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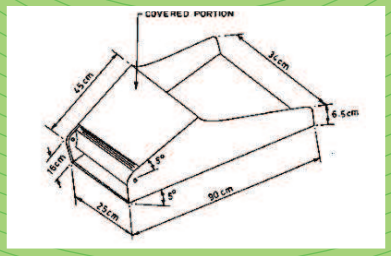
Good Agricultural Practices

through

Agricultural Engineering Interventions



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Good Agricultural Practices (GAP) through Agricultural Engineering Interventions

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FOREWORD

Agricultural engineering in coming decades is poised for fundamental changes in the scope of its agenda and would in all likelihood embrace biological, environmental, food and nutrition engineering for comprehensive and holistic solutions. Agricultural engineering would not only be involved in problem solving but would be playing important role in policy formulation and social engineering. Modern engineering interventions in agriculture that we aim at, are to provide right timing and right sizing of the mechanical inputs, to improve input use efficiencies, to reduce cost of cultivation, to provide better control over the pre and post-harvest operations, to reduce post-harvest losses, to add value to produce, to harness energy through clean sources, to prevent burden on environment, manpower and animal power, and to make agricultural operation safer, more comfortable and gender neutral.

To enable farm produce to be internationally competitive and innovative farming practices incorporating the concept of globally accepted Good Agricultural Practices (GAP) within the framework of commercial agricultural production for long term improvement and sustainability is essential. GAP in addition to improving the yield and quality of the products, also has environmental and social dimensions. Implementation of GAP would promote optimum utilization of agricultural inputs such as pesticides, fertilizers, and water and eco-friendly agriculture. Its social dimension would protect the agricultural workers' health hazard from improper use of chemicals and pesticides. It is particularly opportune time to promote GAP when second generation of reforms in agriculture which would have a critical impact on Indian agriculture, are planned by the Indian Government.

The good agricultural practices through agricultural engineering interventions takes into account the integrated pre-harvest practices like tillage, sowing, soil and water management, nutrient and pest management, harvesting and post-harvest handling. The transfer of GAP through agricultural engineering interventions to the farmers' field is the only option to achieve the goal of sustainable use of natural and man-made resources. This will also help in enhancing sustainable agricultural productivity on long-term basis. The GAP includes almost every aspect of the pre and post-harvest operations for efficient use of resources. The better understanding of these practices will led to quality outcome from field operations in terms of high productivity and better resource-use efficiency. Under present scenario of numerous resource and production vulnerabilities besides climate change, the GAP through agricultural engineering interventions will help to meet these challenges and has great potential in raising the farmersincomes and employment generation, minimizing the risks in farming and enhancing the resource use efficiency, thus, leading to sustainable agriculture.

March 2020

Director
ICAR-CIAE Bhopal

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March 2020

Editors

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Good Agricultural Practices

Good Agricultural Practices (GAP) can be described as a set of codes, standards and regulations governing the agricultural practices at farm level for a range of commodities aiming to address energy efficient, environmental, economic and social sustainability for on-farm processes, that ultimately result in safe and quality food and non-food agricultural products. There are FOUR basic constituents of GAP i.e. economic viability, environmental sustainability, social acceptability and food safety and quality. However, the scope which they actually cover varies widely.

Objectives of GAP

i. To ensure safety and quality in energy efficient agricultural operations and food produce chain of ecosystem.
ii. To explore new market advantages by modifying supply chain governance.
iii. To improve natural resources use, workers health and working conditions, creating new market opportunities for farmers and exporters in developing countries.

Key Elements of GAP

i. Prevention of problems before they occur.
ii. Risk assessments.
iii. Commitment operational and food safety at all levels.
iv. Communication throughout the production chain, data sharing and record keeping.
v. Mandatory employee education program at the operational level.
vi. Field and equipment sanitation.
vii. Integrated pest management.
viii. Oversight and enforcement.
ix. Verification through independent, third-party audits.

Potential benefits of GAP

It helps to ensure the safety and quality in agricultural operations and food and other agricultural products if adopted and monitored meticulously. It also upholds sustainable agricultural practices and contributes to meeting national and

international environment and social development objectives. It guides for compliance with national and international regulations, standards and guidelines such as Codex Alimentarius Commission, World Organisation for Animal Health (OIE) and the International Plant Protection Convention (IPPC) regarding permitted plant protection chemicals, maximum permissible levels of contaminants like pesticides, veterinary drugs, radionuclide and mycotoxins in food and non-food agricultural products, as well as other chemical, microbiological and physical contamination hazards.

Challenges related to GAP

- GAP implementation, particularly record keeping and certification, may increase production costs due to lack of harmonization between existing GAP-related schemes and availability of affordable certification systems.
- The small scale farmers may not be able to seize export market opportunities unless they are adequately informed, technically prepared and organised to meet this new challenge.
- Compliance with GAP standards does not always foster all the environmental and social benefits as claimed.
- Creating awareness among the stakeholders to achieve yield and production efficiencies coupled with environmental and health benefits and safety of workers.
- Protocols of GAP can be used to serve the interests of specific stakeholders in agri-food supply chains.

Good agricultural practices through agricultural engineering interventions

Agricultural engineering applications can play a significant role in confirming good agricultural practices for production process of agricultural commodities. The possible line of actions identified / adopted / developed for ensuring Good Agricultural Practices in agricultural production/ processing systems have been finalized by experts of the major disciplines of agricultural engineering. The suggestive measures need to be ratified for full compliance to form standard guidelines for good agricultural practices of India (INDGAP) with pro. Good Agricultural Practices have been listed below as per different engineering interventions:

1. Farm mechanization

a) Proper tillage practices to maintain a perfect balance between desired tilth and minimum soil disturbance to facilitate favourable environment for seedling and germination.

b) Proper application of soil sanitization technique to prevent soil borne diseases of plants.

c) Suitable mapping of soil fertility status and fertility gradient.

d) Appropriate seed treatment technologies for ensuring uniformity and effectiveness.

e) Planting at proper depth and distance to achieve uniform plant germination and growth.

f) Site-specific application technology for fertilizers and herbicides for improving their input use efficiencies.

g) Application technology for organic manures and bio-pesticides.

h) Calibrations of the high capacity machinery used in fertilizer and pesticide application must be calibrated at prescribed schedules and calibration certificates / records should be maintained in line with the schedule from an accredited calibration agency.

i) Mapping / detection of various abiotic stresses to the plants.

j) Integrated weed management techniques and optimization of intercultural practices.

k) Preventive measures, risk assessment and residue analysis for plant protection measures.

l) Determination of appropriate maturity stage for harvesting based on qualitative parameters set for the end product rather than the total vegetative yield.

m) Prevention of contamination with soil particles, concurrent and incidental adulteration with weeds and cross contamination with other species and extraneous matters during harvesting and threshing. Additional care should be taken for cleaning those machine parts that get into direct contact with the harvested produce. Different agricultural operation wise GAP are mentioned below.

1.1 GAP in tillage

Tillage has been used to prepare the soil prior to sowing of seeds. It involves mechanical manipulation of entire topsoil structure. It has the primary aim of

destroying weeds and pests but is also important for incorporating, redistributing or releasing nutrients and making the soil texture suitable for seed sowing, seed germination aeration and for easy penetration of seedling roots. In the absence of tillage, structural stability of soil aggregates improves after several years, for example, subterranean clover pasture. Apart from many advantage tillage operation also causes some undesired effects like causing increased water erosion particularly on sloping cropland. Erosion by wind is also increased by tillage because the topsoil is left bare and loose, reducing soil organic matter through oxidation and deleterious effects on soil micro flora and fauna and also leading to reduced soil structural stability and increased surface runoff and water or wind erosion.

Do's and don'ts in tillage

- Implements should be maintained in good working condition.
- Equipment/tractors used for cultivation should be cleaned prior to entering fields.
- Soil must be properly tilled and weathered before planting.
- Tillage operations should only be done on friable moisture range of different soils.
- Avoid over-tillage.
- Prepare land using techniques to improve/maintain soil structure and to avoid compaction.
- Tillage operations should be performed at a time that will minimize the soil's susceptibility to generate.
- Use combination tillage equipment for multiple operations at a time.
- Avoid mechanical land preparation on slopes above 20 degrees.
- Use equipment appropriate to soil type and moisture content.
- Mechanical land preparation should be done on land where it will improve/maintain soil structure
- Soil should be brought to the desired tilth to facilitate favourable environment for growing seed and seedling as per the crop requirement,

viz. more tillage for root, rhizome and tuber crop and less tillage for legume, cereal and pulse crop.

