before 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 should be stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.

Transport vehicles must be checked before used for cleanliness, foreign objects and other materials, chemical contamination, pest infestation as well as to make sure that the vehicles body is not wet /moist. The vehicle should be tightly closed to avoid any contamination from external contaminants. Produce should be stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination. (Myanmar GAP Guideline, 2018).

Storage handling and transportation

1. *Refer to **Myanmar GAP Guidelines** annex 1 for practices at S.No. 1.9, 1.11, 1.12, **ASEAN GAP guidelines** annex 3.1 for practices at S.No. 3.1.7, annex 3.2 for practices at S.No. 3.2.7*
2. *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).*

The dry seeds should be stored under moisture-free conditions because moist sesame seeds are prone to fungal diseases, as mold spores are present in all crops. It is recommended that the seed be harvested as dry as possible, and stored at moisture of about 6–10 percent[15]. Bagged seeds should not be placed directly on a concrete floor due to the risk of dampness that may cause mould to develop but should be placed on pallet.

Produce should not be stored in direct contact with fuels, pesticides and fertilizers. Recommended pesticides should be used during the storage period according to the recommended dosage to prevent the storage pest. For safe long-term storage, sesame seed should be clean, have moisture content not more than 6 percent and be stored at a relative humidity of approximately 50 percent and at low temperature (below 18°C)[16]. The container/warehouse must be clean and sacks must be free of live insects.

Bags must be sterilized before using them for storage. Bags should be stacked or piled up systematically to ease counting and removing, inspection and management with a minimum of 2 meter spacing

[15] Alternative Crop Guide; Published by the Jefferson Institute. SESAME A High Value Oilseed https://www.extension.iastate.edu/alternativeag/cropproduction/pdf/sesame_crop_guide.pdf

[16] Global Sourcing Hub of Food & Agriculture. https://www.tridge.com/guides/sesame-seed/topics/storage-methods

between stacks. It is highly important to control pest such as rats and birds. The traps and stimulating foods can be put in targeted places and carefully monitor to minimize the risk of contaminating produce. Under optimum storage conditions, sesame seeds can be stored for up to one year. Equipment as well as working and drying surfaces and preparing and storage rooms, should be cleaned regularly and all sweepings collected from time to time. Each stack should be inspected at least once in two weeks to check whether seeds are damaged by insect, rodents, or dampness or moisture. If any damage is observed, necessary measures have to be taken.

11.3. Packing and labeling

The packing and labelling of GAP products is an important means for recalling traceability of the product. The containers should be marked with an identification number, name of the product, variety, year of production, percentage of inert matter, location of production and source of planting materials. Markings and labels should be waterproof to prevent its deterioration.

Figure 43. Storage of sesame bags in the store in an aerated position using pallets

CHAPTER (6)

12. Other GAP and quality assurance standards

12.1. Produce quality production plan

In order to produce quality food, a quality production plan should be developed, implemented and kept on record. Quality plan should encompass practices that are critical to managing produce quality during production, harvesting and postharvest handling, expected losses, causes, control measure, monitoring activities and record keeping to be practiced to prevent or minimize the risk of the hazards affecting the food quality (Annex 2 ASEAN-produce quality module).

12.2. Building and structure

Building and structure are constructed separated places from farm animals, animal feed and compost making exist. The floor of the building is checked before used for cleanliness, foreign objects, chemical contamination, pest infestation and other materials. The bamboo/timber are placed in the floor of the building with purpose of not being direct contact with the floor. The building is structured and managed to have in 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. (Myanmar GAP Guideline.2018).

12.3. Animals and pest control

The traps and stimulating foods are put in targeted places and carefully monitor to minimize the risk of contaminating produce. A record is kept of places where the traps and stimulating foods are placed. (Myanmar GAP Guideline.2018).

12.4. Agro-chemicals and other chemicals

The Integrated Pest Management should be practiced to minimize 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, 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 Guideline, 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; 1to 4 & Form.2. Agro-Chemicals and Other Chemicals; 1 to 12).

12.5. 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 (Myanmar GAP Guideline, 2018).

12.6. Traceability and recall

To ensure a systematic record for product/produce traceability and recall, each production sites 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.

12.7. Documents and records

Documentation and record keeping in an important step. 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/used. The documents/record should provide GAP practices implemented over the pre and postharvest stages, standards maintained for worker health, safety and welfare, workers training and review of GAP practices.

12.8. Training and awareness

Training and awareness raising of GAP actors such as DoA extension staff, farmers, consumers, merchants, brokers and exporters is highly 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 workers in Integrated Pest Management (IPM), Integrated Crop Management (ICM), record keeping is integral to GAP production and post production activities. The workers should be specifically trained on hazards identification and its safe management upto the GAP compliance standards.

