RESADE

Quality Seed Production Manual for Food and Fodder Crops

Barley, Pearl Millet, Sorghum, Buffel Grass, Cowpea, and Quinoa

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MESSAGE FROM IFAD

Dr. Malu Ndavi
Lead Global Technical Specialist, IFAD

The collaboration between IFAD and ICBA dates back to 2004 when IFAD financed ICBA's major multi-country project titled "Saving freshwater resources with salt-tolerant forage production in marginal areas of the West Asia and North Africa region - an opportunity to raise the incomes of the rural poor".

Since then, IFAD has provided more than 8.5 million USD in funding for a number of projects and activities to improve the lives and livelihoods of smallholder farmers in marginal environments in different countries.

This manual is one of the knowledge outputs of the latest collaborative project titled "Improving Agricultural Resilience to Salinity through Development and Promotion of Pro-poor Technologies" (or RESADE).

RESADE is a four-year project funded by IFAD and the Arab Bank for Economic Development in Africa (BADEA) and is aimed at improving food security and incomes of smallholder farmers, particularly women, in salt-affected areas of seven sub-Saharan African countries.

As capacity development is an integral part of the project, this manual will serve as an important tool to share knowledge with smallholder farmers and other stakeholders.

The manual is a great reference as it explains in detail best practices in the cultivation of crops like barley, pearl millet, sorghum, buffel grass, cowpea, and quinoa. The quality of the publication shows ICBA's great capacity in developing knowledge products tailored to the needs of different stakeholders.

It is hard to overestimate the importance of this resource for extension and other specialists who support smallholder farmers.

Knowledge dissemination through this type of resources is a necessary step towards the introduction and adoption of new cropping systems resilient to salinity and climate change.

We are proud to be part of this crucial work conducted by ICBA and its local partners to enhance food security and livelihoods of smallholder farmers.

We are delighted to see the first results of RESADE and look forward to seeing more achievements as it progresses.

We hope that the manual is widely disseminated and has a broad readership.

Dr. Malu Ndavi
Lead Technical Specialist, IFAD

FOREWORD FROM THE DIRECTOR GENERAL

Dr. Ismahane A. Elouafi
Director General, ICBA

Soil and water salinity is a major constraint on agriculture and food production in marginal environments. It significantly reduces crop yields and incomes. This is especially true for smallholder farmers in low-income countries.

It is estimated that around 1.128 billion hectares of soils are affected globally by salinity and sodicity to varying degrees.

Unfortunately, salinization disproportionately affects small-scale farmers as they are heavily dependent on agriculture for food and income.

Therefore, it is important to equip them with skills, crops and technologies so that they can cope with salinization, as well as other threats to agriculture, and produce more food sustainably for themselves and their communities. This idea is behind our project "Improving Agricultural Resilience to Salinity through Development and Promotion of Pro-poor Technologies" (or RESADE).

Financed by the International Fund for Agricultural Development (IFAD) and the Arab Bank for Economic Development in Africa (BADEA), it is a four-year project targeting seven sub-Saharan African countries: Botswana, The Gambia, Liberia, Mozambique, Namibia, Sierra Leone, and Togo.

Its goal is to increase agricultural productivity and incomes of farming communities in salt-affected agricultural areas by introducing salt-tolerant crops and associated agronomic management practices; establishing value chains for new crops; and developing the capacities of farmers and extension workers in salinity resilience and climate-smart agriculture in collaboration with national agricultural research systems and extension services.

Through a value chain approach, not only will the project create value chains by identifying actors and activities necessary to take produce from the field to the market, but it will also ensure wider adoption of new crops by small-scale growers and their economic sustainability. This approach is critical to transforming food systems and making them more resilient and sustainable and thus safeguarding the livelihoods of rural communities that rely on them.

The project is focused mainly on smallholder farmers, and particularly women, and has a large component dedicated to capacity development.

As the project will introduce new crops, it is necessary to develop the knowledge and skills of smallholder farmers and other stakeholders in quality seed production and crop management.

And this manual has been prepared with this objective in mind.

The availability of quality seed of new crops is crucial for increasing adoption rates among smallholder farmers. And quality seed itself is key to higher yields. It is also a more cost-effective and efficient agricultural input compared to fertilizers, pesticides and others.

The manual is a first step towards ensuring the production and supply of quality seed in rural communities.

It is designed to serve as a handy reference not only for smallholder farmers, extension specialists, public and private seed producers, but also for anyone who is interested in learning best practice in quality seed production.

I hope the manual finds its way to as many users as possible.

I also hope the readers find it informative and interesting.

QUALITY SEED PRODUCTION MANUAL FOR FOOD AND FEED CROPS

RATIONALE

RESADE's project goal is to increase crop yield and cropping intensity in the marginal environments of seven countries situated in the western and southern parts of Africa. Project beneficiaries are farm households located in rural areas with marginal, irrigated, or rainfed environments.

Under the RESADE project, the aim of the farm advisory services component is to operate through researchers and extension workers to improve farmer crop selection and increase farm productivity through the use of high-yielding abiotic stress-tolerant crop varieties and the application of modern soil and crop management technologies.

Quality seed is crucial for increasing agricultural production and productivity. It is the cheapest and most efficient commodity compared to other costly inputs such as fertilizer, pesticide, water, etc. The pace of a program in agricultural production therefore largely depends on seed sector development in a public, private, or integrated approach.

Every effort is therefore needed to make available the right kind of quality seed to farmers, who are the ultimate users. Quality seed production requires competence and it requires several minimum standards to be met. Quality seed should have physical and genetic purity with maximum germination that results in a good crop stand.

OBJECTIVES

The objectives to develop in this document are

- To strengthen the capacity of responsible staff related to seed industry development from public and private partners.
- To improve the understanding of all stakeholders for quality seed development on crop morphology, seed genetics, quality seed production procedures, seed standards, seed certification, seed testing, seed processing, and Distinctness, Uniformity, and Stability (DUS) tests for crops.

1. QUALITY SEED

Quality seed is described as varietal purity with good germination percentage, without diseases and pests, and having an appropriate moisture content and weight. Quality seed guarantees high germination, fast emergence, and robust growth. These traits lead to a healthy plant stand in the field. On the other hand, substandard quality seed results in a poor plant stand, which causes a decrease in yield and lower profitability. Currently, a revolution is taking place in the area of seed quality and the processing industry. It is not enough to have only a desirable cultivar; seed quality along with appropriate management practices are equally important. Therefore, every effort is needed to make available the right kind of quality seed to farmers, who are the ultimate users. Thus, the basic objectives in the seed sector are timely availability of high-quality seeds of superior varieties at an affordable price.