- Levelling the field will give better water coverage, better crop establishment, and better weed control.
- Soil puddling should be done at least 1–2 days before seeding to allow the water to clear when direct seeding.
- Repair bunds, destroy rat burrows, repair any holes and cracks, and re-compact the bunds.
- If required, plough immediately after the previous harvest — especially if the soil is having residual moisture.
- First or primary ploughing: Use a disc or mouldboard plough to kill weeds and incorporate crop residue, preferably 6–8 weeks before planting with maximum depth of 10 cm.
- Plow across the field with the disc or tine harrow at least twice to make small clod sizes. Second ploughing should be 2–3 weeks before planting and the last harrowing 1 week before planting with maximum depth of 5–7.5 cm.
- If condition permits follow conservation tillage system, viz: minimum tillage system, mulch tillage system and reduced tillage system.
- During tractor operated tillage operation, never walk in the side of the implement.
- For attaining higher depth of operation, never sit or stand on the implement. Rather put dead weight on the implement if required.

1.2 GAP on seeding and planting

The basic objective of sowing operation is to put the seed and fertilizer in rows at desired spacing and depth, cover the seeds with soil and provide proper compaction. To achieve optimum yield, the recommended inter and intra row spacing, seed rate are a few important parameters. However it may vary from crop, variety, soil type, agro-climatic conditions and regions. In India, traditional methods of sowing include broadcasting manually, opening furrows by a country plough and dropping seeds by hand and dropping seeds in the

furrow through a bamboo/metal funnel attached to a country plough (Pora). For sowing in small areas dibbling *i.e.,* making holes or slits by a stick or tool and dropping seeds by hand, is practiced. Multi-row traditional seeding devices with manual metering of seeds are quite popular with experienced farmers. Traditional sowing methods involves limitations of uniformity in distribution and uneven inter and intra-row distribution of seeds resulting in bunching and gaps in the field. For excess plant population, additional thinning operation is required. Poor plant stands have been observed in case of crops sown under dry farming conditions. Poor emergence, weed infestation may damage the crop as weeding is very difficult in broadcasted fields. Therefore, the seed drills and planters have been developed. The functions of a well-designed seed drill or planter are to meter seeds of different sizes and shapes, place the seed in the acceptable pattern of distribution in the field, place the seed accurately and uniformly at the desired depth in the soil and cover the seed and compact the soil around it to enhance germination. Selection and use of seed drills and planters with proper power source is also important to use the machines judiciously.

1.2.1 Appropriate seedbeds for seeding and planting

Depending upon climatic and soil conditions, seeds are sown on ridges, in furrows or on beds in well-prepared and levelled fields. Flat seeding and planting refer to operation when the field being sown/planted is levelled and smooth.

1.2.2 Seed treatment

Seed treatment is an integral part of crop protection and defined by this guidelines as the application of chemical ingredients and/or biological organisms to seeds intended for agricultural use to control, suppress or repel plant pathogens, insects, nematodes or other pests that can damage seeds, seedlings or the developing plants as well as improve soil health and utilization of crop inputs. Seed treatment is a term that describes both products and processes. Seed treatment can be done in one of the following types:

Seed dressing: This is the most common method of seed treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation. Dressings can be applied at both farm and industries.

Seed coating: A special binder is used with a formulation to enhance adherence to the seed. Coating requires advanced treatment technology by the industry.

Seed pelleting: The most sophisticated Seed Treatment Technology, resulting in changing physical shape of a seed to enhance palatability and handling. Pelleting requires specialized application machinery and techniques and is the most expensive application.

Following are the advantages of seed treatments:

- Protects germinating seeds and seedlings against soil and seed borne pathogens/insects.
- Seed germination enhancement.
- Early and uniform establishment and growth.
- Enhances nodulation in legume crop.
- Better than soil and foliar application.
- Uniform crop stand, even in adverse conditions (less/high moisture).

1.2.3 Use of proper type of metering mechanism in seed drill/planters

The mechanism of a seed drill or fertilizer distributor which delivers seeds or fertilizers from the hopper at selected rates is called seed metering mechanism. Different types of metering mechanisms have been developed based on type of seed (seed or seedling), type of size seed (small, medium and large), intra row seed to seed spacing required (regular or irregular).

- The established population required and the expected levels of both germination and field emergence
- The range of agronomical acceptable row spacing
- The sensitivity of crop yield to the evenness of plant spacing along the row
- Seed size and variation in seed size, seed shape and seed fragility

While all seed meter types will find a role because of simplicity, cost, flexibility in drive mechanism, ease of adjustment or cleaning, *etc.*, it is anticipated that in the longer term 'fluted feed' and 'vacuum disc' types will predominate for use in drill and precision planting systems, respectively.

1.2.4 Precautions

- Operator must ensure the levelling of the seed-cum-fertilizer drill with respect to the ground.

- The seed drill should always be operated at optimum speed in order to ensure uniformity of seeds and fertilizer application rates.
- After entering in to the field, the operator must select suitable method of operation keeping view the topography of the field
- Before the operator starts the operation, metering mechanism lever should be locked properly at calibrated scale.
- Before starting the operation, the operator should check the slippage/skidding of ground wheel. He should ensure that it should not be more than that desired level which has already taken into the consideration at the time of calibration.
- Depth of sowing should be kept uniform throughout the operation by locking the positon control lever and depth control wheels.
- Operator should ensure the proper and smooth working of agitator.
- Adjustment of marker should be kept uniform throughout the operation. It should be checked and re-adjusted if required after every turn.
- Check that all working parts have been protected properly by providing the guards or cover.
- Grain and fertilizers tanks should he checked at regular interval so that they should not become empty during sowing.
- When the tractor is in operation, the operator should not allow any person to sit on the tractor or to stand on the drill.
- No adjustment, either on tractor or on drill, should be made during operation
- Operation should be done by the skilled operator only.

1.3 GAP in fertilizer application

Fertilizers are organic or inorganic materials that are added to the soil to replenish or supply one or more basic plant nutrients to support healthy and vigorous crop production. Organic fertilizers work over time to create a healthy growing environment, while inorganic fertilizers provide quick nutrition to the crop. Organic fertilizers contain plant or animal based materials that are either a by-product or end product of naturally occurring processes, such as manures, leaves and compost. Inorganic fertilizers can be naturally occurring compounds that are mined for fertilization purposes or they can be manufactured. Any excess of synthetic fertilizers not taken up by the plant crop root system could

find its way into the potable water sources that contaminate the water bodies. Fertilizer which is to be applied depends largely on the needs of plants and its availability in the soil. Following are the measures to enhance nutrients in the soil with a minimal impact to the environment:

- Analyse soil for the available nitrogen, phosphorus and potassium to decide how much fertilizer to apply.
- Plan crop rotation to avoid nutrient loss.
- Decide on the nitrogen and phosphate application of crop requirements to avoid chemical contamination on spillage, run off, or deliberate discharge.
- Determine the nutrient contribution from animal dung that is used for the crop and avoid heavy metal contamination from the use of sewage water.
- Seek professional advice on the quantity of fertilizers that needs to be applied.

1.3.1 Fertilizer hazards

- The use of human sewage and raw animal sewage as an organic fertilizer is not allowed because it contains pathogens that are highly harmful to humans.
- Organic materials must be fully composted at a stable temperature with no foul smell. Heavy metal analyses should be conducted before application.
- Fertilizers (including organic, inorganic) must not come in direct or indirect contact with fresh fruit and vegetable products. Do not use empty/used fertilizer bags for harvested vegetables.

