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Organization of the
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Good agriculture practices (GAP)

Green gram

(Vigna radiata [L.] Wilczek)



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Green gram (*Vigna radiata* [L.] Wilczek)

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Abbreviations

ASEAN	Association of South East Asian Nations
BNF	biological nitrogen fixation
CA	conservation agriculture
CGIAR	Consultative Group on International Agricultural Research
CSA	climate-smart agriculture
DAP	diammonium phosphate
EM	effective microorganism
FAO	Food and Agriculture Organization of the United Nations
FFS	farmer field schools
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
PPE	personal protective equipment
SRI	System of Rice Intensification
SSP	single superphosphate
TSP	triple superphosphate
UDP	urea deep placement
USDA	United States Department of Agriculture

Executive summary

Myanmar ranks as the world's third-largest pulse producer, following Canada and India, cultivating crops like black gram, pigeon peas, chickpeas, and green gram. Green gram constitutes a third of total pulse exports. To enhance productivity, quality, market competitiveness, and exports, Myanmar can leverage improved crop production technologies and adopt good agricultural practices (GAP). Small resource-poor farmers can readily adopt GAP's production standards, aligned with natural agroecosystems and indigenous knowledge. Efficient management of limited resources depends on selecting quality, environmentally safe inputs. Green gram is one of the important annual pulse legume crops in the Central Dry Zone, both in terms of expansive cultivation and high production levels. Its potential for enhanced quality and food safety can easily be promoted through adoption of Good Agricultural Practices. In view of increased consumers awareness, ensuring food safety, quality, efficiency, and conservation becomes crucial. Strengthening farmers through organization and project-guided marketing is essential for sustained productivity and resource sustainability.

Under the Food and Agriculture Organization of the United Nations' Global Agriculture and Food Security Climate Friendly Agribusiness Value Chain (FAO-GAFSP-CFAVC) Programme, GAP dissemination for five crops, including green gram, involves upgrading existing practices based on Myanmar's GAP to ASEAN's GAP standards. The upgraded GAP version focuses on food safety, quality, worker health, safety, and environmental management. Implementing GAP enhances food safety and quality while promoting ecological sustainability in rice-legumes based production systems.

Identified gaps in knowledge, access, and efficiency of inputs and services for green gram were addressed through a comprehensive situational analysis, involving project collaboration with various stakeholders including market actors. Validation and contextualization were achieved through data research, stakeholder discussions, and insights from relevant stakeholders.

The dissemination of GAP involves capacity-building of the farmers and relevant stakeholders, pulse growers associations, public-private partners, and value chain actors. The framework focuses pre- and post-harvest practices for safe, quality green gram production tailored to small and medium farmers. Key messages promote easy agronomic management practices. GAP rollout includes farmer organization support, technical assistance, market linkages, and training, supplemented by on-farm demonstrations, farmer field schools (FFS), and information and communications technology (ICT) tools.

User-friendly integrated pest management (IPM) handbooks and farmer field schools curriculum complement the framework, aiding farmers' capacity-building and supporting existing GAP initiatives.

Glossary of good agricultural practices terms

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

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

Term/Terminology	Definition
	appropriate) which help producers to implement GAP standards towards obtaining certification (or GLOBAL G.A.P. certification).
Compliance Criteria (CC)	Information is provided to further illustrate each control point and how to successfully address the requirement(s) identified in the control point.
Control Points (CP)	Each of the requirements is requested by a standard (or GLOBAL G.A.P. standards) to implement good agricultural practices. Within the GLOBAL G.A.P. standards, control points are classified as major musts, minor musts, or recommendations.
Control Points and Compliance Criteria (CPCC)	The comprehensive set of control points and compliance criteria that define the standard against which a producer's performance is measured both internally and externally.
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 article 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- are established within an organization to help it direct and regulate its activities in order to achieve desired results; this 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 DoA in line with Pesticide Law (Pyidaungsu Hluttaw Law No. 14/2016)
Plot	An area in which a crop is planted and is not connected to other areas. In case the area is connected to others, the production management including inputs, cultural practices and personnel of the area, is clearly distinctive.
Quality Management System (QMS)	The organizational structure, procedures, processes and resources needed to implement quality management.
Record	A document containing objective evidence illustrating activities being performed and/or results achieved.
Risk	The chance that a condition or set of conditions will lead to a hazard.
Risk Assessment	An estimate of the probability, frequency and severity of the occurrence of a hazard.

Term/Terminology	Definition
Sample/Sampling	Selecting a portion of a group of data in order to determine the accuracy or propriety or other characteristics of the whole body of data.
Self-Assessment	Internal inspection of the production system and the registered product carried out by the producer or a sub-contractor, based on the GLOBAL G.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 is 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: Edmund, Thomas. 2017. GAP Audit Training Manual.	

CHAPTER 1 – INTRODUCTION

1.1. Scope of green gram good agricultural practices

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

1.2. Green gram (*Vigna radiata* [L.] Wilczek) origin and history

Green gram, also called mung bean or golden gram (*Vigna radiata* L. [R. Wilczek var. *radiata*]), originated on the Indian subcontinent and is believed to be a native crop of India (Vavilov, 1926). Green gram is currently grown on about six million ha, mainly in South and Southeast Asia, but increasingly extends into Australia, Canada, Ethiopia and the United States of America. Green gram is grown widely for use as human food (as dry beans or fresh sprouts) but can be used as a green manure crop and as forage for livestock (Oplinger *et al.*, 1990). Green gram is a fast-growing legume that reaches maturity very quickly under tropical and subtropical conditions where optimal temperatures are about 28 to 30 °C and always above 15 °C.

1.3. Nutritional medicinal and industrial uses

Green gram (*Vigna radiata* L.) is an important pulse consumed all over the world, especially in Asian countries, and has a long history of use in traditional food and medicine. Green gram is an excellent source of dietary fibre, minerals, protein, vitamins, and significant amounts of bioactive compounds,¹ including peptides, polyphenols and polysaccharides, therefore, becoming a popular functional food in promoting good health (Hou *et al.*, 2019). Green gram's speciality is that its seeds can be consumed as sprouted fresh or canned, for shipment to restaurants as a favourite food, because of calcium, phosphorus, rich protein (21 to 28 percent), and vitamins, as well as easy digestibility. Green gram is a good alternative for animal proteins, especially in the poor regions of the world. Green gram seeds and seed byproducts are also used in the livestock industry as nutrient animal feed, particularly for swine and young calf (Oplinger *et al.*, 1990). The nutritional characteristics and essential amino acid composition of mature and sprouted green gram grain per 100 g of edible portion are given in Tables 1 and 2.

¹ Bioactive compounds: A kind of chemical compound present in small amount in plants and certain foods (such as fruits, vegetables, nuts, oils, and whole grains promoting good health especially prevention of cancer, heart disease, and other diseases such as lycopene, resveratrol, lignan, tannins, and indoles (National Cancer Institute). <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/bioactive-compound>

Table 1. Nutritional composition of green gram

Characteristics	Content 100-1 g of Edible Portion	
	Mature	Sprouted
Water (g)	9.1	90.4
Energy (kcal)	347	30
Protein (g)	23.9	3.0
Fat (g)	1.2	0.2
Carbohydrate (g)	62.6	5.9
Dietary fibre (g)	16.3	1.8
Calcium (mg)	132	13
Mg (mg)	189	21
Phosphorus (mg)	367	54
Fe (mg)	6.7	0.9
Zn (mg)	2.7	0.4
Vitamin A (IU)	114	21
Thiamin (mg)	0.62	0.08
Riboflavin (mg)	0.23	0.12
Niacin (mg)	2.3	0.75
Vitamin B6 (mg)	0.38	0.09
Folate (mg)	625	61
Ascorbic acid (mg)	4.8	13.2

Source: Mbeyagala, K. E., Amayo, R., Obuo, J. P., Pandey, A. K., War, A. R., & Nair, R. M. 2017. A manual for mungbean (green gram) production in Uganda. Natl. Agric. Res Org.(NARO), 32.

Table 2. Essential Amino-acid composition per 100 g of Edible Portion

Characteristics	Content 100-1 g	
	Mature	Sprouted
Tryptophan (mg)	260	37
Lysine (mg)	1 664	166
Methionine (mg)	286	34
Phenylalanine (mg)	1 443	117
Threonine (mg)	782	78
Valine (mg)	1 237	130
Leucine (mg)	1 847	175
Isoleucine (mg)	1 008	132

Source: Mbeyagala, K. E., Amayo, R., Obuo, J. P., Pandey, A. K., War, A. R., Nair, R. M. 2017. A manual for mungbean (green gram) production in Uganda. Natl. Agric. Res Org.(NARO), 32.

1.4. Economic importance

The global green gram area is about 7.3 million ha, and the average yield is 721 kg ha⁻¹. India and Myanmar each account for 30 percent of global output of 5.3 million tonnes. Other large producers are China, Indonesia, Kenya, Tanzania and Thailand. The green gram market is divided into four main categories, by use, i.e. dry grains (important in Kenya and South Asia), sprouts (important in East and Southeast Asia), transparent noodles starch⁻¹ (important in East and Southeast Asia), and paste

(important in East Asia) (Nair *et al.*, 2020). The global green gram market reached a volume of 2.6 million tonnes in 2018.²

In Myanmar, the green gram area has substantially increased from 0.04 million ha in 1980 to 0.74 million ha in 2000 and 1.21 million ha in 2016.³ Myanmar produced 1.6 MT of green gram in 2016 of which 92 percent was exported (Nair *et al.*, 2020). Farming households, approx. 637 000, earn income from green gram in addition to many landless households deriving income from labour while working in crop production and marketing activities. In Myanmar, green gram is grown as a single crop usually in rotation with rice. Green gram is an important crop contributing to the food security of the local population in the form of income from sale or export, though the domestic consumption is less than 10 percent.⁴

1.5. Green gram production in Myanmar

Myanmar is one of the leading green gram producing countries where the crop plays a vital role in the culinary and food industry and is used as a garnish, a snack, a flavouring agent in some foods and as oil for cooking, besides being an important export crop to Europe and Asia, including Japan. Green gram is a leguminous pulse crop produced mainly in Myanmar's CDZ. Myanmar is a top five-world producer for three key pulse crops (chickpeas, green gram and pigeon peas). The country has strong competitive advantage in pulses production due to extensive land, water and labour resources, as well as proximity to fast-growing markets such as ASEAN Countries, China and India (Raitzer *et al.*, 2015). Myanmar produced approximately five million tonnes of green gram in 2018 and has a major share in global exports; exporting approximately one million tonnes each year. Myanmar has a share of 12 percent of total global exports of pulses by volume, and 19 percent by value (DAR, 2017).⁵

Pulses including green gram are cultivated in different seasons in the different agroecological zones of the country. Green gram has the largest diversity in cropping practices, mainly in CDZ and the northern Delta Zone. The total production, area harvested, yield and volume export of green gram from 2014/15 to 2018/19 are presented in the table below (Table 3).

Table 3. Harvested area, production, yield and export of green gram

Year	Area Harvested (000 ha)	Total Production (000 MT)	Yield (MT ha ⁻¹)	Export	
				Volume (000 MT)	Value (million USD)
2014/15	1 173	1 536	1.31	204.44	208.73
2015/16	1 209	1 595	1.32	205.03	202.60
2016/17	1 216	1 590	1.31	183.11	144.00
2017/18	1 238	1 578	1.27	224.90	99.03
2018/19	1 165	1 458	1.25	234.67	173.56
Source: MOALI. 2019. Myanmar Agriculture at a Glance. Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, 209 pp.					

² Mung Beans Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019–2024
<https://www.researchandmarkets.com/r/jet2e5>

³ CSO. Statistical yearbook volumes 2000 to 2017. Central Statistical Organization, Government of the Republic of the Union of Myanmar. 2000–2017.

⁴ CSO, UNDP, World Bank. Myanmar living conditions survey 2017. Report 03 Poverty Report. Nay Pyi Taw: Central Statistical Organization, Ministry of Planning and Finance; 2019.

⁵ Myanmar Pulses Sector Development Strategy 2017. Australian Centre for International Agricultural Research, The Department of Agricultural Research, Ministry of Agriculture, Livestock and Irrigation Yezin, Nay Pyi Taw, Myanmar

1.5.1. Cropping seasons and crop calendar of green gram

Green gram is cultivated in three different seasons in Myanmar, i.e. monsoon (June to September), winter (October to January) and pre-monsoon seasons (February to May), with an average of 65 to 75 days of growth cycle depending on type of variety.

Crop calendar green gram

Seasons	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Monsoon						S*			H*			
Winter	H*									S*		
Pre-Monsoon		S*			H*							

*S-Sowing *H-Harvesting

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

1.6. Morphological characters

Green gram is an annual, erect or semi-erect plant, with a height of 0.15 to 1.25 metres. The leaves are alternate, trifoliolate with elliptical to ovate leaflets, five to 18 cm long and three to 15 cm broad. The flowers (4 to 30) are papilionaceous, pale yellow or greenish in colour. The pods are long, cylindrical, hairy and pending. They contain seven to 20 small, ellipsoid or cube-shaped seeds. The seeds are variable in colour: they are usually green, but can also be yellow, olive, brown, purplish brown or black, mottled and/or ridged. Seed colours and the presence or absence of a rough layer are used to distinguish different types of green gram. Cultivated types are generally green or golden and can be shiny or dull depending on the presence of a texture layer. Golden gram, which has yellow seeds, low seed yield and pods that shatter at maturity, is often grown for forage or green manure purposes. (Lambrides *et al.*, 2006; Mogotsi, 2006 in Heuzé *et al.*, 2015). Self-pollination takes place in green gram, so insect and wind are not required for pollination.

Figure 1. Green gram seeds



Figure 2. Green gram leaves



Figure 3. Green gram flowers



Figure 4. Green gram pods



CHAPTER 2 – CROP PRODUCTION REQUIREMENTS, OPPORTUNITIES AND CONSTRAINTS OF GREEN GRAM IN MYANMAR

2.1. Crop production requirements

2.1.1. Climatic requirements

Green gram has a wider climatic adaptability for production, requiring a warm season and frost-free conditions during the growth cycle (90 to 120 days). High humidity and rainfall during the later growth stage (maturity) can foster disease problems, harvesting losses due to delayed harvesting, and post-harvest losses due to quality deterioration (Opliner *et al.*, 1990).