2. GENETIC PURITY

Genetic purity refers to "trueness to type" or "varietal purity." Varietal deterioration during seed production occurs through mutation, outcrossing, mechanical admixture, disease influences, developmental variations, minor genetic changes, faulty breeding techniques, etc. Various genetic principles to be adopted during seed production are authentic seeds from a known source and from a designated class, adoption of a generation system, maintenance of specific isolation distance, conducting field inspection, timely roguing of off-types, pollen shedders, diseased plants, weeds, etc.

3. SELECTION OF A SEED PLOT

The plot selected for seed production must satisfy soil texture and fertility requirements of the seed crop. The same crop should not have been grown in the previous season or seasons and be free from volunteer plants, weeds, soil-borne diseases, insects, nematodes, etc. The plot should be perfectly leveled. It should be feasible to isolate the plot from any contaminant as per the requirements of certification standards.

4. LAND PREPARATION

The land selected for seed production should be ploughed, repeatedly harrowed, and leveled to facilitate good germination and to destroy weeds; this also helps in proper water management of the seed crop.

5. SEED AND ITS SOURCE

Seed used for raising a seed crop should be of certified purity, of an appropriate class, and obtained from an authentic source. The following factors should be considered when procuring the seeds:

1. The seeds should be of the appropriate seed class.
2. Tags, labels, and seals on seed bags should be intact.
3. The validity period should not have expired.

6. SEED TREATMENT

Seeds must be treated with appropriate fungicide and insecticide before sowing. Seeds treated before sowing by fungicides such as carbendazim or thiram at 2 g/kg are recommended. However, seed biopriming with Trichoderma harzianum or Pseudomonas fluorescens at 5 g/kg is an eco-friendly biological control method. Seed biopriming not only suppresses seed-borne diseases

but also results in better seed germination and seedling growth.

7. TIME AND METHOD OF SOWING

The seed crop should be sown 1 to 2 weeks before the normal crop sowing. Some adjustment could be made to avoid pest and disease incidence. Sufficient moisture should be ensured during sowing to obtain better germination and optimum plant stand. Seed crops should invariably be sown in rows on flat fields/ beds. Row planting helps in conducting proper field inspections and facilitates roguing and plant protection measures. Appropriate depth of sowing is most important for obtaining a good plant stand in the nursery, which depends on soil type, soil temperature, and moisture.

8. SEED CERTIFICATION

Certification guarantees the quality of seed as it ensures that certified seed has the genetic, physical, physiological, and seed health qualities required. Seed certification is done at many stages. It starts with verifying whether seeds were obtained from an authenticated source, verification of isolation distance, and inspection during plant growth, flowering, harvesting, processing, and bagging. Also, seed samples are drawn from a seed lot and sent to a seed testing lab to test whether the seeds possess the required physical purity and germination. The number of roguings depends on the crop; however, a minimum of three roguings going from sowing to maturity stages are necessary.

The purpose of seed certification is to maintain and provide high-quality and genetically pure seeds of superior varieties to farmers. Only those cultivars with superior genetic makeup, multiplied to maintain purity and identity, are normally eligible for government certification. Certified seed is genetically pure, is high in germination and vigor, and has good quality (i.e., is disease-free and without damaged or immature seeds). Cultivar purity is the first consideration in seed certification, but other factors such as viability, mechanical purity, and grade as well as absence of weeds and diseases are also important. One of the most effective ways to limit the distribution of weeds is to plant weed-free seed. Planting disease-free seed can decrease losses in the same way. Properly cleaned and graded, seed is easier to plant and gives more uniform stands. Thus, seed certification has been designed not only to maintain the genetic purity of superior cultivars but also to establish and maintain reasonable standards of seed condition and quality.

Although seed regulation varies from one country to another, invariably seed producers need to register with the Seed Certification Agency of the area within 30 days of sowing or 15 days after transplanting with the prescribed fee. The Seed Certification Agency carries out field inspections and seed tests to ensure that seed crops and seed lots meet the quality requirements prescribed for certification of the given class of seed. This is necessary for the foundation and certified classes of seed production. On the basis of different stages of multiplication, in which the level of physical and genetic purity continues decreasing in successive generations, seeds are classified as nucleus, breeder, foundation, and certified seeds.

This nomenclature could be different in certain countries with other words such as registered, pre-basic, and basic seeds, etc., so one needs to check the equivalences of different classes in different countries. The production of nucleus and breeder seed is of prime importance for proper maintenance of the seed production chain: breeder seed- foundation seed-certified seed.

TERMINOLOGICAL EQUIVALENCE

Terminology 1	Terminology 2 (some places)	Also at some places
Nucleus seed	Nucleus seed	Breeder seed
Breeder seed	Breeder seed	Pre-basic seed
Foundation seed	Foundation seed	Basic seed
	Registered seed	Registered seed
Certified seed	Certified seed	Certified seed

CLASSES AND SOURCES OF SEED

BREEDER SEED: This is seed material directly controlled by the originating or sponsoring plant breeder of the breeding program or institution and/ or seed whose production is personally supervised by a qualified plant breeder, who provides the source for the initial and recurring increase of foundation seed. Breeder seed will be genetically so pure as to guarantee that the subsequent generation (i.e., certified foundation seed) will conform to the prescribed standards of genetic purity. The other quality factors of breeder seed such as physical purity, inert matter, germination, etc., should be indicated on the label on an actual basis.

FOUNDATION SEED: This is the progeny of breeder seed produced by trained persons belonging to a certified institute or agency. Seed stocks are managed to preserve specific character and genetic purity. They are further bred to develop certified seeds. This seed is the source of all other certified seed types either directly or through registered seed.

CERTIFIED SEED: This is the progeny of foundation, registered, or certified seed, and is cultivated by trained farmers under prior prescribed conditions and isolation, and it has to go through field and seed investigation before endorsement by the certifying agency. It is certified by any certification agency established in the country and recognized by the central government through notification in the Official Gazette.

Any seed certified by seed certification agencies will consist of two classes: foundation seed and certified seed.

1. Certified foundation seed will be the progeny of breeder seed or be produced from foundation seed stage I, which can be clearly traced to breeder seed. Thus, foundation seed can even be produced from foundation seed by trained officers of an agricultural station in conformity with regulated national standards and handled to maintain genetic purity and varietal identity.

2. The production of foundation seed stage I and II will be supervised and approved by the Seed Certification Agency and will be handled so as to maintain its specific genetic identity and genetic purity and will be required to conform to the certification standards specified for the open-pollinated variety being certified.