1.3.2 Fertilizer application methods and equipment

Dry fertilizers are applied in connection with practically every kind of field operation performed in the production of crops worldwide. Application methods for dry fertilizers include:

- Broadcasting before and after ploughing using manually operated broadcaster
- Placing at the ploughing depth by a distributor on the plough that drops fertilizer in each furrow using seed-cum-fertilizer drill
- Placing deep with chisel-type cultivators.
- Broadcasting and drilling during the planting operation.
- Side dressing on growing row crops using manually operated broadcaster

- Drilling into established pastures and other sods with special equipment.
- Organic fertilizer are broadcast using tractor trailer attached spreader/ self-propelled spreader

1.4 GAP in weeding and interculture

Weeding is a practice of removing unwanted plant from the field by using hand, tool or implement. Weeding and hoeing helps to avoid the competition for space, nutrients, water and keep the crop healthy. However, weeding is considered as one of the important intercultural operations in agriculture crops.

Weeds have serious impacts on agricultural production. It is estimated that in general weeds cause 5% loss in agricultural production in most of developed countries, 10% loss in less developed countries and 25% loss in least developed countries. In India, yield losses due to weeds are more than those from pest and diseases. Yield losses due to weeds vary with the crops. Every crop is exposed to severe competition from weeds. Most of these weeds are self-sown and they provide competition caused by their faster rate of growth in the initial stages of crop growth. In some crops, the yields are reduced by more than 50% due to weed infestation. An estimate shows that weeds can deprive the crops 47% N, 42% P, 50% K, 39% Ca and 24% Mg of their nutrient uptake.

The use of herbicides has increased due to the lack of labour for weeding and other economic reasons. This use has increased on the medium and even small farm levels. If well-applied herbicides offer a good number of advantages to the farmer; however, it is important to emphasize the need to use other methods to reduce farmers' dependency on herbicides.

Mechanical weed control allows farmers to reduce or even eliminate herbicide use, and contribute to a better environment. It costs the same or less than chemicals while still providing a satisfactory weed control. Mechanical weeding is not widely used for cereal crops because many farmers believe it can reduce yields. In fact, mechanical weeding may do the opposite as it aerates the soil, therefore stimulating crop growth. During mechanical weeding, weeds are mostly destroyed when buried by moving soil.

Inter-cultivation method is very widely adopted in wider row sown crops such as maize, cotton, sugarcane and pigeon pea. Inter-cultivation is done with bullocks or with tractor by adjusting the distance between tines. In rice,

intercultivation is performed in standing water. This method is effective for controlling later flushes of weeds in large area. To make the method effective the weeds near the vicinity of crop plants are removed manually. However, the crops with lateral spread of roots suffer due to root injury. Even the spread of plant diseases may also takes place as in potato.

1.4.3 Weeders and their use for GAP in different crops

Sl No	Type of weeder	Application
1	Khurpi	Weeding in all the crops and vegetables seedlings and crops like onion, garlic, potato
2	Weeding hook	For weeding in nurseries and vegetable gardens, it breaks the soil crust and create aeration in the soil
3	Push and pull type khurpa	Weeding and intercultural operations in field crops
4	Cono weeder	Weeding in line sown paddy crop
5	Dry land peg weeder	Vegetable gardens, basins of orchard trees and Vineyard plantations
6	Wheel hand hoe	Weeding and intercultural operations in vegetables
7	Twin wheel hoe	Soybean, maize, groundnut, black gram, green gram
8	Self-propelled power weeder	Tapioca, cotton, sugarcane, maize, tomato and pulses having row spacing more than 45 cm
9	Sweep tyne cultivator	Soybean, black gram, sorghum, pigeon pea etc.
10	Multi row rotary weeder	Use in wide spaced crops i.e. cotton, sugarcane, maize
11	Torsion weeder	Use in narrow spaced crops i.e. garlic, onion and other horticultural crops
12	Spring type rotary weeder	Use in wide spaced crops i.e. maize, sorghum and pigeon pea
13	Finger weeder	Weeding at later stage in vegetable crops
14	Eco weeder	Use for weeding in vegetable crops

1.4.4 Do's and don'ts in weeding and interculture

- The field should be kept weed-free, especially in the initial stage of plant growth, as weeds compete with the crop and reduce the yield drastically.
- Initial flush of weeds must be controlled effectively so as to ensure a weed free environment to young plants.
- The weeding and hoeing cycles should be so arranged as to keep the field free from weeds.
- Use of herbicides should be avoided as far as possible. In case of their inevitable usage, available evidence of safety to the target crop should be considered adequately.
- Weeding tool/equipment/machinery should be maintained in good working condition.
- Use narrow wheeled tyre in tractor for mechanical weeding
- Mechanical weeding should be done at proper soil moisture condition.
- Mechanical weeding should be avoided when space between crop row is not cler.
- Proper cleaning of weeding tool must be done before or in between weeding operation.
- Selection of weeder should be such that it can't damage the crop as well as root zone.
- Weeder should be operated at proper working depth as per the crop and weed growth

1.5 GAP in plant protection

The amount of chemicals used and the spray efficiency depends on the method with which these pesticides are sprayed. Pesticides are mostly applied through sprayers like manually operated hydraulic sprayers and knapsack mist blower in row crops and air-assisted spray system in orchard crops to control the pest attack. Hence the demand for plant protection machinery in India is increasing every year.

1.5.1 Safety product for plant protection equipment (PPE) application

Farmers directly involved in the handling of pesticides are at a high risk of exposure to pesticides through contact with pesticide residues on treated crops, unsafe handling, storage and disposal practices, poor maintenance of spraying equipment and the lack of protective equipment or failure to use it properly.

Six key safety protective gadgets are

- Coveralls,
- Protective boots,
- Glasses/goggles,
- Gloves,
- Respirator and
- A hat should be used during operation to avoid harm to the operators.

1.5.2 Application methods

1.5.2.1 Biological control

There is considerable interest in use of biological agents as an alternative to chemical pesticides.

Bio-pesticides fall into three major classes:

- Microbial pesticides contain a microorganism, e.g., a bacterium, fungus or virus that attacks a specific pest
- Plant pesticides are substances that the plant produces from genetic material that has been added to the plant and
- Bio-chemical pesticides are naturally occurring substances such as pheromones or plant growth regulators to control pests.

1.5.2.2 Chemical methods

This encompasses the use of any synthetic or organic chemical pesticide. Row crop fields might be treated with a low volume over-the-row precision applicator that places most of the pesticide directly onto the plants. In contrast, orchard crop may require an air blast applicator using a relatively large volume of spray material in order to reach the interior of the tree canopy. Overspray will be deposited on the soil and might be carried by wind into surrounding areas. The residue level in the crop depends largely on the amount of pesticide that is applied directly to the crop.

Hence the proper methods of spray application should be selected for effective application based on crop.

1.5.4 Guidelines for safe use of a pesticide for good agricultural practices (GAP)

Before applying pesticide

- Use pesticides only when really needed.
- Seek advice on the proper method of control.
- Use only the recommended pesticide suitable for the problem.
- Use recommended dose of different pesticides for different pests and insects.
- Read the label and instructions before usage and follow it.
- Make sure the appropriate protective clothing is available and is used.
- Check application equipment for leaks, calibrate with water and ensure it is in proper working condition.
- Check that plenty of water is available with soap and towel and that a change of clean clothing is available.
- Check that pesticides on the farm are in the dry, locked store. Avoid inhaling pesticide mists or dusts, especially in confined spaces such as the pesticide store.

While mixing pesticides and during application

- Wear appropriate protective clothing. If it is contaminated, remove and replace with clean clothing.
- Never work alone when handling the most toxic pesticides.
- Never allow children or other unauthorised persons near the mixing.
- Recheck the instructions on the label.
- Never eat, drink or smoke when mixing or applying pesticides.
- Always have plenty of water available for washing.
- Always stand upwind when mixing.
- Make sure pesticides are mixed in the correct quantities.
- Avoid inhalation of chemical, dust or fumes.
- Start spraying near the downwind edge of the field and proceed upwind so that operators move into unsprayed areas.
- Never blow out clogged nozzles or hoses with your mouth.

- Provide proper supervision of those assisting with the pesticide application and have adequate rest periods.

After application

- Safely dispose of all empty containers.
- It is absolutely impossible to clean out a container totally and never leave pesticides in application equipment.
- Remove and clean protective clothing.
- Wash well and put on clean clothing.
- Keep a record of the use of pesticides
- Do not allow other people to enter the treated area for the required period if restrictions apply to the pesticide used.