2.1.1.1. Temperature

Green gram grows in a wide range of climatic conditions. A warm humid climate with temperatures ranging from 25 to 35 °C is suitable for cultivation. However, this crop is both heat and drought tolerant and thus can be grown in semi-arid environments. Green gram is responsive to day length. Short days result in early flowering, while long days result in late flowering. Different green gram varieties vary in their photoperiod response (Mbeyagala *et al.*, 2017). Seed can be planted when the minimum temperature is above 15 °C. (Production, 2010).

2.1.1.2. Moisture/rainfall

Green gram plants are sensitive to heavy rains and windy storms as well as prolonged waterlogged conditions. High humidity during the growing season creates conducive conditions for diseases while the prolonged season, near or at maturity, causes seed moulding or even sprouting inside the pod. (AVRDC 2006). The overall rainfall requirement of the crop is 400 to 550 mm (16 to 22 inches), well distributed during the growing period (Mbeyagala *et al.*, 2017). The optimum rainfall for green gram is 20 to 50 inches/year (Myanmar GAP Guidelines, 2018). Adequate rainfall is required from flowering to late pod fill to ensure good yield. Late plantings result in flowering during the high temperature and low moisture periods lead to yield reduction. High humidity and excess rainfall in the late growing season can result in disease problems and harvesting losses due to delayed maturity. (Production, 2010).

2.1.1.3. Soil requirements

Green gram is grown on a wide range of soils. However, well-drained loamy to sandy loam soil is best for its cultivation. The crop does not grow well on saline and alkaline soil or waterlogged soils. It can show severe iron chlorosis symptoms in saline soils and certain micronutrient deficiencies on soils that are more alkaline. The soil should have a pH range of 6.3 to 7.2 (Production, 2010). Heavy clay soils restrict root growth and therefore should be avoided (Mbeyagala *et al.*, 2017). The soil should be in good condition for timely drainage and irrigation. Green gram is well suited to no-till situations.

2.2. Constraints and opportunities of green gram in Myanmar

However, Myanmar is among the world's top producers (2nd largest producer) of pulses including green gram, having many comparative and competitive advantages and natural conditions favouring production thereof. However, to achieve maximum yield and productivity, further planning and actions are needed to maximize the return from the crop through better technical support to the farmers, and/or by strengthening agricultural research and extension services in the country.

Some of the major constraints in improving productivity, quality and exports are less availability of improved varieties due to which the farmers rely on traditional varieties with low yield potential. The

growers have no direct access to high-end markets due to export restrictions resulting in low exports of the crop, with the main reliance on exports to India only. Climate change and natural disasters (droughts, flooding and heavy rains) also hamper productivity and quality. Moreover, the pulse growers, including green gram farmers, are not benefiting from the crop due to low adoption of improved techniques, such as seed inoculation, low level of mechanization, and less use and focus on using appropriate soil fertility management. There is less adoption of IPM techniques for insect pest and disease management due to which the farmers are heavily using pesticides, increasing the cost of production. Green gram growers have less access to flexible credit facilities and are thus unable to use innovative and sustainable technologies and rely on defective marketing systems with less value addition; therefore, they sell green gram in raw form, which fetches low prices. The farmers also need support in improved marketing and processing to maximize income from the crop. Public–private partners can facilitate access to quality crop inputs, production, processing and marketing technologies.⁶

⁶ Myanmar Pulses Sector Development strategy 2017. <http://extwprlegs1.fao.org/docs/pdf/mya190978.pdf>

CHAPTER 3 – CROP PRODUCTION TECHNOLOGY

3.1. Site selection

It is important to carefully select a site for safe and quality green gram production. The sites should be assessed for prevention or minimization of chemical and biological hazards and must not have been used previously for disposal of hospital waste, industrial waste, and livestock farms (Myanmar GAP Guidelines, 2018). Low-lying soils with risk of inundation and defective drainage, as well as sites with shading effects, should be avoided for green gram cultivation. The sites should be well exposed to sunlight. Conservation of residual moisture from monsoon rains should be preserved for the successful cultivation of winter green gram. Due to green gram sensitivity to salinity, alkalinity and water logging, soils with these problems should not be selected for cultivation. In the case of new sites, the risk of contamination as on and off sites should be assessed, and if necessary relevant remedial actions should be taken to prevent or minimize the potential hazards of contamination. A site map should be prepared showing the following aspects:

- crop production site with environmentally sensitive areas and highly degraded areas;
- areas for chemical storage, mixing, chemical treatment and spaces used for cleaning of equipment and remedial measures for preventing or minimization of risks;
- areas or facilities used for storage, mixing or composting fertilizers and soil additives should be represented, and remedial actions taken and documented;
- water courses, sewage and drainage lines, areas of active runoff and discharge points;
- farm buildings, farm structures and roads; and
- areas of active degradation and plans of action for minimization of current and potential degradation.

The sites of production and post-harvest management should comply with Myanmar Legislation and National Plans related to the prevention and protection of air, biodiversity, noise, soil, water, and other environmental issues.

Site selection: Refer to [Myanmar GAP Guidelines](#) at Annex 1, for practices at S.No. 1.1 and [ASEAN GAP Guidelines](#) at Annex 3.2 for practices at S.No 3.2.1, annex 3.3 for practices at S.No. 3.3.1

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

3.2. Land preparation

Land preparation is an important step in green gram production. Therefore, considerations such as proper moisture level, soil fertility, drainage, weeds removal, and deep ploughing to break the hardpan for improved germination and nodulation, should be kept in view. The soil should be prepared with two to three ploughings, followed by harrowing using tractor-mounted ploughs, animal-mounted mouldboard ploughs (donkeys or oxen) or by handheld hoes. It is worthwhile to note that summer ploughing (before monsoon rains) is recommended for crop moisture conservation in rainfed areas, allowing for aeration and the effective control of weeds and soil-borne pests. The land should be properly levelled for improved fertilizer and water use efficiency, weed control and avoidance of water inundation in the field. Depending on soil fertility and previous application of organic manures,

farmyard manure at seven to 12 tonnes ha⁻¹ should be applied during land preparation and subsequently be incorporated into the soil (Myanmar GAP guidelines, 2018).

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

Figure 5. Land preparation using bullock drawn plough

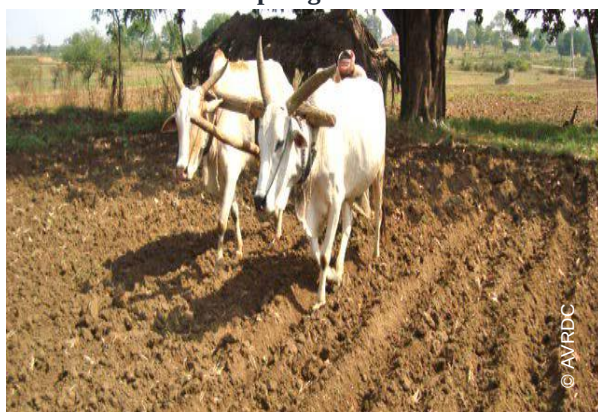


Figure 6. Land preparation for green gram in CDZ using local plough



Figure 7. Using tractor mounted plough for mung bean land preparation



Figure 8. Farmers knowing the importance of gypsum apply it during land preparation along the rows



3.3. Recommended varieties, seed and seed quality

3.3.1. Seed selection

According to the findings of the project GAP situation analysis, 63 percent of interviewed farmers' ranked access to quality seed of improved varieties as one of the main issues.⁷ Green gram varieties recommended by DoA as good quality and locally adaptable with high market value should be selected and used for production (see table. 4). Seeds of known origin, yield characteristics, freedom from physical damages and diseases are important considerations for improved green gram production. Select fresh seeds, not more than two years old, as recommended by DoA. Germination should not be

⁷ GAP (Good Agriculture Practices) Situational Analysis: Problems and Prospects Analysis for GAP Promotion in Magway, Mandalay and Sagaing Regions under Climate-Friendly Agribusiness Value Chains Sector (CFAVC) Project & Global Agriculture and Food Security Programme (GAFSP) Myanmar, March, 2020.

less than 85 percent (Myanmar GAP guidelines, 2018), with physical and analytical purity up to 98 percent. High-yielding, drought-tolerant, shattering-resistant, locally adaptable, disease and insects' pest resistant varieties should be preferred.

An easy way to test seed germination

Conduct the test at home using soft tissues/cloth or through a sample of soil collected in a simple container.

Randomly select 20 or 100 seeds from the seed stock

Evenly place the seeds in a trench of 1–2 meters long (3–6 feet) and cover with 3–5 cm of moist soil

Keep the soil moist on daily basis and observe for 5–7 days to see the germinated seeds

The number of seeds out of the total seeds shows the viability and germination percentage

Calculation of percent germination if 100 seeds are selected for sample germination test

$$\begin{aligned} \text{Germination (\%)} \\ &= \frac{\text{Seeds germinated (85)} \times 100}{\text{Total seeds tested (100)}} \\ &\rightarrow 85 \text{ percent Germination} \end{aligned}$$

Seed selection

See Myanmar GAP Guidelines for green gram at Annex 1 for practices at S.No. 1.3 and ASEAN GAP Guidelines at annex 2.1 for practices at S.No. 2.1.2, annex 2.2 for practices at S.No. 2.2.2, Annex 2.3 practice 2.3.2

Record keeping

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

3.3.1.1. Recommended varieties

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

Table 4. Recommended green gram varieties

Variety name	Cultivation season	Growth cycle (seed to seed)	Yield potential (kg ha ⁻¹)	Good characteristics
Yezin - 1	All season	71 – 75	1 614 – 2 017	Big seed size
Yezin - 4	Monsoon season	65 – 75	1452 – 1 614	Draft resistance
Yezin - 5	Monsoon & post-monsoon	65 – 70	1 775 – 2 017	Big seed size
Yezin - 8	All season	55 – 60	1 210 – 1 614	Resistant to yellow mosaic
Yezin - 9	Monsoon season	65 – 70	1 614 – 2 017	Big seed size, resistant to yellow mosaic disease
Yezin - 11	All season	60 – 65	1 614 – 2 017	Resistant to yellow mosaic disease
Yezin - 14	All season	65 – 70	1 775 – 2 017	Resistant to yellow mosaic disease

Source:

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

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

3.3.1.2. Seed treatment and inoculation

3.3.1.2.1. Seed treatment

Seed treatment before sowing is important for control of soil and seed borne diseases. As per the project GAP situational analysis, 62 percent of farmers are not practising seed treatment with DoA recommended pesticides. Green gram seed should be treated according to DoA's technical recommendation's for compliance with GAP standards to ensure food safety and produce quality. For example, when green gram is cultivated for the first time on a site, the seeds should be inoculated with DoA recommended inoculants for increased nodulation resulting in better nitrogen fixation.

9.3.3.2. Inoculation

Inoculation is important for improved nodulation, especially in soil where green gram is cultivated for the first time. If the seeds are not inoculated or inappropriately inoculated, drastic yield reduction (50 percent) can be expected, particularly in situations where residual nitrogen levels in the soil profile are already very low, i.e. double crop situations. Green gram specific inoculants for more effective nodulation and nitrogen fixation should be selected. The most common means of inoculating green gram is to coat the seed with a slurry of peat-based inoculum immediately prior to planting (Australian Mungbean Association).⁸

Approximately 25 percent of farmers use rhizobium inoculants in pulses production. Lack of availability of good quality inoculants is the main reason for poor adoption of inoculants in Myanmar (Herridge *et al.*, 2016 in DAR, 2017).

Method of inoculating green gram seed: Slurry can be used as a medium for green gram seed inoculation. Green gram specific and compatible inoculum available in the local market should be selected and applied in line with DoA extension technical recommendations. Care should be taken that the *Rhizobia* inoculum is not mixed with pesticides or fertilizers, as it can become toxic. The following steps should be followed for green gram seed inoculation (GRDC, 2017).⁹

- Mix the inoculant with cool water, followed by mixing mechanically with a mixer (feed mixer or augur), to ensure the even coating of the seed.
- Next, mix the seed with slurry at one liter slurry for approximately 100 seeds.

Inoculating green gram seed with rhizobia is the only way to enable the crop to fix its own nitrogen from the air

Key tips for purchasing inoculum

- check the expiry date on the inoculum packet and compatibility with green gram;
- check the storage under the recommended cold chain, i.e. ~4 °C; and
- inoculum should not be frozen (<0 °C) or storage temperature should not exceed 15 °C.

Key tips while applying inoculum

- prepare slurry and apply in the shade;
- avoid exposure to high temperatures (<30 °C), direct sunlight or hot winds;
- avoid injury to the seed during mixing; and
- sow inoculated seed immediately and never delay beyond 12 hours.

⁸ Australian Mungbean Association: Best Management Guide Home.

<http://www.mungbean.org.au/planting.html#inoculation>

⁹ GRDC GROWNOTES Mung beans 2017. ISBN: 978–1-921779–16-9.

https://grdc.com.au/_data/assets/pdf_file/0014/315311/GRDC-GrowNotes-Mungbeans-Northern.pdf?utm_source=website&utm_medium=download_button&utm_campaign=pdf_download&utm_term=North&utm_content=Mungbeans%20Northern%20Region%20-%20GrowNotes%E2%84%A2

Figure 9. Roots of green gram plants at flowering with poor nodulation due to lack inoculation



Figure 10. Roots of green gram plants at flowering with good nodulation due to seed inoculation



Figure 11. A strong pink colour inside the nodules indicates that the rhizobia are active fixing nitrogen



Seed treatment	Record keeping
See Myanmar GAP Guidelines at Annex 1, for practices at S.No. 1.4, 1.6 and ASEAN GAP Guidelines at Annex 2.1 for practices at S.No 2.1.5, annex 2.2 practices at S.No 2.2.5, and Annex 2.3 for practices at S.No. 2.3.6, 2.3.11 and Annex 2.4 for practices at S.No. 2.4.1, 2.4.2, 2.4.5 for further guidance.	Maintain the record of seed treatment with details of chemicals used for seeds, seedlings and plant propagation materials with type, dose and method of application as per the details given in Annex 3 (Form-2, Seed/Seedling; 2).