3 a. Certified seed will be the progeny of foundation seed and its production will be handled so as to maintain its specific genetic identity and purity according to the standards prescribed for the crop being certified.

b. Certified seed may be the progeny of certified seed provided this reproduction does not exceed three generations beyond foundation seed stage I. The Seed Certification Agency determines that genetic identity and genetic purity will not be significantly altered, and the Seed Certification Agency agrees that there is a genuine shortage of foundation seed despite all reasonable efforts made by the seed producer.

c. A certification tag will be of blue color (shade ISI No. 104 AZURE BLUE) for the certified seed class in most countries.

d. Certified seed produced from certified seed will not be eligible for further seed increase under certification. Certification tags for such production, which is not eligible for further seed increase, will be superscribed with "not eligible for further seed increase under certification."

STANDARDS FOR GENETIC PURITY

Class of seed	Minimum genetic purity in percentage
Breeder seed	100.0
Foundation seed	99.5
Certified seed	95.0

OFFICIAL STANDARDS FOR SEED CERTIFICATION

Factor	Breeder seed	Foundation seed	Registered seed	Certified seed
Pure seed (%)	98	98	98	97
Other varieties (grains/500 g)	0	2	5	10
Weed & other crop seed (%)	0	0	0.05	0.1
Inert matter (%)	2	2	2	3
Germination (% minimum)	80	80	80	80
Moisture content (%)	14	14	14	14

** This may vary for some crops.*

PHASES OF SEED CERTIFICATION

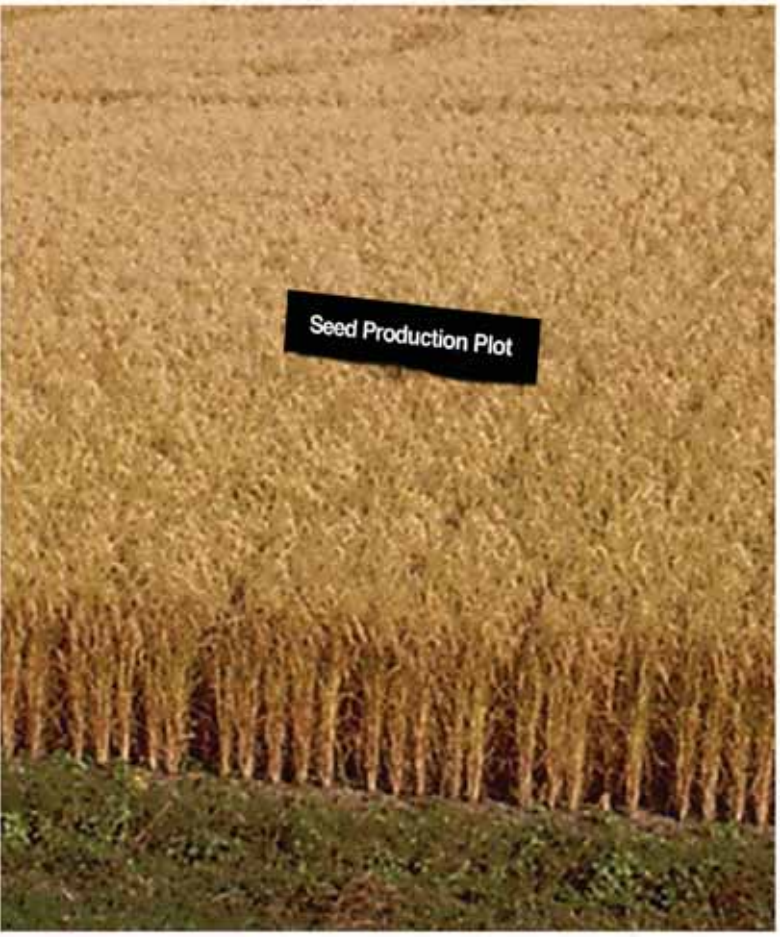
Certification will be completed in six broad phases as follows:

(a) receipt and scrutiny of the application;
(b) verification of seed source, class, and other requirements for the seed used for raising the seed crop;
(c) field inspections to verify conformity to the prescribed field standards;
(d) supervision at post-harvest stages, including processing and packing;
(e) seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards; and
(f) grant of certificate and certification tags, tagging, and sealing.

CERTIFICATION TAGS

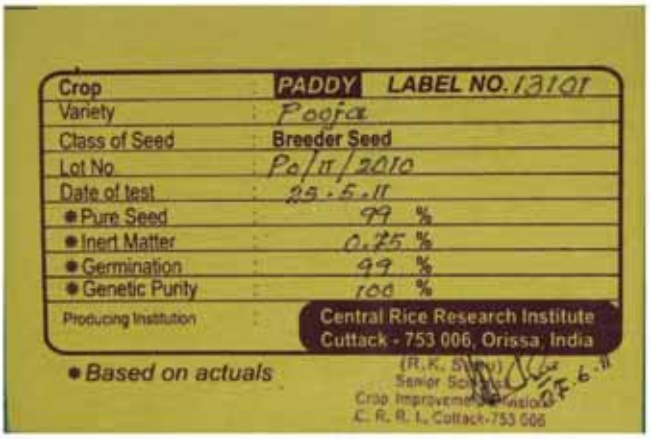
Generally, the specific color and size are fixed for the different classes of seeds as below; however, the size and colors could vary depending on the seed certification requirements of the specific country.

S. no.	Type of seed	Color of tag (as per standard Munsell color chart)	Size of tag
1	Breeder seed	Golden yellow	12 × 6.0 cm
2	Foundation seed	White	15 × 7.5 cm
3	Certified seed	Azure blue	15 × 7.5 cm



EXAMPLES

(A) BREEDER SEED TAG



(B) FOUNDATION SEED (WHITE TAG - EXAMPLE)

CERTIFIED FOUNDATION SEED MONOGRAM

Name of crop: rice Variety:

Name & address of seed grower/dealer:

Lot no.:

Seed testing date:

Date of tag issue:

Valid up to:

This seed ensures the seed standard according to clause 6(A) under Seed Ordinance 1977, the Seed Act (amended) 1997, and the Seed Act (amended) 2005 of Bangladesh Government.

FOUNDATION SEED OF RICE

SEED STANDARD

Pure seed (min. weight):	.....97.0%
Other seed (max. weight):	.....1.0%
(a) Other crop seed (max. no.):	.....5.0/kg
(b) Total weed seed (max. no.):	.....8.0/kg
Inert matter (max. weight):	.....2.0%
Germination capacity (min.):	.....80.0%
Moisture content (max.):	.....12.0%

Seed Certification Agency

(C) CERTIFIED SEED TAG

BLUE TAG: CERTIFIED SEED (EXAMPLES)

CERTIFIED SEED MONOGRAM

Name of crop: rice Variety:

Name & address of seed grower/dealer:

Lot no.:

Seed testing date:

Date of tag issue:

Valid up to:

This seed ensures the seed standard according to clause 6(A) under Seed Ordinance 1977, the Seed Act (amended) 1997, and the Seed Act (amended) 2005 of Bangladesh Government.