1.5.6 Calibration of sprayer

Effective pesticide use requires uniform application of the recommended amount of pesticide. Under-application usually results in poor control, which may require retreatment. Over-application of pesticide seldom increases control and may result in crop damage and needless environmental risk. Calibrations of spray equipment prior to each application are highly required.

The amount of spraying formulation required for a unit area depends on the following factors:

- Spraying pressure
- Diameter of the nozzle opening
- Width of swath
- Travel speed during spraying

Methods of calibration of manually operated hydraulic energy sprayer

- Mark out an area of 2.5 m × 4 m on the ground.
- Fill the sprayer and the discharge line with water.
- Mark the level of liquid in the sprayer and start spraying the marked out area on the ground.
- On completion, fill the sprayer again up to the level marked initially on the sprayer and calculate the volume of water used

Rate of application (l/ha) = volume of water used (l)×1000

For calculating the rate of application for L V and U LV sprayer, the swath width is to be initially determined. In such case the application rate depends on the travel speed of the operator and the rate of discharge from the nozzle.

The discharge rate can be increased or decreased by changing the disc in the nozzle tip. The rate of discharge per hectare depends on the rate of discharge of sprayer, travel speed and the width of swath. The same can be calculated from the following formula

A= (600 x B) / (C x D)

Where,

A = rate of application (l/ha)

B = Discharge rate of nozzle (l/min)

C = travel speed (km/h)

D = width of swath (m)

1.6 GAP in harvesting

Exposure to powerful agricultural machinery occurs most often during the harvest season. Operators may be less familiar with seasonal equipment used only a few days each year and may not be accustomed to handling the situations that pose possible dangers or risk. For these reasons, it is important to be familiar with possible precautions of harvesting equipment and be able to anticipate and avoid potentially hazardous situations. Introduction of power wheat threshers has greatly reduced the time required for threshing as well as drudgery of work on human beings. However, these machines have lead the operators in accidents while unskilfully using the thresher. The threshers are generally of spike-tooth cylinder type, chaff-cutter type and hammer mill or beater type. The crop is fed manually into these machines through a feeding chute. It has been observed that human factors such as inattentiveness, un-skilfulness, overwork, and fatigue, wearing of loose clothes, hand-wears and consumption of intoxicants and liquor are mainly responsible for about 73% of accidents. The machine factors such as improper design of feeding systems, substandard material of cutter bar and defective design contribute to about 13% of accidents. Crop factors such as feeding of ear-heads, short crop stalks and wet crop contributed about 10% of accidents whereas inadequate

visibility/light, crowded surroundings and slipping on the threshing yard contributed to about 4% of accidents.

1.6.1 Pre harvesting GAP

- Equipment should be made ready for harvest well in advance.
- Review operation manuals and follow maintenance guidelines.
- Cleaning, proper lubrication, replacement of worn parts (belts, chains, springs, hydraulic hoses, etc.), and replacing shields may save valuable time.
- Secure all guards and shields before starting the equipment. These protective devices reduce the chance that people will get caught in moving parts.
- Examine fields for changes since last fall: debris, limbs or foreign objects, and driving hazards, such as holes and ditch formation or undercutting.
- Remove stumps, stones, or other debris from the field, or clearly mark them to prevent upsets, turnovers, and damage to equipment. Also mark ditches and banks.
- Plan harvesting so equipment travels downhill on steep slopes to avoid overturns. Space tractor wheels as far apart as possible when operating on slopes.
- Make sure the hydraulic hoses are clean and in good repair and hooked up correctly. Check the twine feeding and cutting mechanisms to see that they are working properly and that your twine is in good condition.
- Crop should be harvested when the ears/spikes turn yellow and becomes fairly dry. To avoid shattering, harvesting should be done before the crop is dead ripe. Harvesting and threshing can be done with combine or manually with in short time and produced can be kept safe for further disposal.

1.6.2 GAP for harvesting of fruits and vegetables

The harvesting staff must have clean hands, short nails, tied hair and no smoking nor drinking during the harvest

- At the fruit trees no fruits should be collected from the ground
- Carefully collect the products avoiding knocks
- The fruits and vegetables harvested should be placed in clean containers without touching the ground

- Do not use garbage and fertilizer containers to collect the fruit and vegetable harvests
- Harvested must be placed under shadow and away from animals and the storage of chemicals and fertilizers

1.6.3 Safety associated with harvest operations

Like corn pickers, combines have numerous areas where individuals can be injured if they fail to follow safe operating practices. These areas, which must remain open for the crop to enter the machine, must be avoided while the machine is operating.

Safety associated with combine harvesters

- Never attempt to dislodge stalks or grain sheaves with your feet or hands while the combine is running.
- Always shut down the combine and turn off the ignition before removing plugged or lodged material.
- Most combine adjustments should be made with the machine shut off to avoid injury to the operator.
- While there are certain adjustments that must be made while the machine is running, such as adjusting the variable speed cylinder or fan, these procedures are outlined in the owner's manual and shielding usually provides protection so adjustments can be made without risk to the operator.
- Don't rely on hydraulic cylinders to hold the header up. Use locks or solid blocks to stabilize the header while working beneath it.
- Properly preparing the combine for transport can reduce the risk of a combine/vehicle accident. This is done by:
- Emptying the grain tank to reduce weight and lower the center of gravity. Move the unloading auger to the transport position.
- When practical, remove the header to reduce width and transport it on a truck or other implement carrier.
- Make sure a slow-moving vehicle (SMV) sign, lights and reflectors are in good condition.
- Check that the combine is not wider than any bridges or culverts that must be crossed to reach the field.

1.6.4 Safety associated with forage harvesters

- Always disengage the PTO and shut off the tractor/harvester before working on equipment. Allow the machine to stop before hooking up wagons.
- Doors and shields should be tightly latched to deflect objects thrown by the cutter.
- Stay well clear of the discharge spout while the harvester is operating. To avoid being hit by objects from the spout, completely stop the machine before hooking up wagons.
- Components may continue to rotate for several minutes after the power is shut off. Do not open doors until all parts have stopped moving.
- Knives must be kept sharp and properly balanced for safe, effective operation. Follow maintenance procedures specified in the owner's manual.

1.7 GAP in threshing

The threshing accidents can be minimized provided the farmers adopt the good agricultural practices. The farmer should buy only those threshers, which are fitted with safe feeding chute/hopper as per B.I.S. standards (Fig. 1).

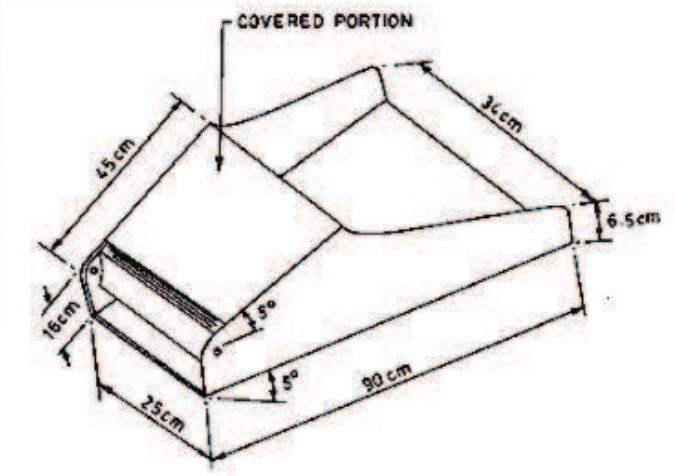

Fig 1 Safe feeding chute

For safety, the minimum length of feeding chute should be kept 900 mm, covered up to a minimum of 450 mm and inclined to the horizontal at an angle of 5-10°. The angle of covered portion with the base length of feeding chute should be kept

equal to 5°. Skilled and trained workers for feeding the crop to the thresher should be engaged. Avoid feeding ear-heads without stalks as it may lead to serious hand injuries. Similarly, feeding of wet crop should also be avoided which otherwise might lead to accidents. Some major precaution during threshing are mentioned below:

1.7.1 Precautions during threshing

- Avoid overfeeding of crop materials in the hopper.
- Avoid talking while working on the thresher.
- Do not work on thresher under the influence of alcohol or any other intoxicants.
- Do not work on thresher for more than 4 hours continuously, take small rest after every 4 hours of threshing.
- Do not stand on unstable platform during threshing.
- Do not wear loose clothes, wristwatch and bangles while working on the thresher.
- Ensure proper lighting in case the machine is to be operated at night, other poor visibility may lead to accidents.
- Keep the work place and surroundings of thresher free of all kinds of obstructions.
- Do not smoke or light a fire near the threshing yard.
- Do not cross over the flat belt or any moving component of the threshing machine.
- Keep a first aid box ready for use in the event of need.
- Keep a fire extinguisher within reach.