3.3.1.3. Seed rate and method of sowing

Using appropriate seed rate is an important step for achieving good quality and high production of green gram. Seed rate depends on various factors, such as seed quality, germination, variety, time of sowing, soil condition, availability of labour, preferred crop management practices, and crop utilization. Recommended seed rate for row planting of green gram is 20 to 30 kg ha⁻¹ (four to six pyi acre⁻¹) if cultivated in monsoon season, while for post-monsoon (winter crop) the recommended seed rate is 30 to 40 kg ha⁻¹ (six to eight pyi acre⁻¹). If green gram is sown with the broadcast method,

the seed rate should be increased to 60 to 80 kg ha⁻¹ (12 to 16 pyi acre⁻¹). Seed depth should be within one to 1.5 inches with enough soil moisture.

Table 5. Planting geometry and sowing method

Season	Planting geometry		Seed rate (kg ha ⁻¹)	Plant population ha ⁻¹	Seeding depth (inches)
	Row to row (inches)	Plant to plant (inches)			
Monsoon	18	4	20–30	215 200	1–1.5
Post monsoon (Winter)	12	4	30–40	322 000	1–1.5
Seed rate for both seasons crop with broadcast method of sowing			60–80	NA	1–1.5

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

Line sowing is more advantageous as it requires less seed, produces a more even crop, facilitates effective weeding and disease management, contributes to increased water and fertilizer use efficiency and other farm operations, besides boosting high yield and quality green gram

Variation in seed rate

Seed rate should be increased if sowing of green gram is delayed, seeds are planted deep, soil moisture is limited, soil temperature is low, soil is more compacted, cloddy or trashy, and when there are risk of seed losses due to insects or other vertebrates

Record keeping

Sowing method, seed rate and field layout map should be recorded as per Annex 3 (Form- 1. Cultivation Method; 1 to 3).

Figure 12. Land preparation for green gram using ridger in Myanmar



Figure 13. Using good quality seed results in seedling vigour, crop purity and minimized incidence of seed-borne disease



Figure 14. Green gram crop cultivated with a geometrical layout



Figure 15. Green gram planted in rows in Myanmar



Figure 16. Green gram at flowering and pod development stage



Figure 17. Green gram crop at the pod development stage in Myanmar



Figure 18. Field inspection of the green gram crop by DoA



Figure 19. Spraying of DoA recommended safe pesticide on green gram crop



3.3.2. Manures and fertilizers

Crop nutrition is an important production factor significantly influencing green gram productivity and quality. Major nutrients, secondary nutrients and micronutrients play a vital role. Application of the right source of fertilizers at the right time, rate, placement, as well as site-specific application, results in increased fertilizers' use efficiency, reduced nutrient losses and crop production cost. Green gram is a legume with the ability to fix atmospheric nitrogen through root nodules, improve soil structure by enhancing the formation and maintenance of soil aggregate, and enhance soil stability resulting in reduced soil erosion and increased water holding capacity (Lupwayi *et al.*, 2011).

The findings from project GAP situational analysis revealed that 49 percent of respondent farmers who were pre-monsoon green gram growers, were unable to irrigate their crops and apply fertilizers as required according to improved crop management regimes, i.e. at critical crop growth stages, such as pre-flowering, flowering initiation and pod filling stages.

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

manures and fertilizers should be applied on site-specific basis in line with the soil test results and technical recommendations of DoA.

To produce safe and quality green gram in line with the current GAP standards, areas and facilities for mixing and loading of fertilizers and soil additives, storage, and for composting of organic materials should be located at a safe distance to prevent or minimize risks of food contamination (Myanmar GAP Guidelines 2018). 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)¹⁰ and biological contamination of produce from the use of fertilizers or soil additives need to be documented for preventing or minimizing contamination. It is also important to obtain information about product safety and quality from the suppliers, and keep it on record for traceability and recall.

<i>Type, method, rate and time of manures and fertilizers should be decided on site-specific basis after soil test with recommendation of DoA</i>	
<i>Fertilizers, manures and soil additives</i>	<i>Record keeping</i>
Refer to Annex 1 practice 1.6 and 1.13 of Myanmar GAP guidelines 2018, Annex 2.1 practice 2.1.3, 2.1.9 Annex 2.2 practice 2.2.3, , 2.2.7, 2.2.8, 2.2.13 Annex 2.3 practice 2.3.3, 2.3.4 Annex 2.4 practice 2.4.1,2.4.3, 2.4.5 of ASEAN GAP guidelines for further guidance.	The fertilizers and soil additives used for GAP crop before and after sowing, soil test result, dose, method and timings of chemical fertilizer application should be recorded as per Annex 3 (Form- 1. Fertilizer Application; 1 to 4 & Form.2; Fertilizers and Soil Additives; 1 to 6).
Think responsibly and act judiciously while adding chemicals to the soil: Use the right fertilizers source with the right rate, time and method of placement	
• Soil management is key to addressing climate change • Make decisions on evidence-based soil nutrient management decisions	• Judicious application of fertilizers increases production • Improves and diversify farm profitability • Protects environment and ensures farm resource sustainability

3.3.2.1. Chemical fertilizers

3.3.2.1.1. Nitrogen and nitrogenous fertilizer types, method and time of application

Role and importance of nitrogen: Nitrogen still has an important role for mung bean, despite the fact that green gram plant has the natural ability for biological nitrogen fixation enabling the crop to fulfill its 80 to 90 percent of nitrogen requirements (Thiyagarajan *et al.*, 2003). When soil N levels are low (total N content <0.05 percent), the application of a small amount of N fertilizer induces *rhizobia* formation and promotes the growth of strong green gram seedlings and improved nodulation (Yin *et al.*, 2018). It has also been reported that application of N fertilizer during the early growth period enhances vegetative growth and creates conditions favoring high yield (Yanni *et al.*, 2001).

Nitrogenous fertilizers: Commonly available source of nitrogen as chemical fertilizers are,¹¹ 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

¹⁰ According to Codex MRL for Agricultural Produce in Myanmar, Maximum limit for heavy metals, Lead: NMT 10.0 mg/kg or 10.0 mg/L (10.0ppm), Arsenic: NMT 5.0 mg/kg or 5.0 mg/L (5.0ppm), Mercury: NMT 0.5 mg/kg or 0.5 mg/L (0.5ppm), Cadmium: NMT 0.3 mg/kg or 0.3 mg/L (0.3ppm); ASEAN guidelines on limits of contaminants for health supplements.

¹¹ Fertilizers and their use, Agriculture extension services, University of Tennessee.
<https://extension.tennessee.edu/publications/documents/pb1637.pdf>

(*Fertilizers and their Use, Agriculture Extension Service, University of Tennessee, United States of America*) and calcium ammonium nitrate (21–27 percent N, 8 percent Ca) (IFDC, 2018).

Rate of nitrogen application: As mentioned earlier, higher doses of nitrogen should not be applied unless N is very low in the soil. Being a leguminous crop, green gram can fulfill its nitrogen requirements if properly inoculated and planted into situations with low background soil nitrogen levels. Source, rate, time and method of N application depend on cropping systems, soil fertility, previous crops cultivated, organic manure application, and availability of water, crop management, and soil chemical and physical properties. However, nitrogen application is important to support plant growth, and often leaves some residual nitrogen for the following crop. The rate of nitrogen application and source of fertilizers can be decided based on site-specific testing and DoA recommendations. As reported by Patra and Bhattacharyya (1997), the highest green gram yield was recorded with a urea application of 25 kg N ha⁻¹. Other researchers (Ashraf, [2001]; Mahboob and Asghar [2002]) reported yield increase with the application of N from 20 to 50 kg ha⁻¹.

Method and time of application: If the level of nitrogen is very low, it creates N hunger signs, adversely affecting yield, nodulation and N₂ fixation. A starter dose as basal application is highly useful to minimize N deficiency during early plant growth. (Singh *et al.*, 2017). As reported by Yanni *et al.*, (2001), application of N during the early growth period promotes vegetative growth and creates conditions favouring high yield. Integrated use of N with *rhizobium* inoculation is the most efficient in terms of high nodulation and grain yield as reported by Singh *et al.*, 2021. Split application of 50 percent N at sowing and remaining at four or six weeks after sowing resulted in high fertilizer use efficiency of 24 to 27 percent (Suwanarit *et al.*, 1984). Nitrogenous fertilizers should be applied as top dressing, band application or application between the rows of the crop, but should be covered with soil to minimize losses, especially in case of urea as source fertilizer. Nitrogen fertilizers, if broadcasted, should be fully incorporated into the soil to minimize N losses. Natural fertilizers along with 14.42 kg N ha⁻¹ should be applied as basal dose (Myanmar GAP guidelines, 2018).

11.4.1.2. Phosphorus and phosphate fertilizers' type, method and time of application

Role and importance of phosphorous: Phosphorus is an important element in almost all biochemical compounds and is important for green gram crop nutrition for better growth and plant development. (Singh *et al.*, 2008). As reported by Singh *et al.*, 2019, the application of phosphorus to green gram increases plant growth, yield attributes and grain yield besides promoting early root formation and the formation of lateral, fibrous and healthy roots, which is particularly important for nodule formation and atmospheric nitrogen fixation.

Phosphate fertilizers: Commonly available phosphate fertilizers are diammonium phosphate (DAP) with 18 percent N and 46 percent P₂O₅, available in granular form, triple super phosphate (TSP) with 46 percent P₂O₅, available in solid granular form, and single super phosphate (SSP) with 20 percent available in solid granular form.¹² Phosphate fertilizers, however, should be applied on site-specific basis for ensuring their effective utilization by the plants (*Fertilizers and their Use, Agriculture Extension Service, University of Tennessee, United States of America*).

Rate of phosphorous application: Phosphorus fertilizers should be applied on site-specific basis after soil testing for soil phosphorus and in line with technical recommendations of DoA. The application of phosphorus also depends on soil structure, previous crop cultivated, losses of phosphorous due to erosion, flooding and other abiotic stress factors. However, if the soil tests are not available, application of phosphorus at five to 10 kg P ha⁻¹ gives good results for rainfed crop and higher dose for irrigated

¹² Fertilizers and their use, Agriculture extension services, University of Tennessee.
<https://extension.tennessee.edu/publications/documents/pb1637.pdf>

crops (GRDC, 2017).¹³ As reported by Khan *et al.*, 2017, the highest grain yield of 1 262.81 kg ha⁻¹ was recorded in green gram with the application of 45 kg P₂O₅ ha⁻¹. According to Myanmar GAP Guidelines 2018, natural fertilizers, along with 28.24 kg P₂O₅ ha⁻¹, should be applied as basal dose.

Method and time of phosphorous application: Phosphorus is less mobile in the soil, so its uptake and absorption by the plant depend on the right time and method of application, especially the soil depth. As reported by Singh *et al.*, 2017, the grain yield of green gram increased by 40 kg ha⁻¹ with phosphate fertilizer placement at a depth 7.5 cm. Application of 100 percent P₂O₅ as basal dose improved nodulation at the initial root development and root proliferation. Split application of phosphorus at 50 percent as basal dose and 50 percent top-dressed at the branch initiation stages contributed to less phosphorus fixation and improved phosphorus use efficiency (Singh *et al.*, 2012 in Singh *et al.*, 2017).

11.4.1.3. Potash and potash fertilizers-type, method and time of application

Role and importance of potash: Potassium is the third important nutrient for plant growth, after nitrogen and phosphorus. Potassium 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. Potassium is also important in enzyme activation besides its role in protein synthesis, plant water regulation, stomatal movement and phloem transport. In case of potassium deficiency, water use and N efficiency are greatly reduced (Mikkelsen and Roberts, 2017). Potassium also induces resistance to disease and improves the growth, quality and nutritional value of green gram, especially under dry arid conditions (Kafkafi *et al.*, 2019).

Potash fertilizers: Commonly available potash fertilizers are potassium chloride, with 60 percent potassium, available in solid granular form, muriate of potash (MoP) with 60 percent K₂O, 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, United States of America*).

Rate of potassium application: Application rate of potassium should be decided based on soil tests, previous crops cultivated and soil physical and chemical properties, as well as previous organic and inorganic potash fertilizers applied to green gram. To ensure site-specific application of potash fertilizers, recommendations of local DoA experts should be followed. Application of 75 kg ha⁻¹ at sowing significantly increased yield and yield contributing parameters of green gram, as reported by Abbas *et al.*, 2011. Chanda *et al.*, 2002 reported maximum yield in green gram with the application of 90 kg ha⁻¹. Similarly, a yield of 1520 kg ha⁻¹ was obtained with application of 80 kg K ha⁻¹ (Fadhel, 2011).

Method and time of potassium application: Method and time of potassium application to green gram depends on the climatic, soil physical and chemical characteristics, and crop growth stage. In areas with cool seasons and soils with low potassium fertility, banded application is recommended, besides other factors such as when the quantity of fertilizer is too small, development of root system is poor, and soil has low potassium levels. However, placement of potassium as band or dressing should be administered enough away from the plant so that the salt content may not negatively affect seed germination or seedling growth. Foliar applications are typically complementary to soil applied K, but rates are low, and sources chosen carefully. (Bell *et al.*, 2017). The broadcast method is also used for potassium application, but it should be subsequently incorporated into the soil to facilitate roots-to-fertilizer contact and effective uptake. As reported by Sangakkara (1990), 100 percent of potassium application

¹³ GRDC (Grain Research and Development Corporation) Grownotes, Mung bean. 2017. ISBN: 978-1-921779-16-

as basal dose resulted high yield of long maturing varieties of green gram. According to Myanmar GAP Guidelines 2018, natural fertilizers, along with 18.83 kg P₂O₅ ha⁻¹, are recommended for application as a basal and the remaining 18.83 kg P₂O₅ ha⁻¹ should be applied during vegetative growth stage with enough soil moisture content.