FOUNDATION SEED OF RICE

SEED STANDARD

Pure seed (min. weight):	.....96.0%
Other seed (max. weight):	.....1.0%
(a) Other crop seed (max. no.):	.....10/kg
(b) Total weed seed (max. no.):	.....10/kg
Inert matter (max. weight):	.....3.0%
Germination capacity (min.):	.....80.0%
Moisture content (max.):	.....12.0%

Seed Certification Agency

ISOLATION

Isolation is the act of keeping the seed crop away from a source of contamination. The main objective is to avoid mechanical admixtures. There are three types of isolation: distance or space isolation, time isolation, and barrier isolation.

(A) DISTANCE ISOLATION

Distance isolation, also called space or spatial isolation, is used to avoid natural outcrossing, spread of disease, or mechanical contamination during harvest and post-harvest operations. This differs from one crop to another based on potential pollen viability time and dissemination ability upon bursting of anthers. It varies greatly between self-pollinated and cross-pollinated crops.

(B) TIME ISOLATION

Time isolation, also called temporal isolation, is a differential blooming date technique and is practiced only if land is limited. Adjust planting time to separate flowering time of one variety from others by at least 2-3 weeks (depending on the crop), which will protect the quality of the seed parent from contamination.

(C) BARRIER ISOLATION

Any natural, artificial, or crop barrier more than 2.5 m high can prevent contamination of the seed parent by pollen grains. A crop barrier around seed production plots should be 3-4 m wide, depending on the type of crop. Sesbania rostrata or a healthy, tall crop of maize, sorghum, or pearl millet makes a satisfactory barrier.

ROGUING AND FIELD INSPECTION

This is the process of removing undesirable plants from a crop for seed production. The rogues may be weeds, off-types, other-variety plants, plants affected by disease, etc. It is necessary to avoid genetic contamination, disease transmission, and mechanical admixtures to meet certification requirements with respect to off-types, diseases, inseparable other crop plants, and objectionable weed plants. Rogues can be identified based on their morphological characteristics besides variations in flowering, mostly DUS traits. The number of roguings depends on the crop; however, a minimum of three roguings going from sowing to maturity are necessary. Roguing can be done at any time of a crop stage. Off-type rogues can be removed from the crop whenever they appear. The most important stages for roguing are

(A) DURING MAXIMUM TILLERING

1. Remove any plants outside the rows.
2. Remove plants that are considerably taller or shorter than the original variety.
3. Remove plants that are off-types for leaf blade size or shape.
4. Remove plants that are off-types for color of the leaf sheath, collar, or lamina.

(B) DURING FLOWERING

1. Remove off-type plants that flower very early or very late.
2. Remove plants that are off-types for flag-leaf size, angle, and panicle shape or size.

(C) BEFORE HARVEST

1. Remove off-types that have different grain characteristics from the original plants. Look for differences in grain shape, grain size, color, or presence or absence of special parts.

SOIL FERTILITY

Sixteen essential plant nutrient elements are obtained from air, soil, and water. Nitrogen, phosphorus, and potassium are major or primary elements as they are required in large quantities by plants. Calcium, magnesium, and sulfur are secondary nutrients as they are required in lesser amounts. Boron, chlorine, copper, iron, manganese, molybdenum, and zinc are called micronutrients or trace elements as they are required by plants in small quantities. These micronutrients are usually present in the soil in sufficient amounts; however, their deficiency may cause non-availability or imbalance of other nutrients. The application of nutrients should be based on the fertility status of the soil. An application of a proper or optimum dose of these nutrients will decrease the chances of variation in plant appearance due to deficiency or toxicity, and also increase seed filling, seed yield, and seed quality parameters such as seed weight, seed size, seed density, seed germination, and seedling vigor.

WEED CONTROL

The problem of weeds and their management assumes greater significance in seed production programs

because of stringent seed standards and high value for seed. Weed plants have a mechanism of wide adaptability to adverse conditions and high growth rate vis-à-vis cultivated species. They compete with a seed crop for space, nutrients, moisture, light, and gases and thereby diminish seed yield considerably. It is essential to keep the seed crop free from weeds in the early stages (up to 20-25 days) by doing one or two manual weedings. Alternatively, chemical weedicides can be applied to control weeds. A pre-emergence spray of weedicides should be selected based on the crop growth stage. There should be sufficient moisture in the soil at the time of spraying of weedicide.

PEST AND DISEASE CONTROL

It is essential to control insect pests and diseases so as to raise a healthy seed crop. These pests affect both seed yield and seed quality.

HARVESTING AND THRESHING

Timely harvesting of a seed crop prevents bird damage, storage fungi, damage by rain, shattering losses, etc., and ensures high-quality seeds. The seed crop harvested should be threshed, winnowed, cleaned, and dried to a safe moisture content before processing.

SEED YIELD

Seed yield depends on the crop variety, agronomic principles followed in raising the seed crop, along with control of pests and diseases.

SEED PROCESSING AND PACKAGING

After drying seeds to the prescribed seed moisture content, they should be processed by using an air/screen cleaner with appropriate sieve size approved by the Seed Certification Agency. After grading, the seeds should be treated with suitable fungicides before packaging.

SEED STORAGE

After packaging, seeds should be stored in a well-ventilated, moisture-proof, insect-free seed warehouse until their use. Dehumidified (controlled) storage should be used for storing seeds for more than one season.

SEED TESTING

Seed quality has a major role to play in the seed industry. Good-quality seed can increase yield by 5-20%. Several genetic and physiological characteristics determine seed quality. The genetic components involve differences between two or more genetic lines, while differences between seed lots of a single genetic line comprise the physiological components. Genetic factors that can influence quality include

- genetic makeup
- seed size
- bulk density

PHYSICAL OR ENVIRONMENTAL CONDITIONS INFLUENCE SEED QUALITY

- injury during planting and establishment
- growing conditions during seed development
- plant nutrition
- physical damage during production or storage by machine or pest
- moisture and temperature during storage
- age or maturity of seed

Deterioration in seed quality may begin at any point in the plant's development stage from fertilization onward. Seed quality depends on the physical conditions that the mother plant is exposed to during growth stages as well as harvesting, processing, storage, and planting. Temperature, nutrients, and other environmental factors also affect seed development and influence seed quality. Seeds of high quality should be true to their kind or variety, contain a minimum of impurities, and have high establishment rates in the field. The main criteria for describing seed quality are the following:

- varietal characteristics
- seed lot characteristics
- seed viability

Through seed testing, we can assess the quality attributes of seed lots, laterwhich have to be offered for sale, and minimize the risk of planting low-quality seeds. Seed tests consist of a series of tests designed to determine the quality of seed and they are conducted by seed testing laboratories. Seed tests are usually conducted on small representative samples drawn from processed seed lots. Before certification, seed lots normally undergo many tests: for purity, germination or seed viability, moisture content, and real value of seed.