1.7.2 GAP for effective threshing

Peripheral speed of the cylinder: Increasing the cylinder speed reduces the cylinder loss but may substantially increase damage. Seeds of dicotyledonous plants, such as beans may be damaged excessively at peripheral speeds as low as 7.6 m/s. Use the manufacturers manual for setting the cylinder speed for different crops.

Cylinder concave clearance: Reducing the cylinder concave clearance tends to reduce the cylinder losses but it increases the seed damage. But the effects are generally small in comparison with the effects of increasing cylinder peed.

Moisture content of the crop: Seed damage increases as the seed moisture content is reduced. Several investigators found that germination of wheat was reduced when

threshed at seed moisture content above or below the optimum range of about 17 to 22%.

Rate of material feeding: Increasing the non-grain feed rate increases the cylinder losses. Increased feed rate tends to reduce seed damage, but the effect is very small.

1.7.4 Safety in threshing operation - GAPs

- Assure all guards and shields are in place when operating the machine
- Before cleaning, servicing, or repairing the machine, disconnect the power to the unit.
- Keep hands out of threshing belt entry area.
- Do not wear loose clothing when operating this machine. Clothing can be grabbed by chain drives or rotating shafts and severe injury can result.
- Keep hands and feet away from chain drives and v-belts when machine is running.
- Thresher injuries result in crush/amputations of upper limbs. Chute design has an important bearing on injuries. Increased chute heights and chute cover lengths as per BIS standard.
- Excess height of platform and wrong posture may cause injury.

1.7.5 Maintenance of a crop thresher - GAPs

- Lubricate cylinder and fan bearings with good-quality general purpose grease every 25 hours of operation. Periodically apply a small amount of oil to all hinge points.
- Inspect the machine regularly for loose, worn, or damaged peg teeth, concave bars, cylinder, discharge paddles and other parts, and tighten, repair, or replace them immediately. Missing bolts or nuts must also be replaced.
- Reduce belt tensions by loosening the idler pulley and engine mounting bolts when the machine will not be used for an extended period to minimize deterioration.

- Check engine crankcase oil level at least every 4 operating hours and follow the engine manufacturer's recommendations for oil change intervals and oil grade. Be sure the recommended oil level is maintained.
- Service the air cleaner, fuel filter, fuel line, carburetor, and spark plug regularly according to engine manufacturer's operation manual.

1.7.6 Storage of a threshing machine -GAPs

- Clean the machine thoroughly.
- Remove belts and store in a dry place.
- Store the machine in a clean, dry location and cover to reduce damage from dust accumulation.
- Paint parts that need repainting.
- Clean and apply oil to exposed metal surfaces to prevent rusting.
- Follow the manufacturer's recommendations on engine storage.

1.8 Safety associated with baling operation

1.8.1 Conventional baler

- The flywheel maintains the uniform momentum of a baler's working parts. It also keeps the machine operating for a considerable time after power is disengaged. Never attempt to work on a baler until the flywheel has completely stopped.
- The flywheel can be turned manually to permit slow motion observation of the knotter function.
- However, it should never be turned while someone else is working on the knives, knotter or other moving parts.
- When loading bales manually, be sure that the driver does not start and stop suddenly. This can throw workers off the wagon or truck. Make sure workers do not ride on top of the stack. They could fall off and be run over.
- Instruct workers to be aware of the stack condition and where fellow workers are throwing the bales. Bales falling off the stack can strike a worker and result in a serious injury. Lock or secure machines such as headers, bars, stackers, when working on them.

1.8.2 Square balers

- Always disengage the PTO and shut off the tractor before working on equipment.
- The flywheel supplies a uniform momentum for operating parts and will continue to turn even after the PTO is disengaged.
- Always allow time for it to stop turning before working on the baler.
- Knotter operation can usually be viewed by a hand turning the flywheel. Be watchful for co-workers when two or more are working on/adjusting equipment.
- Extra caution is needed when bale throwers are used because of potential energy in the unit.
- The newer large square baler's pose an even greater risk because of the larger tractors needed for operation and the weight of the bales produced.
- As always, caution is needed when loading bales by hand onto wagons. The experience of the stacker and the person driving the tractor or truck pulling the wagon are important elements for safely loading and hauling wagons from the field.

1.9 GAP with augers

- Augers can present several safety risks for farmers and workers, including entanglement in the auger shaft, electrocution from touching overhead power lines, and being crushed by the auger if it unexpectedly collapses.
- Collapse of the auger undercarriage during transport and while in use is another common cause of injuries.
- Workers should secure the auger to a vehicle rather than move it by hand to avoid an up end accident where the end of the auger becomes top heavy. Get out of the way if the end of the auger begins to upend and lift the base out of the worker's hands.
- There is little that can be done to stop the auger from upending once the base is lifted above the auger centre of gravity. Moving the auger with a tractor will prevent upending accidents and levelling the soil in the bin area will reduce side to side rocking.
- Once in position, both ends of the auger should be supported before operation. Crank the auger down far enough so the top of the auger rests on the grain bin and block the wheels in place.

- Cable or winch failures are another hazard with augers.
- Never attempt to stop a freewheeling crank handle with your hand or foot. Some augers are equipped with a clutch to prevent freewheeling and others can be raised and lowered with the tractor's hydraulic system. Proper maintenance and storage increases an augers life span and reduces accident risks.
- Frequently inspect and replace any cables or support legs that are worn or damaged.
- An auger can quickly tangle an operator's hand or foot unless precautions are taken to prevent entanglement. Keep all shields in place and warn workers about the dangers of entanglement. Never use your hand or foot to dislodge grain that is plugging an auger. Use a stick or rod to loosen a plug. Tools and other objects should be picked up and put away to prevent someone from tripping and falling into an auger.
- Harvest and Post-harvest sources of contamination are addressed under GAPs as follows Harvest Sanitation
- Workers are trained regarding quality and grade of harvested product.
- Harvest aids, field packing equipment and machinery are washed and sanitized daily.
- Workers practice proper hand washing.
- Gloves are used properly while harvesting.
- Proper procedures are followed when loading field bins. (Workers are not allowed in bins.)
- Harvesting, packing and shipping containers are new or clean and sanitized prior to each use.
- Containers used for packing produce are properly stored.
- Soil is removed from produce and bins in field. Bins are cleaned and sanitized prior to field use.
- Written SOPs exist for all aspects of field harvest sanitation, with documentation that SOPs are being implemented.
- Provide safety training before harvesting to create awareness for safety risks. Entanglement and caught and crush type of accidents are the most common types with harvesting equipment.

- During harvesting ensure that the operators should wear tight clothing and secure their hair to avoid entanglement. Agree clear entanglement and emergency procedures.
- Never clean, maintain, adjust or clear jams when the machine is on.
- Stay clear of discharges, outlets, and all moving parts of the machine.
- Make sure all guards like belt guards, pully guards etc. are in place.
- Always read the operators manual of your machine and make yourself familiar with the safety risks.
- If equipment breaks down make sure that it is properly repaired before it is used again. Improvisation is dangerous and might lead to failure of parts.

1.10 GAP associated with grain wagons

- Riding on grain wagons or any other tractor-pulled equipment places the rider at risk for an injury. Children are especially at risk for falling off a wagon as the wheel hits a bump or drops into a rut in the farm lane. Grain, as it is being unloaded from a gravity wagon, can quickly trap and suffocate a child or worker.
- As the grain flows out the chute it creates a funnel that can drag a person down toward the opening. The walls of the funnel may collapse and bury the person, resulting is suffocation if assistance is not immediately available.

1.11 Safety associated with transportation

- It is recommended that the extremities-the widest part of balers, mowers and forage choppers-have reflectors or reflective tape on them. This will assist the driving public in recognizing the width of the towed equipment.
- Always return the equipment to the roadway position before traveling on public roads. This position makes the equipment as narrow as possible, an advantage when pulling to the side to allow traffic to pass. Make sure a slow moving vehicle emblem is on the last piece of equipment being towed.