3.3.2.1.2. Compound fertilizers (NPK)

Smallholder farmers usually apply compound fertilizers with a different nutrient ratio of the three major nutrients (NPK) due to their difficult access to soil analysis, cultivation of multiple crops and face financial constraints. Blended fertilizers result in high yield but are not addressing other nutrients, especially micronutrient deficiency in the soil.¹⁴ Different blends of NPK fertilizers are available in Myanmar, i.e. 20:20:10 (NPK), 15:15:15 (NPK), 20:10:05 (NPK), 30:10:10 (NPK), 20:20:10 (NPK), 15:15:15 (NPK), and 15:10:05 (NPK) for various types of soils and crops cultivated. However, it is highly important to apply compound fertilizers on site-specific, soil test basis to avoid soil toxicity, optimize the nutrient requirement and uptake for increasing the yield of green gram, and benefits of interactions between the organic and inorganic fertilizers, as well as increased fertilizer use efficiencies. Various blend fertilizers having NPK can be applied as basal dose for better yields. In case of rainfed crops, 12.5 kg N + 25 kg P₂O₅ + 12.5 kg K₂O + 10 kg S ha⁻¹ should be applied, while in case of irrigated crops, the application of compound fertilizer with 25 kg N + 50 kg P₂O₅ + 25 kg K₂O + 20 kg S ha⁻¹ is recommended for green gram (TNAU, 2014).¹⁵

The registered products are only purchased from licensed suppliers and used for crop production. The fertilizers and soil additives used are free from chemical and biological contaminations that may be harmful on and off the site.

3.3.2.1.3. Essential and micronutrients

As pulses including green gram are normally cultivated on low fertile, marginal and rainfed soils, the deficiency of certain micronutrients has therefore been observed which, if not corrected, can also affect the absorption of other plant nutrients due to their synergistic effects.

Sulphur (S): S is important in N-fixation because of its influencing role in nodulation of legumes. S is also part of the nitrogenase enzyme, promoting nodulation in pulses. S deficiency can negatively affect biological N-fixation (BNF) in mung bean (Sachan *et al.*, 2020). S demand for green gram, like other pulses, is higher than cereals because of green gram's high protein content. Application of 30 kg S ha⁻¹ resulted in increased yield (Singh *et al.*, 2015).

Boron (B): Like S, B is also an important micronutrient for green gram and is required in comparatively more amounts than cereal and other crops because of its essentiality in various metabolic and physiological processes, including cell wall structure and function. B deficiency can negatively affect vegetable and reproductive growth of green gram as well as resulting in inappropriate absorption of NPK and S in different field crops, including mung bean. Application of five kg B ha⁻¹ significantly increased green gram yield, as reported by Kaisher (2010).

Zinc (Zn): Zn is another important micronutrient being the functional and structural unit of many enzymes (Coleman, 1992), and enhances other nutrients use efficiency by reducing the leaching of nutrients like nitrates (Zahedi *et al.*, 2009). Data revealed that Zn application of 10 mg Zn kg⁻¹ showed significant effect on yield and yield contributing traits, harvest index and grain Zn concentration of mung bean (Haider *et al.*, 2018).

¹⁴ Myanmar Soil Fertility and Fertilizers Management Conference, Oct 18-19, 2017)

¹⁵ TNAU agritechportal agriculture.

https://agritech.tnau.ac.in/agriculture/CropProduction/Pulses/pulses_greengram.html

Iron (Fe): Fe plays a major role in enzyme activation because it is part of many enzymes and is a cytochrome involved in the electron transport chain; also, it synthesizes chlorophyll and structure of chloroplasts (Eskandari, 2011). As reported by Majeed *et al.*, 2020, the highest grain yield was recorded in green gram with the split application of 15 kg Fe ha⁻¹.

Figure 20. Deficiency symptoms of nitrogen in green gram appears older leaves becoming yellow and reduced in number and die prematurely. Stems become thin with reduced branches leaves number reduction in plants



Figure 21. Deficiency of phosphorus in green gram with discoloration of lower leaves and exhibit a blotchy green appearance



Figure 22. Deficiency of potassium in green gram with leaves malformation with crimped leaves curling inside, lower leaves turn light green



Figure 23. Deficiency of calcium in green gram , top leaves affected first, turning light green with brown necrotic areas, abscission of leaflet and terminal buds



Figure 24. Deficiency symptoms of boron in green gram with upper internodes shortened, rosette appearance, turn yellow and sometimes red



Figure 25. Deficiency symptoms of iron with yellowish green discolorations on new leaves, interveinal chlorosis and death of leaves



Figure 26. Deficiency symptoms of magnesium in green gram, with drooping and downward curled leaves, turn lighter green and finally leaf necrosis and leaves death



Figure 27. Deficiency symptoms of manganese in green gram with older leaves becoming yellow and then turning reddish pale with brownish black spots appear on leaves



Figure 28. Deficiency symptoms of copper in green gram with expanded leaf drooping and wilted, turning colour to a little lighter green, followed by leaf abscission



Figure 29. Deficiency symptoms of zinc in green gram with appearance one month after germination. Interveinal areas of leaves become yellow and die prematurely. Reduction of growth in plants. Yellowish smaller leaves, veins remain green in colour



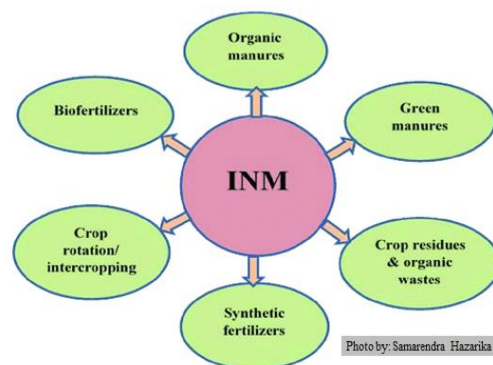
3.3.2.2. Organic manuring

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

Organic manures are a rich source of nitrogen and other essential micronutrients. Poultry manures, FYM composts and crop residues are of immense importance in climate smart and climate resilient agriculture and food systems. Organic manures, besides being a significant source of macro- and micronutrients also improve physiochemical properties of soil such as soil porosity, infiltration rate, total carbon, water holding capacity and action exchange capacity, reducing bulk density, checking soil erosion and leading to increased availability of plant nutrients through mineralization. Use of organic materials as mulch is an important low-cost farm input to control or minimize weed infestation. Proper method, application rate, and time of inorganic fertilizer along with organic manure not only decrease nitrification rate but also play a key role in increasing crop productivity by increasing nitrogen use efficiency (Khan *et al.*, 2009).

To enhance environmental quality and ensure sustainability in food production, make efficient use of nonrenewable on-farm resources in an integrated and synergistic manner.

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



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 green gram-cultivated areas to prevent micro- and macronutrient deficiencies. The main types of organic manures are farm and animal manures, crop residues, green manures, biogas slurry, and biodynamic compost, vermicompost, which if properly prepared and applied, provide the best medium for plant growth and nutrient mobility and uptake by the plant nutrients.

Mulching, a low cost and sustainable climate smart practice that conserves soil moisture, enhances the nutrients' status of soil, controls the erosion losses, suppresses the weeds in crop plants, and removes the residual effects of pesticides, fertilizers, and heavy metals. Mulches improve the aesthetic value of landscapes and economic value of crops (Springer link)¹⁶

Green gram and other pulses are responsive to organic manuring. The yield of green gram increased up to 151.3 kg ha⁻¹ with the application poultry manure, 133.8 kg ha⁻¹ with FYM application, and a yield of 106.3 kg ha⁻¹ with the use of crop residues (Anwar *et al.*, 2018).

¹⁶ <https://link.springer.com/article/10.1186/s42269-020-00290-3#:~:text=Mulches%20conserve%20the%20soil%20moisture,and%20economic%20value%20of%20crops.>

Organic manuring: A climate smart approach for safe, sustainable, resource efficient and eco-friendly system of green gram production and a viable step towards climate smart agriculture

Refer to Annex 1 practice 1.4 and 1.6 of Myanmar GAP Guidelines and Annex 2.1, 2.2 practice 2.1.3, 2.1.9 and figure 65,71,73 Annex 2.3 practice 2.2.3, 2.2.8, Annex 2.3 practice 2.3.4, figure 83, Annex 2.4 practice 2.4.3 for further guidance

Record keeping:

The types, dose, method and timings of organic manures, chemical fertilizers (macro- and micronutrients) should be recorded as per Annex 3 (Form 1. Fertilizer Application; 1-4, Form 2, Fertilizers and soil additives 1-6).

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

9.4.2.1. Farm yard manures (FYM)

FYM are manures collected and decomposed, consisting of both dung and urine with associated litter and remains in the animal sheds. Composting of farmyard manure increases its value in terms of nutrient recycling capacity, texture, friability and absorptive capacity. Application of fresh farmyard manure should be avoided not only due to low nutrient contents but also due to a source of insects' pests and other potential toxicity to the plants. Animal urine is a valuable part of animal manure and contains appreciable amount of nutrients. The animal manure mixture (dung and urine) should be collected and trenched in a pit of the size 6 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 four to six months for application to the crops at the time of sowing/land preparation. Application of farmyard manures depends on soil fertility status and other crop management practices. Application of six to 10 tonnes of well-decomposed FYM ha⁻¹ with full incorporation into the soil during land preparation should be followed for increased soil fertility and increased green gram productivity (Myanmar GAP guidelines, 2018).

Table 6. Average values for moisture and nutrient content of farm animal manures

Source	Portion	%	Moisture Content	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Horse	Manure	80	75	0.55 (0.50–0.60)	0.33 (0.25–0.35)	0.40 (0.30–0.50)
	Urine	20	90	1.35 (1.20–1.50)	Trace	1.25 (1.00–1.50)
	Mixture	—	78	0.7	0.25	0.55
Cattle	Manure	70	85	0.40 (0.30–0.45)	0.20 (0.15–0.25)	0.10 (0.05–0.15)
	Urine	30	92	1.00 (0.80–1.20)	Trace	1.35 (1.30–1.40)
	Mixture	—	86	0.6	0.15	0.45
Swine	Manure	60	80	0.55 (0.50–0.60)	0.50 (0.45–0.60)	0.40 (0.35–0.50)
	Urine	40	97	0.40 (0.30–0.50)	0.10 (0.07–0.15)	0.45 (0.20–0.70)
	Mixture	—	87	0.5	0.35	0.4

Sheep	Manure	67	60	0.75 (0.70–0.80)	0.50 (0.45–0.60)	0.45 (0.30–0.60)
	Urine	33	85	1.35 (1.30–1.40)	0.05 (0.02–0.08)	2.10 (2.00–2.25)
	Mixture	—	68	0.95	0.35	1
Poultry	Mixture	—	55	1.00 (0.55–1.40)	0.80 (0.35–1.00)	0.40 (0.25–0.50)

Source: Van Slyke, L. L. 1933. *Fertilizers and crop production*. Soil Science, 35(2), 171.

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

Avoid application of fresh FYM: Application of fresh farmyard manure should be avoided not only due to low nutrient contents but also due to a source of insects' pests and other potential toxicity to the plants.

Reduce contamination through Best Management Practices of FYM composting

Protect stored manure (and compost) from rain, and safely manage the run-off of effluent from compost heaps to avoid contamination of adjacent soils, work areas and waterways.

Use effective barriers to areas of composting to reduce the likelihood of complaints and contamination. Apart from the visual effect, barriers can also help to filter and thin out odors.

Figure 31. Compost piles in various stages of development



Figure 31. Compost piles in various stages of development



Green gram is highly responsive to application of FYM, improving the availability of soil nutrient, nutrient uptake and increase in yield. Organic manures also enhance soil biological activity, which improves nutrient mobilization from organic and chemical sources, and decomposition of toxic substances (Rana *et al.*, 2014). There lies a synergistic relationship between different plant growth-promoting microorganisms, which is further improves with the application of FYM. Adoption of appropriate strategies for application of organic manures for increasing green gram yield has good prospects (Dkhar *et al.*, 2019). (Choudhary *et al.*, 2011) also reported that organic manures result in better growth and consequently exploitation of greater soil volume for nodulation.

11.4.2.2. Bokashi compost

Bokashi¹⁷ is a Japanese word meaning, "fermented organic matter" which was first developed in early 1980s at the University of Ryukyus, Japan. The method encompasses layering of kitchen scraps (vegetables and fruits, meat and dairy scraps) with a Bokashi inoculant in a specially made bucket. The inoculant used in Bokashi contains wheatgerm, bran of wheat or sawdust mixed with EM and molasses. The bran is food for the microorganism similar to those organisms found in the soil. Application of combined application with NPK enhance the quality of sustainable soil fertility management (Lasmini *et al.*, 2018).

Steps in preparing Bokashi compost (OISCA, DoA Myanmar)

1. place a four to five inches layer of cow-dung and chicken droppings (stage 1);
2. cover cow-dung layer with rice bran. (stage 2);
3. thoroughly mix Bokashi seed (0.5 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 kg of composting materials and mix thoroughly again (stage 5);
9. take a small handful of the mixture and knead it. If the mixture is equally damp and slightly sticks to itself (it cannot be moulded), it is ready to make a Bokashi compost (stage 6); and
10. the mixture is piled up to (1–2) feet height evenly and slightly covered the top with a layer of straw or dried grass or old tarpaulin (stage 7–8):
 - Turn the compost pile once a day depending on the temperature. If it is needed, stir the compost pile to keep the temperature not to be more than at 50–55 °C until five days after piling.
 - Compost can be harvested and used during 7–10 days after piling.
 - Be careful and keep the compost not to be in direct sunlight for a long time before use.
 - For later use, air-dried compost can be stored in polyethene bags or containers. Moisture during storage should be controlled to prevent the development of mould, nor to allow moisture for decreasing enough to leave the compost dry.
 - Compost can be used by mixing with chicken manure/swine manure/cow dung for soil fertility improvement by increasing the number of effective microorganisms.

¹⁷ Bokashi is a Japanese word that means “fermented organic matter.”

Bokashi preparation steps

Figure 32. Bokashi preparation-placing a 4–5 inches layer of cow-dung



Figure 33. Bokashi preparation-covering cow-dung layer with rice bran



Figure 34. Bokashi preparation-spreading sesame oil cake



Figure 35. Bokashi preparation-spreading rice husk charcoal



Figure 36. Bokashi preparation-sprinkle water on Bokashi



Figure 37. Bokashi preparation-mixing thoroughly the composting materials



Figure 38. Bokashi preparation-covering with tarpaulin



9.4.2.3. *Biodynamic/aerobic composting*

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

Store 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.