OBJECTIVES OF SEED TESTING

1. To determine seed quality, that is, suitability for planting.
2. To identify seed quality problems and their probable causes.
3. To determine whether the seed meets established quality standards or labeling specifications.
4. To establish quality and provide a basis for price and consumer discrimination among lots in the market.
5. To determine the need for drying and processing and specific procedures that should be used.

IMPORTANT COMPONENTS OF SEED TESTING

- seed sampling
- physical purity
- germination
- seed moisture
- seed viability
- seed health
- seed vigor

DUS TESTING

According to Article 7 of the 1961/1972 and 1978 Acts and Article 12 of the 1991 Act of the UPOV Convention, protection can be granted in respect of a new plant variety only after examination of the variety has shown that it complies with the requirements for protection laid down in those Acts and, in particular, that the variety is distinct (D) from any other variety whose existence is a matter of common knowledge at the time of the filing of the application and that it is sufficiently uniform (U) for traits and stable (S) over season or locations, or DUS in short. The objectives are

- To generate a basic description of the candidate variety (based on crop descriptor) using relevant characteristics to compare the candidate variety with the reference or example variety.
- To differentiate the candidate variety from other existing varieties.

SEED PRODUCTION OF BARLEY *(HORDEUM VULGARE L.)*

Seed production procedures for all crops must strictly follow standard seed production techniques and certification; however, procedural variation for specific crops happens in view of the technical requirements of specific crops due to floral variation and behavior. The detailed requirements for producing quality barley seed follow.

Barley plants

CLIMATE AND SOIL REQUIREMENTS

Although barley is a temperate zone crop, it can tolerate high temperatures if the humidity is low. It can be grown in high altitudes in the subtropics. It is reasonably tolerant of poorer soils but does well under fertile conditions. Barley does not tolerate waterlogging. In damp weather, seed may germinate on the ear. Barley can be characterized as a facultative long-day plant (needing short nights for flowering).

BREEDER, FOUNDATION, AND CERTIFIED SEED

As mentioned earlier, breeder seed (BS) is the responsibility of the originating institute or center under the guidance of breeders. Pure seed either from nucleus seed or from breeder seed is used to develop BS. It is advisable to keep single heads or panicles, collected from true-to-the-type plants, unthreshed and then sown in panicle-to-row (P to R) methods, following all the precautions for seed production as mentioned earlier in this document. This is the stage of rigorous selection and, if there is even a single variation in a progeny from a single panicle (P to R), all the derived progenies from that single panicle are discarded and cut immediately.

Barley with 2-rowed spike

The rest of the seed derived from each panicle is bagged and threshed separately before mixing as BS.

Each variety is rogued throughout its growth stage based on the specific DUS characteristics linked with that specific variety. The details of the DUS traits are given below in the Table of barley characteristics (refer also to the Barley descriptor: *(https://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-barley-hordeum-vulgare-l/).*

PLANT DESCRIPTION

Barley grows to a height of 30-120 cm, depending on variety and growing conditions. Like many grasses, the stem is hollow. Barley produces several tillers with prominent nodes and internodes. The spike (ear-head) of barley is indeterminate and has three spikelets at each node arranged alternately along the axis (rachis). Two forms are recognized: two-rowed and six-rowed barley. In two-rowed barley, only the central spikelets are fertile. Thus, the spike viewed from the apex appears to have two rows of kernels on opposite sides of the rachis. In six-rowed types, all three spikelets at each node are fertile, giving the appearance of three rows of kernels on each side of the spike. The six-rowed types have fewer tillers, wider leaves, fewer nodes in the spike, and smaller kernels than the two-rowed types.

DUS TRAITS FOR BARLEY

S. no.	Characteristics	State	Note	Stage of observation	Example variety	Type of assessment
1 * (+)	Growth habit	Erect	3	23-25	Amber	VG
		Semi-prostrate	5		Alfa93	
		Prostrate	7		-	
2 *	Stem: basal pigmentation	Absent	1	25-33	Amber	VG
		Present	9		Alfa93	
3 *	Auricle (flag leaf): anthocyanin pigmentation	Absent	1	49-59	Amber	VG
		Present	9		Alfa93	
4 *	Upper node Pigmentation	Absent	1	49-59	Amber	VG
		Present	9		Alfa93	
5 * (+)	Flag-leaf: attitude	Erect	1	51-59	Amber	VG
		Semi-erect	5		BCU73	
		Drooping	9		Alfa93	
6 *	Flag leaf: waxiness of sheath	Absent	1	51-59	Ratna	VG
		Present	9		Alfa93	
7 *	Spike emergence	Very early (<65 days)	1	51-59	-	MG
		Early (65-75 days)	3		BCU73	
		Medium (76-86 days)	5		Amber	
		Late (87-96 days)	7		Dolma	
		Very late (>96 days)	9		Alfa93	

S. no.	Characteristics	State	Note	Stage of observation	Example variety	Type of assessment
8 * (+)	Spike type	Two-row	3	59-69	Alfa93	VG
		Six-row	7		Amber	
9 (+)	Lateral florets (two-row barley)	Rudimentary	1	59-69	DWRB73	VG
		Developed	9		Alfa93	
10 *	Spike: waxiness	Absent	1	59-85	BCU73	VG
		Present	9		Alfa93	
11	Spike: color	Pale green	1	69-77	DWR28	VG
		Green	2		Alfa93	
		Dark green	3		DWRUB64	
12 *	Spike: attitude	Erect	3	69-77	Amber	VG
		Semi-erect	5		BHS169	
		Drooping	7		Alfa93	
13	Awn: roughness	Smooth	3	69-77	BH393	VG
		Rough	7		Alfa93	
14	Flag-leaf length	Short (<10 cm)	3	71-85	Alfa93	MS
		Medium (10-14 cm)	5		Amber	
		Long (>14 cm)	7		Ratna	
15	Flag-leaf breadth	Narrow (<1.0 cm)	3	71-85	Alfa93	MS
		Medium (1.0-1.5 cm)	5		Amber	
		Wide (>1.5 cm)	7		BH75	
16	Awn: tip pigmentation	Absent	1	73-87	Amber	VG
		Present	9		BH393	
17	Spike: basal sterility	Absent	1	73-89	Alfa93	VS
		Present	9		RD2715	
18	Lemma: pigmentation	Absent	3	73-87	Dolma	VG
		Nerve pigmented	5		Alfa93	
		Present	7		DWRB91	
19	Spike: length	Small (<7 cm)	3	75-89	Ratna	MS
		Medium (7.1–10.0 cm)	5		BH75	
		Long (>10 cm)	7		Alfa93	
20 *	Plant: height	Very short (<75.0 cm)	1	75-89	-	MG
		Short (75.1–85.0 cm)	3		BCU73	
		Medium (85.1-95.0 cm)	5		Alfa98	
		Tall (95.1–105.0 cm)	7		BHS169	
		Very tall (>105.0 cm)	9		Amber, Jyoti	