12.9. Review of practices

Regular and need based review of practices at least once in a year should be followed to ensure for taking timely and effective actions against the complaints related to produce quality, food safety, workers safety and health and environment management. Record of practices review and action taken should be appropriately documented and kept on record.

12.10. Personal hygiene and worker welfare

Personal hygiene is of immense importance for food safety and workers health. Key instruction and guidance should be displayed at prominent locations on and off the farm and should be reinforced for compliance. Visible and potential sources risking hygiene of workers and produce such as sewage should be identified and remedial measures taken/to be taken should be documented and kept on record. Regular demonstration and role-play should be practiced for implementation of personal hygiene practices. Appropriate hygiene facilities should be provided at the toilets and hand washing places as well as cleaning of equipment.

12.11. 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 contaminating 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 (Annex 2.2. Food safety module).

12.12. Conservation of biodiversity

To conserve and protect the 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 environment quality environmental through application of safe, efficient and approved management of the farm operations. Employers and workers should have appropriate knowledge and

trained in their area of responsibility relevant to good agricultural practices for environmental management. Burning of crop residues, packing/packaging materials has tremendous deleterious effects on the air quality; therefore safe disposal of wastes is highly important. A safe disposal plan should be available for any verification and compliance. Complaints and actions taken to resolve complaints related to environmental management, should be documented and record should be available (ASEAN GAP-Annex 2.3-Environmental Management, practice 2.3.1 and 2.3.9)

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 sesame

S.No	GAP parameters	Recommended GAP practices
1.1	**Site Selection**	The site and its surrounding areas must not be contaminating with any chemical and biological hazards. 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. Sesame is well grown in silt, sandy silt, clay silt and red-colour sandy soil. The soil should be good condition for timely drainage and irrigation. The optimum temperature should be at 25 degree centigrade for vegetative growth while (24–27) degree centigrade for flowering time. Above 40 degree centigrade at flowering time may affect the fruit setting. Sesame can be grown in monsoon, post-monsoon and pre-monsoon seasons.
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**	Good quality, local adaptable and marketable varieties should be selected and used for production. (eg; Red colour sesame (25/160), Sin Ya Da Nar-3, Sin Ya Da Nar-4, Sin Ya Da Nar-14, Sin Ya Da Nar-12, Sa Mon Net). It must be free from seed borne disease. A record is kept of the source of supply, amount of supply and the date of supply for seeds.
1.4	**Fertilizers and Soil Additives**	Fertilizers and soil additives are systematically applied based on the result of soil testing. The fertilizers and soil additives used are free from chemical and biological contaminations that may be harmful on and off the site. Areas or facilities for mixing and loading of fertilizers and soil additives, storage and for composting of organic matter that may be harmful on soil and water resources are avoided. The registered products are only purchased from licensed suppliers and used for crop production. The application of fertilizers and soil additives are recorded. Soil conservation measures and good soil management practices may reduce the risk of environmental pollution, food quality, food safety and soil contamination. The recommended fertilizer/foliar application methods are used. The cow-dung and other animal feces are used after making thoroughly 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 sesame straws that are free from diseases are used as a natural fertilizer after making compost.
1.5	**Agro-Chemicals and Other Chemicals**	The Integrated Pest Management should be practiced to minimize 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. Pre-Harvest Intervals (PHIs) are observed and followed exactly. The training on systematic chemical application method should be attended. The chemicals obtained, stored, used, application and disposals of chemicals are systematically handled and recorded. A record is kept of all actions taken. 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 practiced for producing good quality sesame; - Sowing time should be (February – March) for pre-monsoon season, (May – June) for monsoon season while September for winter season. - (1.5 – 2) Pyi/acre of seed rate (about 5–6.75 lb/acre) which is 80 percent of germination rate and 98 percent of seed purity should be used. - Seed treatment with appropriate fungicide should be done to prevent seed borne disease. - About 6 inches of deep ploughing should be done. - Row to row and plant to plant spacing should be 12 × 4 inches for single type while 15 × 4 inches for branching type. Plant population per acre should be at least 100 thousand. - Seed depth should be within 1.5–2 inches. - The irrigation and drainage channels should be well prepared according to the weather condition and water availability. - Thinning should be done during 2 weeks after sowing at the time of emergence of 6 true-leaves. - Weeding should be done before fertilizer application. - Soil moisture content should be enough at the time of fertilizer application. - For the effective use of fertilizers, the split dose application at different stages; land preparation, vegetative stage, flowering time and initial fruiting stage should be used. - The Integrated Pest Management should be practiced. - Irrigation should be done, if necessary, at initial flowering time and fruit initiation stage. - The proper harvesting should be done when the colour of sesame field turns yellow according to the days to maturity. Then, pile-up sesame plants in the sun and threshing at once in the cotton blanket or tarpaulin sheets for reducing the waste
1.7	**Agriculture and other related materials**	Farm machineries, seed 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. Fertilizers, chemicals, other dangerous subsistence and materials are clearly identified and are not used for storage and holding produce.
1.8	**Harvesting and Handling Produce**	It should be harvested when the colour of sesame field turns yellow. Avoid harvesting before or after the maturity stage. Once harvesting, the sesame plants are dried by piling-up in the sun. If it is not possible, those plants are placed in a thin layer. Harvested produce are placed in cleaning floor or container to prevent sesame seed bug. Pesticides which are low residue effect should be used according to the instruction. Produce are cleaned at 9 percent of seed moisture content. The containers are cleaned and dried. For export purpose, the prevention measures for storage pests/disease are practiced during the storage period to meet the requirements of the different exporting countries.
1.9	**Storage and Transport**	If there is no permanent silo, the super bags, tins boxs and pote (a kind of traditional container made of bamboo) are used. Produce is not stored in direct contact with fuels, pesticides and fertilizers. Recommended pesticides are used during the storage period according to the recommended dosage to prevent the storage pest. Transport vehicles are checked before 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. And, the vehicles are tightly closed to prevent from any infection. Produce is stored and transported in

		areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.
1.10	**Building and Structure**	Building and structure are constructed separated places from farm animals, animal feed and compost making exist. The floor of the building is checked before used for cleanliness, foreign objects, chemical contamination, pest infestation and other materials. Produce is not stored in direct contact with fuels, pesticides, fertilizers including farm implements and other materials. The bamboo/timber are placed in the floor of the building with purpose of not being direct contact with the floor.
1.11	**Animals and Pest Control**	Prevention and control measures are managed/ prepared to prevent pest, rats and birds are excluded from the production site particularly for the areas where produce is harvested, packed and stored. The traps and stimulating foods are put in targeted places and carefully monitor to minimize the risk of contaminating produce.
1.12	**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.
1.13	**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.
1.14	**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.
1.15	**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.
1.16	**Personal Hygiene and Worker welfare**	The trainings about personal hygiene practices are provided to the workers to have appropriate knowledge in personal hygiene. Written instructions on personal hygiene practices are also displayed in prominent locations and also distributed to them and encourage them to practice. The rest rooms and cleaning facilities are placed for easy access. Sewage is carefully disposed of in a manner that minimizes the risk of contamination of workers All actions taken are emphasized on personal hygienic and worker welfare. For personal hygiene and workers 'welfare, team work activities and educational meetings are conducted.

Annex 2: Relevant ASEAN17 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[18]	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 fertilisers 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 of organic materials are located, constructed and maintained to prevent contamination of crops by diseases. 4. The application of fertilisers 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.

[17] Interpretive guide for ASEAN GAP, produce quality module, 2007 by AusAID

[18] 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 practiced to prevent or minimize the risk of the hazard affecting the quality.

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 of 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 of 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 in 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 minimise mechanical damage. 13. Equipment is constructed to minimize excessive drops and impacts. 14. Equipment, containers and materials that contact produce are regularly cleaned and maintained to minimise 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 minimise disease development and loss of quality. 17. Water used after harvest for handling, washing, and produce treatment is treated or changed regularly to minimise 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[19] 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.
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.

[19] The production site be identified by a name or cod 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.

Figure 44. Compost and crop residues should be stored away from production sites to avoid produce contamination

Figure 45.Workers training through demonstration

Figure 46.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 productions 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 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 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 fertilisers 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.

			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. 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 minimises 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 minimise 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. 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 minimise 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 minimise 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 minimise 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 minimise 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 minimises the risk of direct or indirect contamination of produce.
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.

Figure 47. 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

Figure 48. The types of microorganisms that cause illness are bacteria, parasites and viruses.

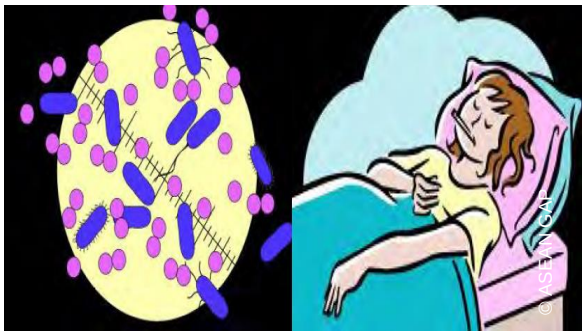

Figure 49. Physical hazards are foreign objects that become embedded in produce or fall into packages

Figure 50. The risk of chemical and biological contamination of produce from previous use of the site and from adjoining sites must be assessed

Figure 51. 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

Figure 52.The location of organic materials beside waterways used to irrigate or wash produce can lead to biological contamination of produce

Figure 53. 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

Figure 54. Chemicals must be stored in a well lit, sound and secure structure, with only authorized people allowed access