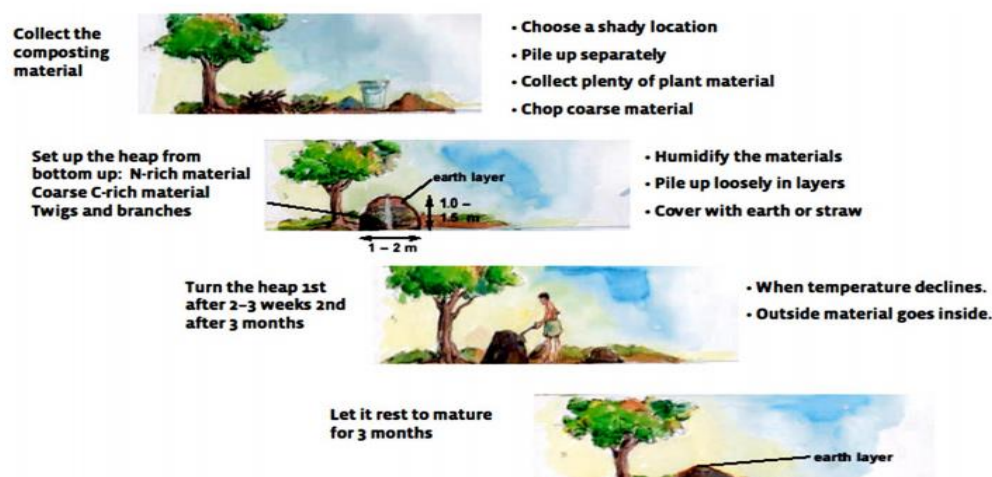
To regulate the temperature, turning of compost is especially important. Compost can be ready for application to the crops in six to eight months. To prepare quality biodynamic compost, ensure ventilation into the compost heap through punching a hole in the pile at many places or inserting a bamboo and withdraw them after some days. Keep on turning the compost to improve aeration three to four times during the maturation time. To further improve the quality of compost and enhance its fertility aspect and decomposition, inoculation with cost-effective EM (Effective Microorganisms) such as fungi such as *Trichoderma* sp. and *Pleurotus* sp. is important (*Composting process and techniques, aerobic composting process-FAO*).¹⁸

Figure 39. Biodynamic compost making in Myanmar



¹⁸ <http://www.fao.org/3/y5104e/y5104e05.htm>

Figure 40. Steps in compost making



Source: FAO. 2015. FAO training manual for Organic Agriculture.

https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Compilation_techniques_organic_agriculture_rev.pdf

9.4.2.4. Vermicomposting

Vermicompost, which is also called worm compost, and worm manure, is decomposed materials broken down by some earthworms. The compost prepared with worms is rich in nutrients, improves soil fertility and acts as soil conditioner. The compost is a rich source of nutrients, improves soil microbial activities and also contains beneficial growth hormones. The application of vermicompost in green gram crop gives beneficial results in terms of increased produce and improved nutrient use efficiency. Due to the declining soil fertility and nutrient losses, the use of organic manures is becoming popular. As reported by Rajkhowa *et al.*, (2017), integrated use of 50 percent RDF + VC 2.5 t ha⁻¹ + lime 400 kg ha⁻¹ significantly increased yield of green gram up to 100.0 kg ha⁻¹ and also improved soil organic carbon (2.5 percent), bacterial and fungal population, pH and available NPK compared to application of fertilizers alone. Moreover, application of vermicompost at eight tonnes ha⁻¹ increased the yield of green gram up to 131.3 kg ha⁻¹ in combination with potassium at 20 kg MoP ha⁻¹ (Biswash *et al.*, 2014). It is therefore important that the application of mineral fertilizers should be combined with organic manures such as vermicompost for increased green gram productivity and to improve farmer's income and livelihoods.

Steps in preparation of vermicompost

Vermicompost can be prepared from biodegradable materials such as crop residues, weeds biomass, vegetables wastes, leaf litter, hotel and kitchen refuse, and waste from agroindustries and biodegradable waste of rural and urban wastes. Vermicompost also enriches microbial population and soil biodiversity, particularly fungi, bacteria and actinomycetes.

The following steps are involved in the preparation of vermicompost (Kaur, 2020).

Store the vermicompost in a proper place to maintain moisture and allow the beneficial microorganisms to grow

Step 1	→	Collect wastes, shred, mechanically separate the metals, glass and ceramics and store the organic wastes
Step 2	→	Predigest organic wastes using dry cattle dung and slurry for making it suitable for earthworm feeding
Step 3	→	Prepare the bed for earthworms, for which a concrete base is required for the placement of waste for vermicompost preparation
Step 4	→	Loosen the soil to allow the worms to enter it, as well as all the dissolvable nutrients (while watering)

Step 5	→	Collect the earthworms after vermicompost collection
Step 6	→	Sieve the partially composted material to separate the fully composted material
Step 7	→	Put the partially composted material into a vermicompost bed
Step 8	→	Store the vermicompost in a proper place to maintain moisture and allow the beneficial microorganisms to grow

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

Figure 41. Sorting through a tray of Malaysian blue worm (*Perionyx excavatus*) earthworms, also known as Indian Blues



Figure 42. African nightcrawler (*Eudrilus eugeniae*) earthworms, note the distinctive blue sheen



9.4.2.5. Green manuring

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

Crops for green manuring should be multipurpose, fast-growing and of short duration with a high nutrition accumulation ability. For the crops to be readily decomposed in the soil after incorporation, they should be herbaceous in nature and have the ability to be successfully cultivated as green manure crops under shaded, low moisture, and widely adapted to various ecological conditions. More importantly, green manuring crops should not be an (alternate) host to any known insect pest. The suitable crops for green manuring in the project areas (CDZ) are cowpea, mungbean and *Sesbania aculeata* (FAO, 2019).¹⁹

¹⁹ FAO handbook on climate smart agriculture in Myanmar, Sustainable Cropland and Forest Management in Priority Agroecosystems of Myanmar 2019.

Process of green manuring

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

Figure 43. Green manure crops



Figure 44. Incorporation of green manure crops into the soil using tractor



Figure 45. Green manuring (*Crotalaria juncea*) for paddy cultivation, Myanmar



Figure 46. Incorporation of green manures into the soil



3.3.2.3. Soil additives and amendments

To improve soil biological, chemical and physical environment for increased rice production and produce quality, soil additives should be applied, especially in acidic, alkaline, clayey, loose, rocky, sandy, and waterlogged soils susceptible to erosion and sloppy soils. Addition of sand to heavy clayey

soils improves soil aeration, drainage and root growth, resulting in high yield and quality produce. In the case of soils with low pH (acidic), application of lime, and soils with high pH (alkaline), application of sulphur is recommended to neutralize soil pH. Application of organic manures such as compost application, green manuring, stubble mulching and peat mass addition also improves soil texture, aeration, water retention, and absorption of nutrients, especially locked up soil nutrients, and mitigate drought in arid and semi-arid areas. Important considerations while deciding about the use of soil additives are: a) how long the additive will last in the soil; b) existing soil texture; c) salinity status of the soil; d) plants sensitivity to salts; e) soil pH; and f) pH of the additives (Davis and Whiting, 2000). Additives should be applied on a site-specific basis after soil tests and in consultation with DoA.

What soil additives to apply to what type of soil problems?

Soil additives or soil conditioners are materials (organic and inorganic) applied to various types of soils to improve soil physiochemical conditions, i.e. reducing compaction, correction of soil pH, improving soil aeration, nutrient retention and mobility to the plant roots and moisture retention (Soil and soil amendment guide, 2020).²⁰

Apply organic composts	→	To enrich soil with nutrients, improve moisture retention and aeration
Apply organic composts	→	To improve soil bio- and physiochemical conditions for better plant growth and increased nutrient use efficiency
Apply lime	→	To raise soil pH and reduce soil acidity
Apply sulphur-based additives	→	To decrease soil pH and increase soil acidity
Apply gypsum	→	To improve aeration of compacted soil and drainage
Apply vermicompost	→	To improve aeration and moisture retention

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

In view of the climate change induced problems of drought and growing soil salinity, farmers are coping through application of traditional knowledge and skills to adapt to the climate changes. Soils of the target regions are fragile and sensitive to degradation due to low soil fertility, deficient organic matter, salinity, high intensity but brief rainfall, causing soil runoff. Because of these problems, soils in the upland areas are exposed to water erosion. Progressive farmers practice water harvesting through traditional means, changing growing seasons to evade extreme weather events, applying gypsum to improve soil status and growing of drought resistant varieties (Zin *et al.*, 2019). Gypsum is a good soil additive rich in calcium and sulphur, as they are essential elements for plant growth and yield, besides increasing water-holding capacity of soil resulting in reduced erosion and improved soil aeration (Susan V. Fisk, 2019).²¹ Gypsum should be applied to areas of green gram production based on soil tests and identification of conditions for the recommended dose. If soil tests are not available, application of 300 kg ha⁻¹ gypsum is recommended for application to green gram (Than *et al.*, 2017).²²

²⁰ Soil and soil amendment guide by Marc. M, 2020. <https://www.lowes.com/n/buying-guide/soil-and-soil-amendments-guide>

²¹ <https://www.soils.org/news/science-news/gypsum-agricultural-product/#:~:text=Improving percent20soil percent20structure percent20helps percent20farmers,percolation percent20through percent20the percent20soil percent20profile.>

²² Myanmar Soil fertility and fertilizers management: Conference proceedings. pp 57. <https://ifdc.org/wp-content/uploads/2018/03/Conference-Proceedings-3-22-2018.pdf>

Figure 47. Gypsum application to the crop rows makes Ca available to the crop and reduces injury of the crop due to salts accumulation in the root zone



Figure 48. A women farmer applying gypsum to groundnut crop in CDZ Myanmar



3.3.3. Crop rotation and intercropping

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

3.3.3.1. Crop rotations

Crop rotation is a common and beneficial farming practice that promotes soil health by switching the crops grown on a plot of land every season or every few seasons.

Farmers in CDZ decide for specific crop rotation because of certain considerations, such as:

- 1) Using the same crop by changing the long duration varieties to short duration to avoid the risks of crop losses and market varieties preference;
- 2) Switching to another crop, i.e. from groundnut to sesame or other crops under circumstances such as high market demand, yield, and government incentives for certain crops;
- 3) Scaling up of farm size due to high resources to buy more land, renting more acreage for cultivation, inheriting more land and scaling down of farm size due to labour shortage, diverting expenditure to other priorities, high debt and loss of farming income (Proximity, 2019);²³
- 4) Some samples of crop rotation in green gram growing areas of CDZ are as follows:
 - green gram-sesame; and
 - green gram-groundnut.

²³ *When it rains, it pours*. 2019. Challenges and Opportunities in Myanmar's Sesame Value Chain, Field Institute San Francisco, Tokyo, 2019 for Myanmar small holders by Proximity Design.
<https://proximitydesigns.org/wp-content/uploads/When-It-Rains-It-Pours-.pdf>

Crop Rotation and Intercropping: 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.

Principles of efficient crop rotation

Deep rooted crops should be followed by shallow rooted crops such as chickpea, green gram and sesame;

Crops requiring heavy irrigation and intensive labour should be followed by less labour and irrigation intensive crops;

Crops sensitive to soil borne pathogens, and parasite (Nematode) should be followed by Nematode tolerant crops;

Crops with perennial and invasive weeds should be followed by clean crops or those requiring clean cultivation in rows;

Non legume crops should be followed by legume crops; sesame should be followed by chickpea, green gram and groundnut for maintaining soil fertility;

Include short duration, fast growing fodders, and legume crop for green manuring, also as animal fodder;

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

3.3.3.2. Intercropping and mixed cropping

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

Types of intercropping

- Row intercropping, where one or more crops are simultaneously cultivated in rows with variation in number of rows based on demand and local preferences. The ratio of rows of the crops may vary from 1:1, 1:2 and 1:3, etc.
- Mixed intercropping, where one or more crops are simultaneously cultivated with no fixed row or geometrical layout arrangements.
- Strip cropping, where one or more crops are simultaneously cultivated in stripes wide enough to allow independent cultivation.
- Relay cropping, where one or more crops are cultivated during the life cycle of each of the crop. Normally, a second crop is planted when the first crop has attained the reproductive stage but before the first crop is ready for harvest.
- Some samples of intercropping with green gram in CDZ are as follows:
 - green gram and sesame (monsoon);
 - green gram and groundnut (monsoon); and
 - green gram and pigeon pea.

Benefits of intercropping

- Higher production with lower levels of external farm inputs, especially for small farmers where the growing cycle is short.

- Efficient use of farm resources as intercrops components are not in competition for the same niche (ecological nest) due to differences in morphological and growth characteristics but symbiotic in terms of legumes and non-legumes, shallow and deep rooted crops.
- Reduced pests, diseases and weeds, due to the crops species diversity in agriculture ecosystem because of which pathogen spreading is limited. Similarly, weeds also compete with main crops for water, light, nutrients, and space and sometimes cause allelopathic²⁴ effects on the main crop. Due to efficient utilization of farm spaces with useful and economic crops, weeds are controlled thanks to less availability of light, water, space, and nutrients being diverted to useful crops in intercropping.
- Stability and uniformity yield in case of small farmers having limited sources, income and stability yield. It is therefore important, that in case of failure of one crop, the second compensates for income and production, thus mitigating the risk of crop failure.
- Improved soil fertility and increase in nitrogen due to conservation of soil fertility in intercropping, as in crop rotation. *Rhizobium*²⁵ bacteria are able to have a symbiotic relationship with plants of the legume family and can thereby fix atmospheric nitrogen into available nitrogen for plants uptake; as a result, nitrogen (as an essential element for soil fertility and plant growth) is added to the soil.

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

Principles for successful intercropping

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

Source: Chandrasekaran *et al.*, 2010

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

²⁴ Allelopathy is a biological phenomenon by which an organism produces one or more biochemical that influence the germination, growth, survival, and reproduction of other organisms. ... Allelo-chemicals with negative allelopathic effects are an important part of plant defense against herbivory.

²⁵ *Rhizobium* are present in the soil in two different forms: if the host plant exists in the soil, they establish a symbiotic association with their host plant and fix the atmospheric nitrogen, and if not, they act as free-living saprophytic heterotrophs.