S. no.	Characteristics	State	Note	Stage of observation	Example variety	Type of assessment
21	Peduncle: length	Short (<22.0 cm)	3	75-89	Alfa93	MS
		Medium (22.1–27.0 cm)	5		Amber	
		Long (>27.0 cm)	7		Dolma	
22	Awns	Absent	1	83-87	-	VG
		Present	9		Alfa93	
23 * (+)	Awn: type	Hooded	1	83-87	-	VG
		Awnletted	3		-	
		Normal	5		Alfa93	
24	Awn: length	Short (<8.0 cm)	3	83-87	BH75	MS
		Medium (8.1–11.0 cm)	5		BHS169	
		Long (>11.0 cm)	7		Alfa93	
25 * (+)	Spike: density	Lax	3	83-89	Azad, Jyoti	VG
		Intermediate	5		Alfa93	
		Dense	7		Ratna	
26	Grain: hullness	Naked (hulless)	1	87-92	Dolma	VS
		Covered (hulled)	9		Alfa93	
27 *	Grain: color	White	1	92	Dolma	VG
		Yellow	2		Alfa93	
		Purple	3		Bilara2, Jyoti	
		Black	4		-	
28 * (+)	Grain: shape	Oval	1	92	Alfa93	VG
		Oblong	5		BHS169	
		Elliptical	7		Amber	
29 *	Grain: size (1,000-grain weight)	Small (<30 g)	1	92	Dolma	MS
		Medium (30–40 g)	3		Alfa93	
		Large (41–50 g)	5		Amber	
		Very large (>50 g)	7		BCU73	
30	Grain: surface	Smooth	1	92	Amber	VG
		Wrinkled	9		JB58	
31 (+)	Rachilla hairs	Rudimentary	1	92	Alfa93	VS
		Prominent	9		BHS46	
32 * (+)	Grain: crease width	Narrow	3	92	BHS169	VS
		Intermediate	5		Alfa93	
		Wide	7		-	

MG = measurement by a single observation of a group of plants or parts of plants.

MS = measurement of several individual plants or parts of plants.

VG = visual assessment by a single observation of a group of plants or parts of plants.

VS = visual assessment by observation of individual plants or parts of plants.

** Characteristics that should be observed during every growing period on all varieties and should always be included in the description of the variety, except when the state of expression of any of these characteristics is rendered impossible by a preceding phenological characteristic or by the environmental conditions of the testing region. Under such exceptional situations, adequate explanation should be provided.*

+ Please refer to the characteristics in the descriptor.

Source: 1. Barley descriptor (https://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-barley-hordeum-vulgare-l/).

2. Protection of Plant Varieties and Farmers Rights' Authority. 2011. Guidelines for the conduct of test for distinctiveness, uniformity and stability on barley (Hordeum vulgare L.). Protection of Plant Varieties and Farmers Rights' Authority (PPV & FRA), Government of India, 13 p.

Barley seeds

ISOLATION REQUIREMENTS

Barley is a self-pollinating crop, but some six-rowed cultivars can cross-pollinate to some extent. Thus, being a self-pollinating crop, barley needs an isolation distance of 3 m for nucleus seed and breeder seed and 2 m for foundation and certified seed, or else a physical barrier is required for quality seed production.

LAND REQUIREMENTS

A clean, fertile, and leveled land at an experiment station or secured area is recommended. The area must be appropriately prepared and the plot isolated so as to make sure that there is categorically no chance of mechanical contamination by volunteer plants, of mixture with seed from next-door plots or fields, of mixture with seed transferred by birds or water, or of contamination through cross-fertilization by wind-borne pollen. Successful production of BS is more effectively accomplished when it is separated from the regular breeding and testing program.

FERTILIZER APPLICATION

Fertilizer should be applied based on soil testing results. However, in the absence of test results, one can use the following recommendations.

1. Nitrogen (N): An application @ 120 kg/ha in three splits:
   a. Basal dose @ 40kg/ha at the time of sowing (1/3rd)
   b. First top dressing @ 40 kg/ha (1/3rd) at 6-leaf stage to early tillering
   c. Second top dressing @ 40 kg/ha (1/3rd) at late tillering to stem elongation stage

Urea is better option for the top dressings

2. Phosphorus (P_2O_5): Basal dose @ 30 kg/ha
3. Potassium (K_2O): Basal dose @ 25 kg/ha if soil testing is not done
4. Micro-nutrients: Trace elements are be replenished based on the soil testing results.
5. Organic fertilizers (Compost or Farmyard Manure): An application of 10-15 t/ha well-decomposed organic matter can ensure good grain yield equivalent to that with chemical fertilization. Sowing on crop residues (stubble) and zero-tillage also improves yield.

SOWING

Seed can be sown by hand or with a small-scale plot machine as production areas are usually small. The rows should be sufficiently spaced to permit easy passage of a person between them for roguing as well as inter-culture operations. The depth of sowing should not be more than 5 to 7 cm for proper establishment. The row-to-row distance for barley is approximately 20 cm and plant-to-plant distance 2-5 cm; however, this can vary based on inter-culture operability requirements.

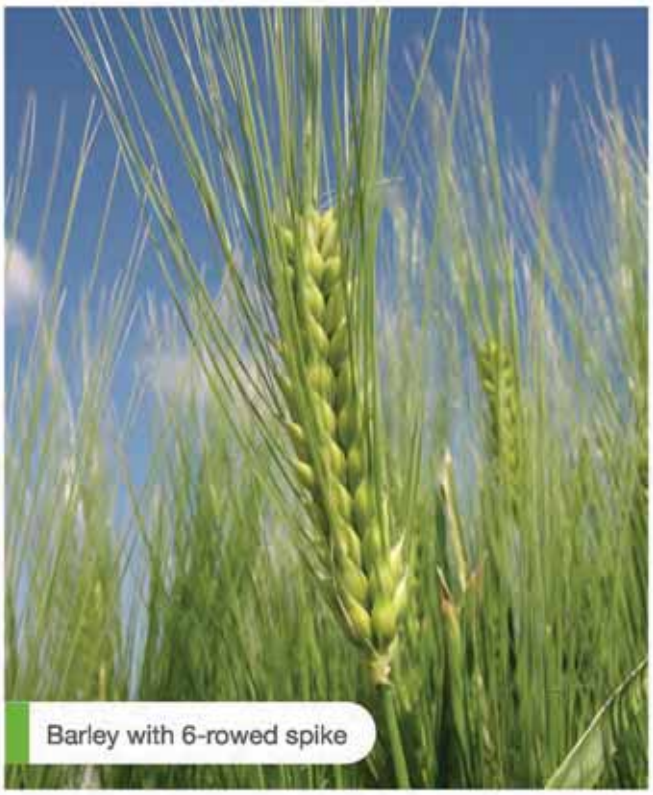
ROGUING

Roguing is the activity of eradicating by hand unwanted plants from a plot of a variety. Seed production plots of breeder seed should be meticulously rogued to remove any off-type plants that might be present. Roguing can be carried out throughout the plant growth cycle, whereas roguing just before flowering is very important. Intensive roguing should be continued from flowering to maturity following DUS traits. When roguing, the whole plant should be removed from the base, including all the tillers. Plants that have been rogued must be taken away; they should not be dumped in the plot.