2. Post-harvest processing of agro-produces

a) Laying down of washing and cleaning methods for freshly harvested materials particularly fruits and vegetables and development of technologies with minimum human interference.

b) Removal of traces / residue of chemicals / contaminants / pollutants / toxins from the harvested materials.
c) Drying and handling of produces prior to storage in a manner so as to prevent degradation or rotting. Drying procedure and maintenance of temperature in conformity with the quality needs of the farm produce.
d) Processing area and sites to be kept clean, well ventilated, and protected against sunlight, dust, rain, rodents, insects and livestock.
e) Sorting procedure to be carried out after completion of drying phase and before the material is packed.
f) Use of appropriate packaging material (food-grade, biodegradable, eco-friendly, low carbon emitting etc.).
g) Appropriate norms for container filling to prevent damage or deterioration.
h) Maintaining cool and dry conditions in storage area and protection from insects, rodents and other detrimental factors to the quality of the products.
i) Separate storage areas for different varieties to avoid varietal mixing and caution exercised to prevent product mix up and cross contamination for multiple commodities in the same storage area.
j) Labelling of produces inscribing on every pack with the product name, month and year of harvest, name of farmer/farming agency and appropriate label indicating quality approval for material tested before.

Food safety has gained increasing importance over the years because of its significance both from health and trade perspectives. The production of safe food is essential for protecting consumers from the hazards of foodborne illnesses and is important both in the domestic food business as well as for increasing competitiveness in export markets. Hazards may occur at different stages of the food chain starting right from the primary production, e.g. residues above permitted levels, microbial contaminants and heavy metals. It therefore becomes important to address food safety right from food production at farm level. Implementing GAP during on-farm production and post-production processes resulting in safe agricultural products is of immense importance for ensuring a safe food supply.

As the concern about consumption of fresh produce has increased in worldwide, it was also noticed that there was significant increase in the number of

foodborne disease outbreak associated with fresh produce. There were few cases where documented evidence had shown that the foodborne illness could be traced back to poor agricultural practices. Media attention related to foodborne diseases associated with fresh produce caught attention and consequently many food experts have developed a strategy that would reduce the occurrence of microbial contamination. Consequently, the food retailers have enforced their growers to follow certain growing practices which could reduce, not eliminate, the microbial contamination of produce. These practices are known as GAP. The concept of GAP has evolved in recent years in the context of a rapidly changing and globalising food economy and as a result of the concerns and commitments of a wide range of stakeholders about food production and security, food safety and quality, and the environmental sustainability of agriculture. These stakeholders include governments, food processing and retailing industries, farmers and consumers, who seek to meet specific objectives of food security, food quality, production efficiency, livelihoods and environmental benefits in both the medium and long term.

According to the Food and Agriculture Organisation (FAO), GAP is the application of available knowledge to addressing environmental, economic and social sustainability for on-farm production and post-production processes resulting in safe and healthy food and non-food agricultural products. Many farmers in developed and developing countries already apply GAP through sustainable agricultural methods such as integrated pest management, integrated nutrient management and conservation agriculture. These methods are applied in a range of farming systems and scales of production units, including as a contribution to food security, facilitated by supportive government policies.

Presently, GAP is formally recognized in the international regulatory framework for reducing risks associated with the use of pesticides, taking into account public and occupational health, environmental and safety considerations. The use of GAP is also being promoted increasingly by the private sector through informal codes of practice and indicators developed by food processors and retailers in response to emerging consumer demand for sustainably produced and wholesome food. This trend may create incentives for the adoption of GAP by farmers by opening new market opportunities, provided they have the capacity to respond.

2.1 GAP for fruits and vegetables handling

- Fruit and vegetable should be pick in cool (early morning or evening) and keep it in cool during handling (avoid direct sun)
- Punctures and bruises provide an opening for foodborne illness pathogens. Harvest care and culling is crucial to safety and quality
- Proper trimming of foreign unwanted adherence before send in market, packaging and pot-processing
- Cutting and harvesting tool must be sanitized before operate it in actual operation
- All produce should be clean with recommended detergents and sanitizers when sent to market.
- Clean produce must be: Visually free of dust, dirt, soil, and other debris.
- All wash water must be potable: It should have tested for pathogens and nitrates free
- Use equipment for cleaning and grading having less manual intervention and exposure to atmosphere.
- Immediately removing field heat is the most important step you can take in extending shelf life.
- Maintain the proper temperature, humidity and ventilation during storage of commodity
- Maintain the cold chain for fresh fruits and vegetables during transportation and storage.

2.2 GAP for microbial and food safety

- The harvesting staff must have clean hands, short nails, tied hair and no smoking nor drinking during the harvest.
- Remove as much dirt and mud as practicable from fresh produce outside of packing facilities or packing areas. Take additional care to protect fresh field-packed produce from possible contamination because of possible exposure to manure and animal faecal material in the soil. Operators of open packing facilities should also be aware of potential contamination from airborne contaminants from any nearby livestock or poultry areas or manure storage or treatment facilities.

- Inspect containers for damage on a regular basis. Because damaged container surfaces may harbour pathogenic microorganisms and cause damage to the surface of fresh produce, they should not be used.
- Operators might set aside an area in the receiving yard to clean pallets and containers used for whole fresh fruits and vegetables. Containers used for ready-to-eat fresh produce should be cleaned and sanitized. Care must be taken when packing produce in the field not to contaminate containers or bins by exposure to soil and manure.
- Packing containers and other packing materials that are not used right away should be stored in a way that protects them from contamination by pests (such as rodents), dirt, and water condensing from overhead equipment and structures. If packing containers are stored outside the packing facility, they should be cleaned and sanitized before use.
- At the fruit trees no fruits should be collected from the ground while avoid the contact of ground after harvesting.
- There should be minimum disturbance to individual fruit by mechanical harvesting tools and hence avoid mechanical injuries and brushings.
- Carefully collect the products and avoiding knocks.
- The fruits and vegetables harvested should be placed in clean containers (washed and new) without touching the ground.
- Do not use chemical and fertilizer containers to collect the harvest.
- The fruits and vegetables harvested must be placed under shadow and away from prevailing wind, animals and the storage of chemicals and fertilizers.
- Postharvest water management is critical; use only potable water that has no detectable generic E. coli in 100 mL water sample.
- Wash water should be warmer than the product to avoid thermal shock that can lead to water absorption and bacteria entry.
- If ice or ice slurry is used for cooling, it must be made from water that is free of detectable generic E. coli/100 mL water.

2.3 GAP for transport after harvesting

- Inspect trucks or transport cartons for cleanliness, odours, obvious dirt or debris before beginning the loading process.
- Keep transportation vehicles clean to help reduce the risk of microbial contamination of fresh produce. Operators should be aware of prior loads

carried in a transport vehicle and take this information into consideration when determining use of a vehicle. Trucks that were recently used to transport animals or animal products, for example, would increase the risk of contaminating fresh produce if the trucks were not cleaned before loading produce. Consult local or state agencies or universities to determine the most appropriate cleaning and sanitization methods for individual operations.

- Maintain proper temperatures to help ensure both the quality and safety of fresh produce. Operators should work with transporters to ensure adequate control of transport temperatures from the loading dock to the receiving dock. Transporters should be aware of temperature requirements for produce being hauled and avoid delivery of mixed loads with incompatible refrigeration requirements.
- Load produce in trucks or transport cartons in a manner that will minimize damage. All fresh produce should be carefully loaded in trucks or transport cartons in a manner designed to minimize physical damage to the produce and to reduce the potential for contamination during transport. Produce should also be loaded so as to allow proper refrigerated air circulation.
- Transport food stuff in a clean transport vehicle, in good conditions and in compliance with transit regulations.
- Take care while loading food stuff especially for mechanical damages and injuries.
- Do not transport together with animals, fertilizers, or agrochemicals.
- In case of using an open transport medium, the load must be covered to avoid the sun, dust and rain.
- The staff participating in loading and unloading must keep hygiene and cleanness the same as the rest of the workers.
- Register the type and amount of product loaded, the date, name of the worker or family member that made it and the name of the person driving the transport.