Figure 49. Geometrical layout of intercropping between green gram and pigeon pea in CDZ

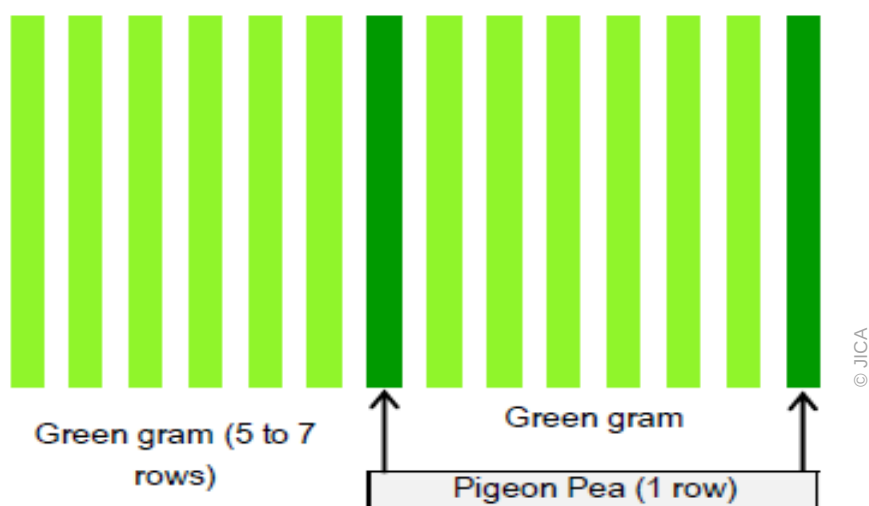


Figure 50. Relay cropping green gram into maize



According to DAR Myanmar, green gram crop is adversely affected if there is no rain for about 15 to 20 days, while pigeon pea is more drought resistant. Intercropping between green gram and pigeon pea is the most commonly practised and recommended intercropping in CDZ (JICA, 2013).²⁶

3.3.4. Irrigation and water management

Green gram production on irrigated lands is successful and being a short duration crop, the water requirements are not too high. The crop is also sensitive to water logging, therefore uniform irrigation to avoid water inundation in the field is important²⁷. The need for crop irrigation depends on many factors, such as weather, soil and field. Irrigation at critical growth stages, such as flowering and pod formation, is highly crucial for yield and quality of the crop. No irrigation is needed in case of rainy season, as additional water application to the field may create waterlogging conditions which adversely affect the green gram crop. (Mung bean production guidelines). It was reported by Uddin & Parvin

²⁶ Data collection survey on the project for development of water saving agricultural technology in the central dry zone in the republic of the union of Myanmar. <https://openjicareport.jica.go.jp/pdf/12127163.pdf>

²⁷ Mung bean production guidelines, Agriculture, Forestry and Fisheries Republic of South Africa.

(2013) that irrigation after emergence, flowering and pod setting resulted in highest green gram seed yield of (169.0 kg ha⁻¹).

Water logging adversely affects the nodulation ability of the crop, therefore frequent but light irrigation is more efficient than heavy and uneven irrigation. Irrigation at the pre-flowering stage (one to seven days before flowering or 30 to 40 days after planting), followed by irrigation at early pod development, is highly beneficial. The best method to prevent water inundation in the field is to plant the crop on raised ridges. Late irrigation at the grain fill stage can cause another flush of flowering, resulting in split maturity of the crop and seed quality deterioration.²⁸ The following are the critical growth stages for irrigation depending on the local conditions of soil, rainfall, soil physiochemical features, manuring and method of cultivation.

- seven to ten days after crop emergence;
- irrigation at the pre-flowering stage (one to seven days before flowering or 30 to 40 days after planting); and
- irrigation at pod development stages.

It is important to note that both irrigation and water quality are important for safe and quality green gram production, according to GAP standards. The water used for irrigation and other crop treatments should be tested for any pathogenic, chemical, and biological contamination. The water flowing down from livestock farms, hospitals, industries, wastewater and any sources that may cause environmental harm are not used for irrigation purposes. (If the treated sewage water is used, it needs to comply with WHO Guidelines). Where the risk of chemical and biological contamination of produce is significant, either a safe alternative water source is used, or the water is treated and monitored, and a record is kept of the treatment method and monitoring results.

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

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

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

²⁸ GRDC Grains Research and Development Corporation, October 2017, Grow notes on Mung bean

Figure 51. Green gram critical growth stages for irrigation



Source: Elaborated by the author

3.3.5. Harvesting and produce handling

3.3.5.1. Harvesting

Green gram crop should be harvested when 75 to 85 percent of pods are mature. Harvesting before and after the maturity causes yield reduction and impair green gram quality. Harvesting too early can result in the loss of green gram seed quality, while harvesting too late can result in shattering losses during the harvest operation (Myanmar GAP guidelines, 2018). Green gram pods can easily split or be damaged during harvesting, but the farmer can minimize this by harvesting at the correct seed moisture content (14 to 16 percent). Harvesting should be avoided during the middle of the day because of high shattering losses.²⁹ Manual or mechanical harvesting can be applied. According to the AVRDC³⁰ (1990), manual harvesting is usually practised, but the use of mechanical harvesters is also recommended in order to save on labour costs. Harvested produce should be placed on a clean floor, tarpaulin sheets, mats or concrete floors. Once harvested, the pods are placed outside for sun drying, for about two to three days (Myanmar GAP guidelines, 2018). In case of manual harvesting, threshing must be done as soon as the pods are dry. Pods must be beat with a stick until open, or put in a jute bag once dry, which will then be placed on the floor and walked on. Any foreign material must be removed by winnowing.

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

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

²⁹ Mung bean production guidelines agriculture, forestry & fisheries Department: Agriculture, Forestry and Fisheries Republic Of South Africa

³⁰ Mung bean seed production manual AVRDC- the World Vegetable Center. AVRDC.org

Figure 52. Green gram crop near to maturity with pods turning black in colour



Figure 53. Manual harvesting of mature pods from the green gram



CHAPTER 4 – POST-HARVEST MANAGEMENT

4.1. Drying and threshing

Threshing should be done as soon as the pods are dry. The dried stalk with pods should be beaten gently with a stick until pods are open. Seeds are then cleaned and dried up to 8 or 9 percent of seed moisture content and safely stored (Myanmar GAP guidelines, 2018)

Figure 54. Green gram threshing



Figure 55. Drying of green gram after threshing in the field yard



Preventing aflatoxins development in green gram: Proper drying of green gram is especially important to prevent the growth of fungi and contamination with aflatoxins. Infected grains should be separated from sound grains to avoid aflatoxin contamination.

4.2. Cleaning and sorting

After harvesting, the seed should be cleaned rapidly to remove green pods, leaf material, debris, etc., prior to storage, since these could create drying and storage problems. Small cracks in the seed coat that are not readily visible can occur with incorrect harvester settings or rough handling and can cause downgrading of a seed lot because of high over-soak levels. Grading of seed size, identification of seed colour and unfilled grains, removal of dusts, sands and small gravel should be done by machine or manually. Seeds are systematically graded and packed according to different specifications of different crops (Myanmar GAP guidelines, 2018).

While cleaning and sorting green gram seeds, defective kernels with bin-burn or heat damaged, broken, split, shrivelled and immature, insect damaged, mouldy, poor colour, sprouted, stained and weather damaged, must be removed for better food quality and food safety.

4.3. Packing and packaging

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

Figure 56. Hermetic (airtight) storage containers prevent aflatoxin-producing moulds in pulses



Figure 57. Green gram stored in gunny jute bags for better air circulation and prevention of condensation



Figure 58. Packaging and labelling of green gram in small marketable packing



Figure 59. Green gram sprouted for selling as preserved and canned



Figure 60. Grading and sorting of green gram and quality assessment



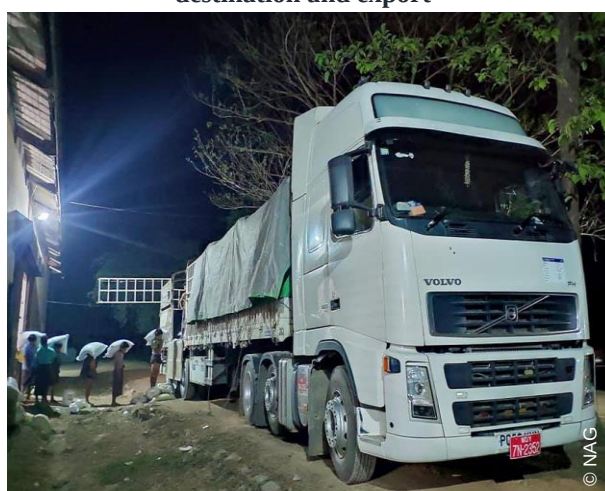
Figure 61. Packing, packaging and storage



Figure 62. GAP certificate issued for green gram by DoA



Figure 63. Loading of green gram from the local warehouse sold out to big dealers for further destination and export



4.4. Storage and transport

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

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

4.4.1. Storage

The storage facility should be clean and designed to promote good sanitation standards for food safety and to prevent product degradation and cross-contamination.

Other useful practices for safe storage are described below:

- Produce should not be stored in the containers previously used for chemicals and other dangerous substances and materials.
- For export purposes, the prevention measures for storage pests/diseases are practised during the storage period to meet the requirements of the different exporting countries.
- Transport vehicles should be checked before use for cleanliness, availability of proper tarpaulins to cover the cargo, foreign objects and other materials, chemical contamination and pest infestation, and must also be checked to ascertain dryness and the lack of moisture.
- Produce is stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.
- All facilities where green gram is stored in bulk need to have a detailed sanitation plan and designated persons be trained in maintaining the hygiene and safety of the premises and the produce stored therein.
- All good management practices must be documented, and workforce must understand to comply and adopt the guidelines.
- In order to ensure safe storage, the storage building should be rodent proof and in case there is risk of rodent infestation, take preventive/protective measures, such as closing all the holders at the roof of the door, etc., where pests can enter, and also repair cracks in walls where pests can hide.
- The infested residue, which can contaminate the newly introduced produce in the store, should be removed.
- In order to maximize the use of space, ensure hygienic conditions and facilitate effective management, bags should be put in stacks.
- Sanitation of the storage place is highly important and can be attained by not mixing the old grain with new grain. Old, infested materials should either be removed or thoroughly fumigated. The storage structure, including machinery, packing bags and baskets, should be disinfected with fumigants or exposed to sun heat. Hermetic storage is also an effective way of safe storage as the airtight conditions cause reduced oxygen supply and increased carbon dioxide, reducing the chances of insects' infestation and mould development. Some special plants acting as natural fumigants can also be used.
- The stores should be well ventilated to prevent water condensation or dampness. The filled bags should be disinfected through exposure to sun for one to two days to destroy any remnants of insect pests (eggs, larvae). Bags' stacking should not be more than ten bags per stage, keeping inter-stage space for air circulation.
- Pellets should be used for each stack and regular turning over of the stacks performed to avoid buildup of moisture and fungus in the underneath bags. Storage at locations with a temperature of more than 3 000 °C should be avoided. As organic practices, the leaves of Neem (*Azadirachta indica*) can be used in stores to avoid stored grain pests and insects.

It is crucially important, especially for green gram produced for export, that the pesticide maximum residue limits and standards (Codex standards) of countries of export are complied with.

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

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

CHAPTER 5 – OTHER GOOD AGRICULTURAL PRACTICES AND QUALITY ASSURANCE STANDARDS

5.1. Other good agricultural practices and quality assurance standards

5.1.1. Produce quality production plan

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

5.1.2. Buildings and structures

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

5.1.3. Animals and pest control

Farm animals and pets are excluded from the production site, particularly in areas where produce is harvested, packed, milled, and stored. Prevention and control measures are put in place to ensure insect pests are excluded from the production site, particularly in the areas where the produce is handled, packed and stored. The produce, packaging materials, other goods, traps, rodenticides and stimulating foods are stored in targeted places to minimize the risk of contamination (Myanmar GAP Guidelines, 2018).

5.1.4. Agrochemicals and other chemicals

Only registered products are purchased from licensed suppliers and used for crop production. Banned pesticides are not used. In the case of green gram production for export purposes, the banned pesticides by the importing countries are not used. IPM should be practised minimizing pesticide use. Use of physical and biological control measures is better than using pesticides, fungicides and herbicides to minimize the risks of contaminating the environment (Myanmar GAP Guidelines, 2018).

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

5.1.5. Agriculture and other related materials

Equipment, materials and storage containers that come in contact with produce are cleaned to avoid contamination. Waste, chemicals, dangerous substances and other hazardous materials are not used for storage or for holding produce (Myanmar GAP guidelines, 2018).

5.1.6. Traceability and recall

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

5.1.7. Documents and records

Documentation and record-keeping is 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. The documents should provide GAP practices implemented over the pre- and post-harvest stages, standards maintained for worker health, safety and welfare, workers training and review of GAP practices.