HARVESTING

It is difficult to harvest and thresh breeder seed with large-sized machinery as it is not feasible to clean such equipment completely. Preferably, harvesting and threshing should be done manually for small seed production units, or the harvesting can be performed by hand and the threshing with a self-cleaning-type plot-size portable or immobile thresher. Complete cleaning of the threshing machine is a must if working with different seed lots.

However, for foundation and certified seed production, mechanization is desirable to improve efficiency, such as using a motorized reaper and immobile threshing machine. A prolonged and large seed production program cannot be based on manual labor and animal power. Harvesting should start shortly after maturity to avoid losses due to shattering and unfavorable weather. The seed should be dried enough at the time of harvesting with moisture content of 8-20%.



Barley with 6-rowed spike

BARLEY SEED STANDARDS

Factor	Standards for each class	
	Foundation seed	Certified seed
Pure seed (minimum)	98.00%	98.00%
Inert matter (maximum)	2.00%	2.00%
Other crop seed (maximum)	10/kg	20/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Weed seed (maximum)	10/kg	20/kg
Germination (minimum)	85%	85%
Moisture content (maximum)	12.00%	12.00%
For vapor-proof containers (maximum)	8.00%	8.00%

BARLEY PERMISSIBLE OFF-TYPES FOR SEED PRODUCTION

Factor	Maximum permitted (%)*	
	Foundation seed	Certified seed
Off-types	0.05	0.2
**Inseparable other crop plants	0.01	0.05
***Plants affected by seed-borne diseases	0.1	0.5

**Standards for off-types and inseparable other crops should be met at final inspection before harvesting and for loose smut of barley at any inspection conducted between ear emergence and harvesting.*

***Inseparable other crops are wheat, gram, and triticale.*

****Seed-borne diseases are loose smut (Ustilago nuda (Jens.) Rostr.).*

SAVE THE REMNANT SEED

Remnant seeds must be carried over, with at least a sufficient seed amount to protect against loss of the variety if a total failure occurs during the seed multiplication stage. Even a few seeds will do in case of emergency. In addition, the variety should be protected by planning to have a fraction of the seed originally released stored under the ideal conditions provided by gene banks or centers. The persons responsible should plan to produce enough breeder seed at one time to meet the needs of two to three production cycles of basic seed. The carryover or remnant seed should be conserved under optimal conditions to preserve its vigor and viability.

DRYING AND STORAGE

Seeds should be dried to a moisture content below 12% to prevent deterioration. Although sun drying is a common practice in tropical countries, it might result in losses due to incomplete drying, birds, rodents, and spillage. Natural drying by forced air can be employed when the ambient relative humidity is below 50%. At RH above 60%, heated air drying can be used to decrease the moisture to a safe amount. For medium-term storage, moisture content should be further decreased to 8% before the seed is placed in moisture-proof containers.
Seed yield

SEED YIELD

Average yield varies from 3.0 to 3.5 t/ha.

SEED PRODUCTION OF QUINOA *(CHENOPODIUM QUINOA* WILLD.)

Quinoa plants growing in a field

Seed production procedures for all crops must strictly follow standard seed production techniques and certification; however, procedural variation for specific crops happens in view of the technical requirements of specific crops due to floral variation and behavior. The detailed requirements for producing quality quinoa seed follow.

CLIMATE AND SOIL REQUIREMENTS

Quinoa is a day-neutral plant and can be grown under a wide range of conditions. It tolerates adverse environmental conditions such as cold, soil salinity, drought, and humidity. However, for seed production, areas with cool temperatures are generally preferred as the seeds may not germinate if conditions are too warm at the time of sowing. Optimal temperatures for growth are around 20 °C. Temperatures exceeding 35 °C cause pollen sterility and failure to set seed. Quinoa grows well on sandy-loam to loamy-sand soils. The optimum soil pH for quinoa growth is 5.5-8.0.

BREEDER, FOUNDATION, AND CERTIFIED SEED

As mentioned earlier, breeder seed is the responsibility of the originating institute or center under the guidance of breeders. Pure seed either from nucleus seed or from breeder seed is used to develop BS. It is advisable to keep the single heads or panicles, collected from true-to-the-type plants, unthreshed and then sown in panicle-to-row (P to R) methods, following all the precautions for seed production as mentioned earlier in this document.

Quinoa plant

Quinoa panicle

This is the stage of rigorous selection and, if there is even a single variation in a progeny from a single panicle (P to R), all the derived progenies from that single panicle are discarded and cut immediately. The rest of the seed derived from each panicle is bagged and threshed separately before mixing as BS.

Each variety is rogued throughout its growth stages based on the specific DUS characteristics linked with that specific variety. Details of quinoa DUS traits are available at *https://www.upov.int/edocs/mdocs/upov/en/twa_46/tg_cheno_proj_4.pdf.*

PLANT DESCRIPTION

Quinoa plants have an upright stem, branched or unbranched, depending on the cultivar. Quinoa has a deep and highly branched root system that makes plants tolerant of drought. The lower leaves are mostly rhomboidal, while the upper leaves are triangular or lanceolate. Quinoa has a racemose inflorescence (panicle). Flowers are incomplete without petals. Most of the flowers are hermaphrodite although some female flowers also occur on the same plant. The fruit is an achene protected by a perigonium. Seeds vary in color from yellow to purple, depending on the cultivar. A detailed description of quinoa traits can be found at *https://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-quinoa-chenopodium-quinoa-willd-and-wild-relatives/.*

LAND REQUIREMENTS

A clean, fertile, and leveled land at an experiment station or secured area is recommended. The area must be appropriately prepared and the plot isolated so as to make sure that there is categorically no chance of mechanical contamination by volunteer plants, of mixture with seed from next-door plots or fields, of mixture with seed transferred by birds or water, or of contamination through cross-fertilization by wind-borne

Quinoa Seeds

pollen. Successful production of BS is more effectively accomplished when it is separated from the regular breeding and testing program.

FIELD PREPARATION

Land for quinoa planting should be ploughed twice to eradicate weeds and bring the soil to fine tilth stage.