2.4 GAP for harvest and on-farm processing and storage

- Quality of the processing products depends upon implementation of acceptable protocols for harvesting, storage, and where appropriate, processing of farm products.

- Harvesting must conform to regulations relating to pre-harvest intervals for agrochemicals and withholding periods for veterinary medicines.
- Food produce should be stored under appropriate conditions of temperature and humidity in space designed and reserved for that purpose.
- Operations involving animals, such as shearing and slaughter, must adhere to animal health and welfare standards.
- The commodity should harvest following relevant pre-harvest intervals and withholding periods; provide for clean and safe handling for on-farm processing of products.
- For washing, use recommended detergents and clean water;
- Store food products under hygienic and appropriate environmental conditions;
- Pack food produces for transport from the farm in clean and appropriate containers;
- Use methods of pre-slaughter handling and slaughter that are humane and appropriate for each species, with attention to supervision, training of staff and proper maintenance of equipment.

2.5 GAP for primary processing

2.5.1 Clean harvest aids

- Bins and all crop containers have to washed and rinsed under high pressure.
- All crop containers should be sanitized before harvest.
- Bins should be properly covered, when not in used to avoid contamination by birds and animals.

2.5.2 Monitor wash water quality

- Potable water should be preferably used in all washing operations.
- Clean water should be maintained in dump tank by sanitizing and changing water regularly.
- Use chlorinated water and other labelled disinfectants to wash fresh produce.

2.5.3 Grading packing and loading

- All packing areas must have sanitation practices that minimize contamination.
- Worker hygiene is essential; sick workers should be sent home.
- Only new, single-use containers or cleaned, reusable containers should be used to pack fruits and vegetables.
- Identify all of the food-contact surfaces as produce moves through the packing and storage areas, focus on keeping these surfaces clean.
- Clean all surfaces that come in contact with produce using a sanitizer on the surface.
- Safety practices such as cleaning, maintenance, and general housekeeping along with pest control are essential to reduce risks. Remove all trimmings and culled product and garbage every day or as needed throughout the day.
- Record keeping is critical and should include cleaning and sanitizing of contact surfaces, tools, equipment, and containers; pest management; building maintenance and monitoring; worker training on sanitation procedures; packing area and cold storage cleaning and monitoring; and vehicle cleaning and inspections prior to loading.

2.5.4 Sanitize packinghouse and packing operations

- Loading, staging, and all food contact surfaces should be cleaned and sanitized at the end of each day.
- Exclude all animals, especially rodents and birds from the packinghouse.
- Wash, rinse and sanitize the packing line belts, conveyors, and food contact surfaces at the end of each day to avoid build-up of harmful microorganisms.
- Packaging material should be stored in a clean area.

2.5.5 Pre-cooling and cold storage

- After harvesting, fruits and vegetables should be quickly cooled to minimize the growth of pathogens and maintain good quality.
- Water bath temperature for cooling should not be more than 10 ^{o}F cooler than the produce pulp temperature.
- Refrigeration room should not be overloaded beyond cooling capacity.

2.5.6 Worker hygiene

- Hands can contaminate fresh fruits and vegetables with harmful microbes.
- Packing area should be cleaned and sanitized.
- Supply liquid soap in dispensers, potable water, and single-use paper towels for hand washing.
- Workers should be properly educated about the importance of restroom use and proper hand washing.
- Encourage proper use of disposable gloves on packing lines. Sick employee should not be given food-contact jobs.

2.5.7 Worker hygiene and training

- Good personal hygiene is particularly important during the harvest of crops.
- Sick employees or those with contaminated hands can spread pathogens to produce.
- Employee awareness, meaningful training and accessible restroom facilities with hand wash stations encourage good hygiene.

2.6 GAP for millets

- Millet grains shall be free from abnormal flavours and living insects.
- Millet grains shall be free from filth (impurities of animal origin, including dead insects) in amounts that may represent a hazard to human health.
- The moisture content of the grain should be the maximum after harvest and storage 14.5%.
- Defects must not be more than 8.0% total defects
- The grains shall be free from the following in amounts that may represent a toxicity and hazard to human health: Crotolaria (*Crotolaria* spp.), Corn cockle (*Agrostemma githago* L.), Castor bean (*Ricinus communis* L.), Jimson weed (*Datura* spp.) and other seeds that are commonly recognised as harmful to human health.
- The grains shall be free from heavy metals in amounts that may represent a hazard to human health.
- The millet shall comply with the maximum pesticides residue limits established by the Codex Alimentarius Commission.
- The millet shall comply with the maximum mycotoxin limits established by the Codex Alimentarius Commission.

- It shall comply with the respective standards established by FSSAI for direct consumption and processing.
- To the extent possible, the product shall be free from objectionable matter. Shall be free from microorganisms in amounts that may represent a hazard to health. Shall be free from parasites in amounts that may represent a hazard to health. Shall not contain any substance originating from microorganisms in amounts that may represent a hazard to health.

3. GAP associated with energy utilization in agriculture

Good Agricultural Practices for efficient energy utilization in agriculture should be adopted with utmost priority for efficient utilization of available energy for safeguarding environment which has a direct impact on food quality and safety. In spite of having technical feasibility and economic viability appropriate renewable energy gadgets could be underutilized till now in the country due to quicker availability and easy access of conventional fuels like petrol, diesel and coal as primary commercial energy source. As a result plenty of environmental pollution is occurring in almost every part of the nation. The renewable energy sources like solar, wind and biomass needs to be encouraged especially for thermal and electrical applications. However, certain limitations exist with renewables and the prominent gaps may be described as follows.

- Use of solar energy during off sun shine hours is a prevailing considerable problem and needs to be addressed appropriately.
- Storage of solar energy utilizing batteries is currently being practiced for various on farm and off farm applications. However, utmost attention is required for judicious use of batteries and posing future problems of battery disposal in safer manner.
- Low wind speed during required periods especially during irrigation period has been a major limiting factor. On contrary very good wind speeds are available when requirement of irrigation is very nominal in agricultural sector. This factor limits the wide application of wind energy in agricultural operations. However, wind mills could be used appropriately for other agricultural operations like milling of grains, oil extraction, etc.
- Available surplus biomass has great potential for energy generation through bio-chemical and thermo-chemical routes but handling, collection and safe

storage of biomass poses very huge problem resulting to very low utilization of the available resources.

- Comparison of renewable energy costs with commercial energy also poses the major bottleneck in wide application of renewable. Generally, the physical costs of renwables is compared with prevailing costs of commercial energy sources neglecting environmental benefits and it hampers the popularization of renewable energy sources to the greater extent.
- There exits great potential of energy saving in presently utilized commercial fuels like petrol and diesel in agriculture. Operation of agricultural prime movers like tractors, power tillers waste a lot of valuable fuel due improper selection of operating gears. Similar is the case for diesel fuelled irrigation pumps employed in agricultural operations. Energy auditing of such operations may save valuable fuels considerably besides increasing the life of agricultural prime movers.

Considering the limitations of available renewable energy gadgets some of the feasible ways for better agricultural practices are presented below.

- Use of renewable / green energy sources in agricultural production process needs to be encouraged to reduce the use of commercial energy sources resulting to reduction in foreign import and to stopping further the environmental loading with pollutants.
- Appropriate handling, collection & storage of surplus biomass needs to be developed on priority for judicious utilization of agro biomass for energy generation.
- Bio-char produced utilizing surplus agro-residues may be produced in bulk and may be used as soil conditioner for restoring the soil health.
- Use of renewable energy resources in processing of agro-produces may be maximized considering their feasibility for certain operations or seasons.
- Proper handling and safe disposal of all non-biodegradable items/materials like single use plastics needs to be restricted to prevent their re-entry in soil-water-environment circles.
- Pilot scale bio-ethanol production plants utilizing surplus agro biomass needs to be developed, demonstrated and popularized for better use of available biomass.

- Energy auditing of each unit of production and post-production activities needs to be conducted to prevent losses and leakages.