Figure 55. Empty chemical containers are not re-used and are kept secure until disposal

Figure 56. 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

Figure 57. 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 minimise 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 fertilisers 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 minimise 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 minimise soil compaction and erosion are used. 4. The use of chemical fumigants to sterilise soils and substrates is justified and a record is kept of the location, date, product, application rate and method, and operator name.
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 minimise nutrient runoff and leaching. 2. Areas or facilities for storage, mixing and loading of fertilisers and soil additives and for composting of organic matter are located, constructed and maintained to minimise the risk of environmental harm on and off the site. 3. Equipment used to apply fertilisers 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 fertilisers 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 minimise 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 minimise the risk of environmental harm. 7. Water from toilets and drainage systems are disposed of in a manner that minimises 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 minimise 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 agrochemcals	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 minimise 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.

			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 minimise the risk of spray drift to neighbouring properties and environmentally sensitive areas. 10. Appropriate volumes of chemicals are mixed to minimise the amount of surplus chemical remaining after application. 11. Surplus chemical mixes and tank washings are disposed of in a manner that minimises 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 authorised people allowed access. The structure is located and constructed to minimise 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 minimises the risk of causing environmental harm on and off the site. Official collection and disposal systems are used where available. 17. Obsolete chemicals, that 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 minimises 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 products generated by property activities and using practices to minimise 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 minimise 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 to show 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.
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.

Figure 58. For new sites the risk of causing environmental harm on and off the site is assessed for the proposed use

Figure 59. Highly degrade areas must be managed to minimise further degradation

Figure 60. To minimize the risk of soil erosion, use natural contour lines and organic mulches

Figure 61. The use of chemical fumigants to sterilise soils and substrates is justified

Figure 62. Storage, mixing and loading areas for fertilizers and soil additives should be positioned to minimise the risk of pollution of waterways and groundwater

Figure 63. Chemicals are applied according to the label directions or a permit issued by a competent authority

Figure 64. Waste management and documentation is an important aspect for 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 authorised workers with appropriate knowledge and skills. 2. Chemicals are stored in a well lit, sound and secure structure, with only authorised people allowed access. The structure is located and constructed to minimise 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 with suitable protective clothing and equipment for the 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 minimise 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 minimises 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 minimise 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 well being 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 well being. 3. Evidence of regular review of practices for workers welfare and safety is available for varification
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 to 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.

Figure 65. Protection from the hazardous effects of chemical must be complied with

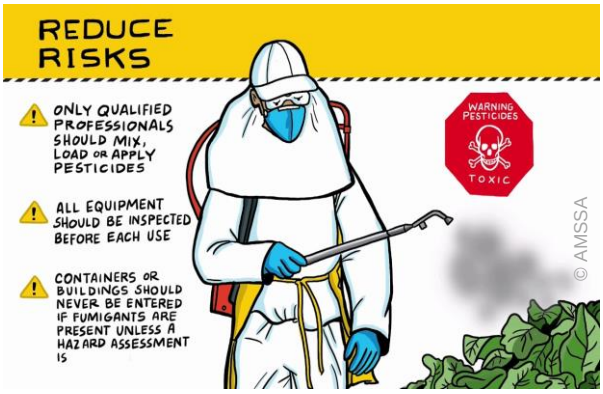

Figure 66. Posters and signs in the work area help to reinforce instructions for workers

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)	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)	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 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 (PHIs)			
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			

FORM-2

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.			
2	Records of all trainings maintained by the farm			
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.			

Annex 4. Nutritional characteristics of sesame

Principle	Nutrient value	Percentage of RDA
Energy	573 Kcal	29 percent
Carbohydrates	23.45 g	18 percent
Protein	17.73 g	32 percent
Total fat	49.67 g	166 percent
Cholesterol	0 mg	0 percent
Dietary fiber	11.8 g	31 percent
Vitamins		
Folate	97 µg	25 percent
Niacin	4.515 mg	28 percent
Pantothenic acid	0.050 mg	1 percent
Pyridoxine	0.790 mg	61 percent
Riboflavin	0.247 mg	19 percent
Thiamine	0.791 mg	66 percent
Vitamin A	9 IU	<1 percent
Vitamin C	0	0 percent
Vitamin E	0.25 mg	2 percent
Minerals		
Calcium	975 mg	98 percent
Copper	4.082 mg	10 percent
Iron	14.55 mg	182 percent
Magnesium	351 mg	88 percent
Phosphorous	629 mg	90 percent
Selenium	34.4 mg	62.50 percent
Zinc	7.75 mg	70 percent
Source: Nutrition and you. 2022. Sesame seeds Nutrition facts. https://www.nutrition-and-you.com/sesame-seeds.html		

GAFSP
global agriculture & food security program

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