5.1.8. Training and awareness

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

5.1.9. Review of practices

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

5.1.10. Personal hygiene and worker welfare

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

5.1.11. Cleaning and sanitation plan

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

5.1.12. Conservation of biodiversity

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

**Refer to part II as ICM handbook
on integrated pest, disease and weed
management for pulses (Green gram
and chickpea)**

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Annexes

Annex 1. Myanmar good agricultural practices guidelines for green gram

S.No	GAP parameters	Recommended GAP practices
1.1	Site selection	The site and its surrounding areas must not be contaminated with any chemical and biological hazards. The layout map of the site and a record are kept of the actions taken. The optimum soil pH is at (6.5–7.5) for green gram and (6.5–7.0) for black gram. Plant growth may be poor if the soil pH is lower than 5.5. It should not be grown in saline soil. The soil should be in good condition for timely drainage and irrigation. The optimum rainfall is (20–50) inches/year for green gram and black gram. It can be grown at 6000 ft. above sea level. The optimum temperature is at (20–40) degree centigrade for green gram and (25–35) for black gram and getting sunlight is good for plant growth. The cowpea is well grown in any type of soil condition and the soil should be good condition for timely drainage and irrigation. 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. Deep ploughing and harrowing is good for plant growth.
1.2	Water	Water quality should be tested for health and systematically utilized. The water flowing down from livestock farms, hospitals, industries, wastewater and any sources that may cause environmental harm are not used for irrigation purposes.
1.3	Seed	Good quality and local adaptable varieties that are free from pests and disease should be selected and used for production. It must be free from seed-borne disease. The germination percentage should be over 85 percent and the seed law must be complied. 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 registered products are only purchased from licensed suppliers and used for crop production. The fertilizers and soil additives used are free from chemical and biological contaminations that may be harmful on and off the site. The (3–6) kg of Furadan insecticide is applied in the plant rows to prevent soil-born pests and stem borders. Seed treatment should not be done together with fungicides and Rhizobium. Fungicides should be applied in the plant rows before sowing time while the rhizobium is used as a seed treatment at sowing time. About 3–5 tons/acre of natural fertilizer and green manure are annually applied for improving the physical and chemical properties of the soil. The plant residues used for compost-making are free from pests and diseases. The application of fertilizers and soil additives is recorded. Areas or facilities for mixing and loading of fertilizers and soil

S.No	GAP parameters	Recommended GAP practices
		additives, storage and for composting of organic matter that may be harmful on soil and water resources are avoided. A record is kept of the source of supply, amount of supply and the date of supply for the fertilizers and soil additives.
1.5	Agrochemicals and other chemicals	The integrated pest management should be practised minimizing the pesticide use. The registered plant extract and bio-pesticides are only purchased from licensed suppliers and used. It is careful to minimize the risks of contaminating the environment and harmfulness to the people's health according to the Pesticide/Fertilizer Laws and Regulations. The registered products are only purchased from licensed suppliers if necessary and used for crop production. pre-harvest intervals (PHI) are observed and followed exactly. Systematic chemical application method should be known and applied. The chemicals obtained, stored, used, application and disposals of chemicals are systematically handled and recorded. Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating produce.
1.6	Care and management	The following measures should be practised for producing good quality green gram, black gram and cowpea; - For row to row planting of green gram and black gram, (4 – 6) Pyi acre⁻¹ of seed rate (about 18–27 lb acre⁻¹) for monsoon season and (6–8) Pyi acre⁻¹ (about 27–36 lb acre⁻¹) for post-monsoon season while (8 – 12) Pyi acre⁻¹ of seed rate (about 36–54 lb acre⁻¹) for cowpea in the post-monsoon season. - For green gram and black gram, the spacing should be (18 × 4) inches for monsoon season with a plant population of at least 85 000 and (12 × 4) inches for post-monsoon season with a plant population of at least 130 000. - For cowpea, the spacing should be (18 × 6) inches in post-monsoon season with a plant population of about 58 000. - For green gram and black gram with a broadcasting method, (12–16) Pyi/acre of seed rate (about 54–72 lb acre⁻¹) for all seasons. The optimum sowing time for green gram is; May–June for early monsoon season, August for mid-monsoon, October–November for post-monsoon and February–March for pre-monsoon season. - For black gram and cowpea, the optimum sowing time is; October–November for post-monsoon season. - Rhizobium is applied as a seed treatment with a recommended dosage. - Seed depth should be within 1–1.5 inches with enough soil moisture content.

S.No	GAP parameters	Recommended GAP practices
		- The irrigation and drainage channels should be well prepared according to the weather conditions and water availability to prevent the flood. Hand weeding and inter-cultivating weeding are properly done before flowering time (one month after sowing). Double cropping of pulses after pulses is avoided. - For effective use of fertilizer, it is placed at the middle of plant rows at the time of enough soil moisture content by harrowing and then, covered with soil. - The split dose application of Potash and Urea fertilizer should be used to prevent unnecessary losses. - Natural fertilizers, 28 lbs of Urea, 56 lbs of T-Super and 28 lbs of Potash are applied as a basal and other 28 lbs of Potash is applied during vegetative growth stage with enough soil moisture content. - The 20 Pyi/acre of Gypsum including 5 percent of sulphur is applied at sowing time for good seed formation. The foliar spray is used if necessary. - The solution including four teaspoons of Urea, 1 tablespoon of borax and 1 gallon of water is put into a sprayer (four gallon capacity) and applied at the initial flowering and fruit initiation stage with a dose of two times spraying of 5–6 sprayers/acre/time. - Irrigation should be done at the initial flowering time and fruit initiation stage.
1.7	Agriculture and other related materials	Farm machineries, grading machines, processing complex and packaging materials are placed in cleaning areas. Building and structure used for packaging, handling and storage of produce are cleaned. Chemicals used for cleaning are identified and carefully selected not to contaminate the produce.
1.8	Harvesting and handling produce	The optimum harvesting time is when 75 percent – 85 percent of pods are mature. Avoid harvesting before or after the maturity stage. Harvested produce are placed in cleaning floor, tarpaulin sheets, mats or concrete floors. Once harvesting, the pods are placed outside for sun drying about 2–3 days. Seeds are cleaned and dried up to 8–9 percent of seed moisture content and safely stored. Grading of seed size, identification of seed colour and unfilled grains, removal of dusts, sands and small gravel is done by machine or manually. Seeds are systematically graded and packed according to different specification of different crops.
1.9	Storage and transport	Produce is not stored in the containers previous used for chemicals and other dangerous subsistence and materials. If there is no permanent silo, the super bags, hermetic bags and tin boxes are used for systematic storage. Seeds that are properly graded and packed are systematically stored. Recommended pesticides are used during the storage period according to the recommended dosage to prevent the storage pest. For export purpose, the prevention

S.No	GAP parameters	Recommended GAP practices
		measures for storage pests/disease are practised during the storage period to meet the requirements of the different exporting countries. Transport vehicles are checked before used for cleanliness, foreign objects and other materials, chemical contamination, pest infestation and are also checked to make sure to be dry without any moisture in the vehicles. Produce is stored and transported in areas separated from materials and goods that are a potential source of chemical, biological and physical contamination.
1.10	Building and structure	Building and structure are constructed separated places from farm animals, animal feed and compost making exist. The building is checked before used for cleanliness, foreign objects, chemical contamination, pest infestation and other materials. The bamboo/timber floors 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.
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 and amount of supply, and destination for each consignment of produce.
1.14	Training	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 by the Technical Advisory Team to ensure that they are done correctly, and organizing with SMS. 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 restrooms and cleaning facilities are placed for easy access. Sewage is carefully disposed of in a manner that minimizes the risk of contamination of workers. For

S.No	GAP parameters	Recommended GAP practices
		personal hygiene and workers 'welfare, teamwork activities and educational meetings are conducted.

Annex 2. Relevant ASEAN guidelines

Annex 2.1. Module for produce quality–good agricultural practices requirements

S.No	GAP requirement	Objectives	Required practice (s)
2.1.1	Quality production plan	To manage produce quality ³¹	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, eco-friendly, 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 fulfilment 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.

³¹ 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 being practiced to prevent or minimize the risk of the hazard affecting the quality.

S.No	GAP requirement	Objectives	Required practice (s)
2.1.5	Chemical (Agrochemicals)	To prevent quality losses of the produce by using safe, approved and integrated methods of agrochemical 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.

S.No	GAP requirement	Objectives	Required practice (s)
			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 minimize 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 minimize mechanical damage. 15. Measures are taken to prevent the presence of pests in and around handling, packing and storage areas. 16. Where required, produce is treated to minimize disease development and loss of quality. 17. Water used after harvest for handling, washing, and produce treatment is treated or changed regularly to minimize contamination from spoilage organism. 18. Produce is packed and stored in covered areas. 19. Produce is not placed in direct contact with soil or the floor of handling, packing or storage areas. 20. Produce is graded and packed according to customer or market requirements. 21. Protective materials are used where required to protect produce from rough surfaces of containers and excessive moisture loss. 22. Field heat is removed using appropriate cooling methods.

S.No	GAP requirement	Objectives	Required practice (s)
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 ³² 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.

³² 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.

S.No	GAP requirement	Objectives	Required practice (s)
2.1.11	Review of practices	To confirm and reinforce the implementation of practices and improvement as necessary	1. All practices are reviewed at least once each year to ensure that they are done correctly, and actions are taken to correct any deficiencies identified. 2. Record is kept of practices reviewed and corrective actions taken. 3. Actions are taken to resolve complaints related to produce quality, and a record is kept of the complaint and actions taken.

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



A2.2. Worker's training through demonstration



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



Annex 2.2. Module for food safety–good agricultural practices requirements

S.No	GAP requirement	Objectives	Required practice (s)
2.2.1	Site history and management	To document and manage sites of production for prevention/control of chemical, biological and physical contamination for improved food safety	1. The risk of contaminating produce with chemical and biological hazards from the previous use of the site or from adjoining sites is assessed for each crop grown and a record is kept of any significant risks identified. 2. Where a significant risk of chemical or biological contamination of produce has been identified, either the site is not used for 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 are 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 are 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

S.No	GAP requirement	Objectives	Required practice (s)
			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.

S.No	GAP requirement	Objectives	Required practice (s)
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 agrochemicals 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

S.No	GAP requirement	Objectives	Required practice (s)
			produce and is 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 reused and are kept secure until disposal. 17. Empty chemical containers are disposed of according to relevant country regulations and in a manner that minimizes the risk of contaminating produce. Official collection and disposal systems are used where available. 18. Obsolete chemicals that are unusable or no longer approved are clearly identified and kept secure until disposal. 19. Obsolete chemicals are disposed of through official collection systems or in legal off-site areas. 20. The application of chemicals is recorded for each crop, detailing the chemical used, reason for application, treatment location, date, rate and method of application, withholding period, and operator name. 21. A record of chemicals obtained is kept, detailing chemical name, supplier of chemical, date and quantity obtained, and expiry or manufacture date. 22. Where applicable, a record of chemicals held in storage is kept, detailing the 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.

S.No	GAP requirement	Objectives	Required practice (s)
2.2.6	Harvesting and handling produce	To prevent or reduce the risk of physical, chemical, biological contamination during postharvest handling	1. Equipment, containers and materials that contact produce are made of materials that will not contaminate produce. 2. Containers used for storage of waste, chemicals, and other dangerous substances are clearly identified and are not used for holding produce. 3. Equipment and containers are regularly maintained to minimize contamination of produce. 4. Equipment, containers and materials are stored in areas separated from chemicals, fertilizers and soil additives and measures are taken to minimize contamination from pests. 5. Equipment, containers and materials are checked for soundness and cleanliness before use and cleaned, repaired or discarded as required. 6. Harvested produce is not placed in direct contact with soil or the floor of handling, packing or storage areas.
2.2.7	Buildings and structures	To prevent or reduce the risk of physical, chemical, biological contamination during handling and storage	1. Buildings and structures used for growing, handling and storage of produce are constructed and maintained to minimize the risk of contaminating produce. 2. Grease, oil, fuel and farm machinery are segregated from handling, packing and storage areas to prevent contamination of produce. 3. Sewage, waste disposal and drainage systems are constructed to minimize the risk of contaminating the production site and water supply. 4. Lights above areas where produce and packing containers and materials are exposed, are either shatterproof or protected with shatterproof 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	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.

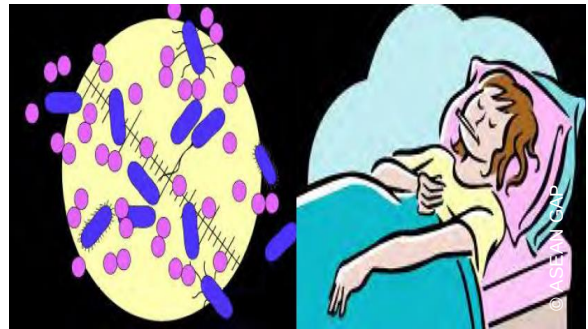
S.No	GAP requirement	Objectives	Required practice (s)
		cleaning and sanitation	2. Appropriate cleaning and sanitation chemicals are selected to minimize the risk of these chemicals causing contamination of produce.
2.2.9	Animals and pest control	To prevent or reduce the risk of biological contamination through animals such as rodents, insects and feral animals and birds	1. Domestic and farm animals are excluded from the production site, particularly for crops grown in or close to the ground, and from areas where produce is harvested, packed and stored 2. Measures are taken to prevent the presence of pests in and around handling, packing and storage areas. 3. Baits and traps used for pest control are located and maintained to minimize the risk of contaminating the produce and packing containers and materials. The location of baits and traps is recorded.
2.2.10	Personal hygiene	To prevent or reduce the risk of physical and biological contamination by following hygiene standards	1. Workers have appropriate knowledge or are trained in personal hygiene practices and a record of training is kept. 2. Written instructions on personal hygiene practices are provided to workers or displayed in prominent locations. 3. Toilets and hand washing facilities are readily available to workers and are maintained in a hygienic condition. 4. Sewage is disposed of in a manner that minimizes the risk of direct or indirect contamination of produce.
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 separately 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,	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

S.No	GAP requirement	Objectives	Required practice (s)
		tracing and recalling unsafe produce and removal from sale as well as to identify the cause of contamination and prevent re-occurrence.	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 complaints and actions taken.

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



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



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



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



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



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



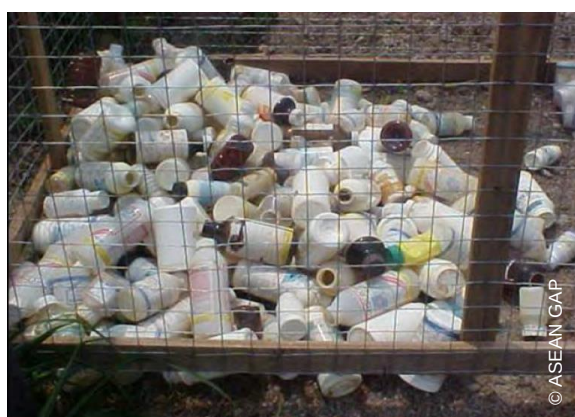
A2.10. For side-dressing produce grown close to the ground, use only fully composted materials or treated proprietary organic products, and do not apply them within two weeks of harvest



A2.11. The location of organic materials beside waterways used to irrigate or wash produce can lead to biological contamination of produce



A2.12. Empty chemical containers are not re-used and are kept secure until disposal



A2.13. Domestic and farm animals must be excluded from the production site, particularly for crops grown in or close to the ground, and from areas where produce is harvested, packed and stored



A2.14. Toilets and hand washing facilities must be readily available to workers and maintained in a hygienic condition



Annex 2.3. Module for environmental management ASEAN GAP

S.No	GAP requirement	Objectives	Required practice (s)
2.3.1	Sites history and management	To prevent or minimize the risk of hazards causing environmental harm while selecting site for production and postharvest handling	1. Sites used for production comply with country regulations that restrict production at high altitudes or on steep slopes. 2. For new sites, the risk of causing environmental harm on and off the site is assessed for the proposed use and a record is kept of all potential hazards identified. The risk assessment shall consider: - the prior use of the site, - potential impacts of crop production and postharvest handling on and off the site, and - potential impacts of adjacent sites on the new site. 3. Where a significant risk is identified, either the site is not used for crop production and postharvest handling, or measures are taken to prevent or minimize the potential hazards. 4. property layout map is available showing the location of: a. crop production sites; b. environmentally sensitive areas and highly degraded areas; c. chemical storage and mixing areas, chemical application equipment cleaning areas, and postharvest chemical treatment areas; d. areas or facilities for storage, mixing and composting of 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 minimize further degradation. 6. Management of site activities conforms to country environmental legislation covering air, water, noise, soil, biodiversity and other environmental issues.
2.3.2	Planting material	To minimize or prevent the risk of chemical contamination by selecting disease resistant and environmentally compatible	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.