3.1 Production agriculture

3.1.1 Use of solar energy in crop production and processing

It is well accepted fact that solar energy is the abundantly available source in most part of the country. It can be judiciously used for thermal as well as electrical applications. Some of the possible uses of solar energy are given below;

- Application of solar energy for operation of cold storage systems to preserve high value produces for certain days enable to take them to the nearby markets / mandis.
- Application of PV based solar energy for operating low horse power tractors/ power tillers
- Utilization of solar energy for spraying, intercultural and threshing operations
- Development of solar powered ergonomic designed hand tools for pruning and other horticultural operations.
- Solar powered hybrid drying system for processing of agricultural produces.
- Solar thermal energy storage systems including scope for utilization of solar energy in steam generation and sterilization applications
- Development, demonstration and popularization of solar powered agro-produce processing centres in rural areas.

3.1.2 Biogas from crop residues

Production of biogas from crop residues both in in-situ and ex-situ conditions could be practised to address the crop burning issues and resulting air pollution. Biomass accounts for catering the needs to the tune of about 75% of the rural energy needs. The major crops contributing the residue are paddy, wheat, cotton, mustard, sugarcane, soybean, pigeon pea, cereals, maize, sorghum, millet, coconut, etc. Although several biogas plants capable of utilizing surplus agro-residues have been developed for biogas production but

they necessitates for size reduction and pre-treatment. Hence, there is need to develop appropriate economical biogas plants capable of anaerobic digestion of surplus agro-residues with minimal pre-treatment for biogas production.

3.1.3. Bio-CNG and power generation from crop residue

This technology is environment friendly, commercially viable and socially acceptable. This process leads to production of minimal effluent and can generate employment in remote areas. Some of the important considerations need to be followed while adapting such plants.

- The plant should be designed following the standard methods and available local service provider for continuous & trouble free operation. Feasibility study of such plants should be carried out.
- Instead of higher capacity reactor, few small capacity reactors connected in series needs to be installed to combat the irregular supply of raw material.
- Suitable slurry (liquid and solid) handling methods and marketing strategies for promoting organic farming need to be promoted to improve the soil health resulting to increased fertility.
- The small scale biogas plants of 2-3 m^3 should also be considered to be installed the plants at farmers' field considering the crop residue production from 1 acre land. This means both centralized and de-centralized approach should be there to combat the paddy straw burning to save environment.
- Suitable farmers' cooperative group needs to be constituted so that the supply of raw material for CNG production could be ensured. The MoU could be made to distribute the digested mass to the group commensurate with the agro-residues supplied.

3.2 Energy auditing of production and post-production agriculture

Energy input is directly related to productivity. Rising energy price has adversely affected the use of different energy sources and net return of farmers has decreased compared to earlier times. The animal energy use has been reduced in agricultural operations due course as a result of high cost of animal raising. Mechanization has increased in view of maintaining timeliness of agricultural operations and due to labour scarcity during peak periods. Tractors, power tillers and combine harvesters have replaced the manual and animate power in agricultural systems to a greater extent. The total energy use in production agriculture has increased mainly in area shifting from traditional

animal farm to mix or tractor farms. However, a considerable amount of energy is lost in conducting agricultural operations due to inefficient utilization of available energy sources. Hence conduction of energy audit is necessitated for utilization of available energy sources in judicious manner. This is also essential to increase the energy efficiency and to reduce the energy intensity in various agro operations. Hence, energy in production and post-production management strategies need to be carried out frequently to remain competitive and sustainable. Energy audits can help farmers to save energy and money. They serve as a baseline upon which better comparisons and decisions can be made about which changes offer the quickest payback. Further, the output of energy audit will be helpful in assessing the future demand of energy for the country. Hence, conduction of energy audit is need of hour and it needs to conducted periodically to update the energy use pattern in agricultural operations.

4. Irrigation and drainage engineering

Good Agricultural Practices in irrigation and drainage operations is indispensable to assess and address practices on the farm that are important for food safety, including irrigation water quality. It can be addressed through the following approaches:-

- Decontamination of surface water both recycled and freshwater from pollutants, heavy metals, toxins, microbial contaminants, residue of agro-chemicals and bio-hazardous materials for using irrigation purposes.
- Preventing site specific moisture-stress in crops for maintaining the quality standards.
- Surface and sub-surface drainage technologies for sustaining crop and soil health with special reference to physical, chemical and biological activities in soil.
- Technologies for maintaining optimum water balance for ground water (drawn vs. recharged) at farm level.
- Promotion of use of alternate materials that can be endorsed for preventing deterioration of waterbodies.

4.1 On-farm water is important to food safety because

Irrigation water can act as a carrier for foodborne pathogens and has been identified as a contributing factor. Once pathogens contaminate the surface of produce, these microscopic organisms are difficult to remove.

4.2 Do's and don'ts for suitability of water for irrigation

- Identify all the water sources (well water, surface water, municipal water) as well as storage practices for water delivery systems on the farm.
- Run-off from agricultural lands, animal housing or composting areas into irrigation water sources should be considered.
- Based on the initial assessment and water quality testing results, alterations in irrigation and other farming practices may be modified. For example, if irrigation water quality consistently exceeds recommended water quality levels, it may be prudent to switch from overhead irrigation to drip or furrow irrigation systems to reduce the risk of pathogen contamination on edible product. Also, physical barriers such as berms or moving composting areas further from irrigation water sources and crops to reduce the risk of run-off may be appropriate.
- Irrigation water samples must be analysed at the beginning and middle of irrigation season as well as a few weeks prior to harvest if irrigation
- Samples should be collected as close to point of water delivery to the crops as possible in a sanitized container.
- Laboratory bacterial testing should include faecal coliforms or generic E. coli.
- Document all assessment activities identifying water sources and uses. Site maps can be useful to document upstream or neighbouring influences as well as topography issues.
- Reassessment should be performed on at least once in a year to address changes in non-point source pollution.
- Whereever, waste water is being used for irrigating crops especially in peri-urban areas, heavy metal contamination assessment is a must. Otherwise, heavy metals may be reflected in food-chain.

4.3 Pre-cursors of good agricultural practices of irrigation and drainage

- What is the source of irrigation water (Pond, Stream, Well, Municipal, Other)?
- How are the crops irrigated (Flood, Drip, Sprinkler, Other)?
- What is the quality of water used for irrigating the crops?
- Where and how to drain excess water from agricultural fields?

4.4 Points to be considered based on source of irrigation water

- When the irrigation water source is pond, stream or open sources, there are chances of entry of trash and algae through irrigation system, it is therefore recommended to adopted media filters incase of micro irrigation systems are used for irrigating the crops.
- When the irrigation water is contaminated with silt, it is recommended to adopt hydro-cyclone filters incase of micro irrigation systems are used for irrigating the crops.
- Municipal/Industrial waste water when used for irrigation wetland filtration system be adopted.

4.5 Points to be considered for different irrigation systems

- When flood irrigation systems are adopted for irrigation, the conveyance and application losses be minimized.
- When micro irrigation systems are adopted follow the operation and maintenance schedules as per the recommended practices.

4.6 Points to be considered for quality of irrigation water

- Irrigation water quality interms of EC should be less than 1 dS/m and pH of about 6.5 is good for crop growth.
- Suitability of water for irrigation can also be based on SAR, Na, EC, TDS and specificion toxicity.

4.7 Points to be considered for draining agricultural fields

- Topography and natural outlets are the most important considerations.
- Type of crop decides the depth of water to be removed from the root zone.
- Installation of surface drain or subsurface drainage systems is to be decided based on the soil physical and chemical properties.

- When the cost of drainage network is costly affair, Bio-drainage systems can be adopted.

4.8 Points to be followed at a glance for good agricultural practices in irrigation and drainage

- Analyse the water of the field at least once a year to see if it is contaminated.
- Use the required amount of water for savings and care of the crop.
- Incase of sediments are found in irrigation water, low cost gravel filters be adopted at appropriate locations.
- Do not perform applications and agro-chemical preparations near the water sources.
- Identify the water sources used for irrigation and with the assistance of the technician verify that they are not contaminated.
- Use always the irrigation method recommended for your crop.
- An incorrect use of water may damage the quality of the crop
- Maximize water infiltration and minimize unproductive efflux of surface waters from watersheds.
- Adopt techniques to monitor crop and soil water status and accurately schedule irrigation.
- Enhance the functioning of the water cycle by establishing permanent cover, or maintaining or restoring wetlands as needed.
- Manage water tables to prevent excessive extraction or accumulation.

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