S.No	GAP requirement	Objectives	Required practice (s)
		planting materials for reduced use of fertilizers and pesticides	
2.3.3	Soil and substrates	To minimize or prevent soil degradation through soil erosion, salinity, alkalinity, sodicity and acidity land through improved land, irrigation and crop management practices	1. The intended production practices are suitable to the soil type and do not increase the risk of environmental degradation. 2. Where available, soil maps are used to plan rotation and production programs 3. Cultivation practices that improve or maintain soil structure and minimize soil compaction and erosion are used. 4. The use of chemical fumigants to sterilize soils and substrates is justified and a record is kept of the location, date, product, application rate and method, and operator name.
2.3.4	Fertilizers and soil additives	To prevent or minimize environmental harm through chemical contamination using improved and sites/location specific fertilizers and soil additives management	1. Nutrient application is based on recommendations from a competent authority or on soil, leaf or sap testing to minimize nutrient runoff and leaching. 2. Areas or facilities for storage, mixing and loading of fertilisers and soil additives and for composting of organic matter are located, constructed and maintained to minimize the risk of environmental harm on and off the site. 3. Equipment used to apply 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 minimize wastage of water and the risk of environmental harm on and off the site. 3. The irrigation system is checked for operational efficiency during each use, according to manufacturer's instructions or other appropriate methods, and maintained to ensure efficient delivery.

S.No	GAP requirement	Objectives	Required practice (s)
			4. A record is kept of irrigation use, detailing crop, date, location, volume of water applied or duration of irrigation, and name of person who managed the irrigation activity. 5. Water collection, storage, and use is managed to comply with country regulatory requirements. 6. Water used from sources that may cause environmental harm to land and soil, waterways and sensitive areas is managed or treated to minimize the risk of environmental harm. 7. Water from toilets and drainage systems are disposed of in a manner that minimizes the risk of environmental harm on and off the site. 8. Water discharged from the property, including wastewater from harvesting, cleaning and handling operations, is managed or treated to minimize off site environmental harm.
2.3.6	Chemical (Agrochemicals)	To prevent or minimize loss /damages to the local ecosystem through safe and approved use of agrochemicals	1. Employers and workers have been trained to a level appropriate to their area of responsibility for chemical application. 2. If the choice of chemical products is made by advisers, proof of their technical competence is available. 3. Crop protection measures are appropriate for the control of pests and based on recommendations from a competent authority or monitoring of crop pests. 4. Integrated pest management systems are used where possible to minimize the use of chemicals. 5. Chemicals are only obtained from licensed suppliers. 6. Chemicals used are approved for the targeted crop by a competent authority in the country of application, and up to date documentation is available to demonstrate the current approval status. 7. Chemicals are applied according to label directions, or a permit issued by a competent authority. 8. A rotation strategy for chemical application and other crop protection measures are used to avoid pest resistance. 9. The application of chemicals (ground and aerial) is managed to minimize the risk of spray drift to neighbouring properties and environmentally sensitive areas.

S.No	GAP requirement	Objectives	Required practice (s)
			10. Appropriate volumes of chemicals are mixed to minimize the amount of surplus chemical remaining after application. 11. Surplus chemical mixes and tank washings are disposed of in a manner that minimizes the risk of environmental harm on and off the site. 12. Equipment used to apply chemicals is maintained in working condition and checked for effective operation at least annually by a technically competent person. 13. Chemicals are stored in a well-lit, sound and secure structure, with only authorized people allowed access. The structure is located and constructed to minimize the risk of contaminating the environment and equipped with emergency facilities in the event of a chemical spill. 14. Chemicals are stored in the original container with a legible label and according to label directions or instructions from a competent authority. If a chemical is transferred to another container, the new container is clearly marked with the brand name, rate of use and withholding period. 15. Empty chemical containers are not reused and are kept secure until disposal. 16. Empty chemical containers are disposed of according to relevant country regulations and in a manner that minimizes the risk of causing environmental harm on and off the site. Official collection and disposal systems are used where available. 17. Obsolete chemicals, which are unusable or no longer approved, are clearly identified and kept secure until disposal. 18. Obsolete chemicals are disposed of through official collection systems or in legal off-site areas. 19. The application of chemicals is recorded for each crop, detailing the chemical used, reason for application, application date, treatment location, application rate and method, weather conditions, and operator name. 20. Where applicable, a record of chemicals held in storage is kept, detailing chemical name, date

S.No	GAP requirement	Objectives	Required practice (s)
			and quantity obtained and date when completely used or disposed of. 21. Fuels, oils, and other non-agrochemicals are handled, stored and disposed of in a manner that minimizes the risk of contaminating the environment. 22. The application, storage, and disposal of chemicals used after harvest, such as pesticides and waxes, follow the same practices as described in the Chemicals section. 23. A waste management plan is documented and followed, including identifying types of waste products generated by property activities and using practices to minimize waste generation, reuse or recycle waste and store and dispose of waste.
2.3.7	Harvesting and handling produce	To prevent or minimize damage to the environment through safe and approved use of chemicals used for application such as pesticides, fungicides, insecticides, weedicides, fumigants and wax used for surface coating	All the procedures and safety protocols given in S.No. 6 for chemicals and agrochemicals are followed.
2.3.8	Waste and energy efficiency	To prevent or minimize environmental harm through safe, efficient and improved wastewater 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 are 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.

S.No	GAP requirement	Objectives	Required practice (s)
			6. The generation of offensive odour, smoke, dust, and noise is managed to minimize the impact on neighbouring properties.
2.3.9	Biodiversity	To preserve and protect local biodiversity through safe crop management practices	1. Local legislations and laws are followed for preservation and protection of local biodiversity for improved ecosystems
2.3.10	Air	To prevent or minimize environmental pollution through safe, efficient and approved management of the farm operations	1. Employers and workers have appropriate knowledge or are trained in their area of responsibility relevant to good agricultural practices and a record of training is kept. 2. Records of good agricultural practices are kept for a minimum period of at least two years or for a longer period if required by legislation or customers 3. Out of date documents are discarded and only current versions of documents relevant to good agricultural practice are used. 4. All practices are reviewed at least once each year to ensure that they are done correctly, and actions are taken to correct any deficiencies identified or if changes occur to environmental regulations. 5. A record is kept showing that all practices have been reviewed and any corrective actions taken are documented. 6. Actions are taken to resolve complaints related to environmental management, and a record is kept of the complaints 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 records as evidence for traceability and implementation of GAP	1. Documents and records 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

S.No	GAP requirement	Objectives	Required practice (s)
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 corrections taken are available 2. Record of the complaints and corresponding corrective actions taken are maintained.

A2.15. For new sites, the risk of causing environmental harm on and off the site is assessed for the proposed use



A2.16. Highly degrade areas must be managed to minimize further degradation



A2.17. To minimize the risk of soil erosion, use natural contour lines and organic mulches



A2.18. The use of chemical fumigants to sterilize soils and substrates is justified



A2.19. Storage, mixing and loading areas for fertilizers and soil additives should be positioned to minimize the risk of pollution of waterways and groundwater



A2.20. Chemicals are applied according to the label directions, or a permit issued by a competent authority



A2.21. Waste management and documentation is an important aspect for environmental safety



Annex 2.4. Module worker health, safety and welfare module–ASEAN good agricultural practices

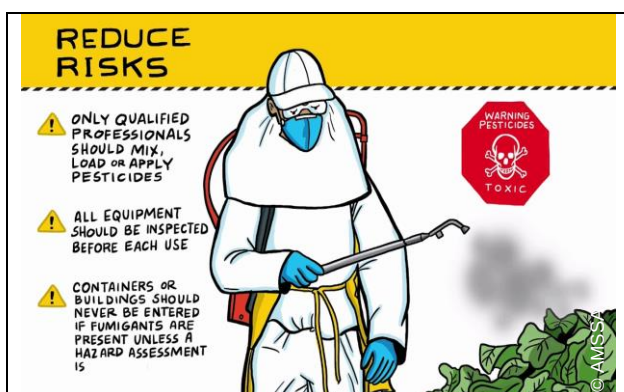
S.No	GAP requirement	Objectives	Required practice (s)
2.4.1	Chemicals	To ensure workers health, safety and welfare through prevention or minimization of exposures to the hazardous effects of chemicals.	1. Chemicals are handled and applied by authorized workers with appropriate knowledge and skills. 2. Chemicals are stored in a well-lit, sound and secure structure, with only authorized people allowed access. The structure is located and constructed to minimize the risk of contaminating workers and is 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

S.No	GAP requirement	Objectives	Required practice (s)
			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 minimize the risk of injury from lifting heavy

S.No	GAP requirement	Objectives	Required practice (s)
			objects and excessive twisting and reaching movements.
2.4.3	Personal hygiene	To prevent or minimize biological, physical and chemical contamination through implementation of personal hygiene practices by farm family and workers and provision of personal hygiene facilities at the farm	1. Workers have appropriate knowledge or are trained in personal hygiene practices and a record of training is kept. 2. Written instructions on personal hygiene practices are provided to workers or displayed in prominent locations. 3. Toilets and hand washing facilities are readily available to workers and are maintained in a hygienic condition. 4. Sewage is disposed of in a manner that minimizes the risk of contamination of workers. 5. Where employers are required to provide medical and health cover, any serious health issue is reported to the relevant health authority. 6. Where required, foreign workers complete mandatory medical checks, and a record is kept. 7. Measures are taken to minimize the presence of animals and pests with infectious disease in production sites and around handling, packing and storage areas.
2.4.4	Worker welfare	To ensure welfare and wellbeing of workers and productivity of the farm or packing shed through prevention of exploitation due to age, gender, race and any other reason	1. Where provided by an employer, living quarters are suitable for human habitation and contain basic services and facilities. 2. The minimum working age shall comply with country regulations. Where regulations are absent, workers shall be older than 15 years of age.
2.4.5	Trainings	New workers should be informed and trained about the risks to their health and safety and safety measures	1. New workers are informed about the risks associated with health and safety when starting at the worksite.

S.No	GAP requirement	Objectives	Required practice (s)
2.4.6	Documents and records	To ensure implementation of GAP for protection of workers health, safety and welfare.	1. Documents and records provide evidence that good agricultural practices have been implemented to protect worker health, safety and welfare. 2. Workers trainings record are available for safety and wellbeing. 3. Evidence of regular review of practices for workers welfare and safety is available for verification
2.4.7	Review of practices	To ensure workers safety and wellbeing through regular review of practices.	1. Review practices are documented and implemented for workers safety and welfare. 2. Records of compliance standards to workers safety and wellbeing are available for assessment and verification. 3. Record of Complaints related to worker health, safety and welfare investigated and actions taken to resolve the Complaints are maintained.

A2.22. Protection from the hazardous effects of chemical must be complied with



A2.23. Posters and signs in the work area help to reinforce instructions for workers



Annex 3. good agricultural practices check lists–green gram

FORM-1		
CHECK LISTS FOR FARMERS' FIELD		
Site Inspection		
S.No	Parameter	Required Compliance /Record Keeping/Documentation
1	Name of Crop	
2	Total Sown Area	
3	Area of GAP Registered Crops/Plant Population	
4	Land Preparation before Sowing Time	
5	Land Preparation after Sowing	
Surrounding Areas		
1	Surrounding Areas of GAP field	
2	Are there any other crops cultivated in surrounding areas of GAP field?	☐ Yes ☐ No
3	Distance between GAP field & Toilet	
Seed Selection		
1	Name of Crop Variety	
2	Any plant parts for plant propagation	
3	Seed/Plant Propagation Source	
Cultivation Method		
1	Row & Plant Spacing	
2	Status of Inter-cropping	☐ Yes ☐ No
3	Crop Duration	

Fertilizer Application						
S.No.	Parameter	Inspection Record				
		Fertilizer used	Fertilizer rate (kg acre ⁻¹)	Frequency	Mode of application	Application date
1	Fertilizer used before sowing					
2	Fertilizer used after sowing					
3	Farmyard Manure used					
4	Soil additives & other supplements used for GAP crop					

FORM-1

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

Irrigation & Source of Irrigation Water		
Sr.No.	Parameter	Inspection Record
1	Source of irrigation water	
2	Distance between irrigation source & GAP field	
3	Irrigation System	
Postharvest Practices		
1	Packaging & Cleaning	
2	Storage & Transportation	
3	Warehouse existences for harvested crops	
Personal Hygiene and Worker welfare		
1	Total number of workers	
2	Number of workers who received the trainings on “Systematic Pesticide Application Methods”	
3	Number of workers who received other trainings	
4	Compliance of Personal Hygiene	
5	Existences of housing for the workers	
6	Work done for personal hygiene and worker welfare	

FORM-2				
CHECK LISTS FOR FARMERS' FIELD				
C- Compliance		NC- Non Compliance		NA- Nail
1. Site Selection		C	NC	NA
1	The site and its surrounding areas used for production of GAP crops are not contaminating with any chemical and biological hazards.			
2	The layout map of the site and a record are kept of official document of land use permission (Form-7).			
2. Irrigation				
1	The results of 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. Agrochemicals 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			

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 and plant protection Training attended Review of practices Other records (field maps,.)					
12. Traceability and recall						
1	Packed containers are clearly marked with an identification and registration number to enable traceability of the produce to the farm or site where the produce is grown.					
13. Training						
1	Employers and workers are trained to have appropriate knowledge in their area of responsibilities relevant to good agricultural practices.					
14. Personal hygiene and worker welfare						
1	Written instructions on personal hygiene practices are displayed in prominent locations or are provided to workers.					
2	All actions taken are emphasized on personal hygiene of the workers from packaging sites & packaging, washing and produce treatment is clean.					
3	Toilets, water used for washing & cleaning for personal hygiene practices are easily provided to workers.					
4	All actions taken are emphasized on personal hygiene and worker welfare.					

Contact information

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