FERTILIZER APPLICATION:

Although quinoa requires relatively less fertilizer quantities but still fertilizer application should be based on soil testing results only. However, in the absence of such information, one can use the following recommendations.

1. Nitrogen (N): An application @ 120 kg/ha should be applied in three splits:
   a. Basal dose @ 40 kg/ha at the time of sowing (1/3rd)
   b. First top dressing @ 40 kg/ha (1/3rd) at branching stage (30-35 days after sowing)
   c. Second top dressing @ 40 kg/ha (1/3rd) at around 50-55 days

Urea is better option for the top dressings

QUINOA SEED STANDARDS

Factor	Standards for each class	
	Foundation seed	Certified seed
Pure seed (minimum)	98.00%	98.00%
Inert matter (maximum)	2.00%	2.00%
Other crop seed (maximum)	10/kg	20/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Weed seed (maximum)	10/kg	20/kg
Germination (minimum)	85%	85%
Moisture content (maximum)	12.00%	12.00%
For vapor-proof containers (maximum)	8.00%	8.00%

2. Phosphorus (P_2O_5): Basal dose @ 50 kg/ha
3. Potassium (K_2O): Basal dose @ 50 kg/ha
4. Organic fertilizers (Compost or Farmyard Manure): An application of 15-20 t/ha well-decomposed organic matter suffice the nutrient requirements of quinoa; substitutes requirement of any other kind of fertilizer.

ISOLATION REQUIREMENTS

Quinoa is largely self-pollinating. The recommended minimum isolation distance from other quinoa fields is 20 m for nucleus, breeder and foundation seeds and 10 m for certified seeds.

SOWING

The best time for sowing depends on the climatic conditions prevailing in the area. Sowing dates should be adjusted to ensure that flowering and seed maturity coincide with the favorable conditions for seed set. Many different sowing methods are used, but it is recommended to establish the crop in rows. The most suitable row spacing is 45-60 cm and plant-to-plant distance is 15-20 cm. The required seed rate is 1-2 kg/ha, depending on spacing. Seeding rates are usually doubled when growing conditions are not optimal. Seeds should be planted at a depth of 1-2 cm and better stands are obtained when seeds are planted in moist soil, instead of irrigating after sowing. To ensure good stands, two to three seeds can be dibbled per hill and thinning can be performed 20-30 days after planting to keep one seedling per hill.

ROGUING

This is a regular exercise in all crops for seed production and has been mentioned in an earlier section in detail.

QUINOA PERMISSIBLE OFF-TYPES IN SEED PRODUCTION PLOTS

The quinoa seed industry is not yet as highly developed as that of other crops; however, the maximum permissible mixtures in seed production units are as follows:

Foundation seed I: 10 plants per 10,000-plant stand
Foundation seed II or registered seed: 15 plants per 10,000-plant stand
Certified seed: 20 plants per 10,000-plant stand

DRYING AND STORAGE

Seeds should be dried to a moisture content of 12-14% to prevent deterioration. Although sun drying is a common practice in tropical countries, it may result in losses because of incomplete drying, birds, rodents, and spillage. Natural drying by forced air can be employed when the ambient relative humidity is below 50%. At RH above 60%, heated air drying can be used to decrease the moisture content to a safe amount. For medium-term storage, moisture content should be further decreased to 8% before the seed is placed in moisture-proof containers.

SEED YIELD

Average seed yield varies from 2,000 to 2,500 kg/ha.

SEED PRODUCTION OF PEARL MILLET *(PENNISETUM GLAUCUM L.)*

Seed production procedures for all crops must strictly follow standard seed production techniques and certification; however, procedural variation for specific crops happens in view of the technical requirements of specific crops due to floral variation and behavior. The detailed requirements for producing quality pearl millet seed follow.

CLIMATE AND SOIL REQUIREMENTS

Pearl millet grows best from 20 to 28 °C. Very hot and dry weather conditions and extreme cold temperatures adversely affect seed setting and are generally not suitable for seed production. Similarly, areas prone to excess rain and high humidity, which promote higher incidence of pests and diseases, are not suited for seed production. Strong winds may cause lodging. Pearl millet does not grow well in soils prone to waterlogged conditions. Some cultivars of pearl millet are sensitive to photoperiod and flower in short day lengths. Shallow and light-textured soils are best suited for pearl millet seed production. The optimum soil pH is 5.5-6.5, but the crop can tolerate acid subsoils to as low as pH 4 and high in aluminum content. Pearl millet does not grow well in calcareous soils. Accordingly, seed production plots must be selected for optimum seed production.

DUS TRAITS FOR PEARL MILLET

Each variety is rogued throughout its growth stages based on the specific DUS characteristics linked with that specific variety as below.

S. no.	Characteristics	State	Note	Example variety/ line (new)	Stage of observation	Type of assessment
1 (*)	Plant: anthocyanin coloration of first leaf sheath	Absent	1	843-22B, GHB 558	Five-leaf stage (8)	VG
		Present	9	J 2340, Kaveri Super Boss		
2 (+)	Plant: growth habit	Erect	1	842B, G 73-107	Spike emergence (45)	VG
		Intermediate	5	-		
		Spreading	7	-		
3 (*)	Time of spike emergence (50% of plants with at least one spike emerged fully)	Very early (<43 days)	1	HHB 67 Imp., RHB 177	Spike emergence (45)	VG
		Early (43-46 days)	3	ICMH 356, H 77/833-2202		
		Medium (47-50)	5	RIB 3135-18, GHB 719		
		Late (51-54 days)	7	Nandi 61		
		Very late (>54 days)	9	ICMB 97444		

S. no.	Characteristics	State	Note	Example variety/ line (new)	Stage of observation	Type of assessment
4	Leaf: sheath pubescence	Absent	1	842B, GHB 558	Spike emergence (45)	VG
		Present	9	81B		
5	Leaf: sheath length (cm)	Short (<11)	3	H 77/29-2	Spike emergence (45)	MS
		Medium (11-15)	5	ICMB 92777, J 2340		
		Long (>15)	7	841B, ICMB 94555		
6	Leaf: blade length (cm)	Very short (<41)	1	RHRB 5B, H77/29-2	Spike emergence (45)	MS
		Short (41-50)	3	ICMB 94111, RHRBI 1314		
		Medium (51-60)	5	GHB 744, J 2454		
		Long (61-70)	7	86M64		
		Very long (>70)	9	IP No. 6061, IP No. 20593		
7	Leaf: blade width (at widest point) (cm)	Narrow (<3)	3	H 77/833-2, ICMB 88004	Spike emergence (45)	MS
		Medium (3-4)	5	842B, ICMH 356		
		Broad (>4)	7	Nandi 61, 86M86		
8	Spike: stigma pigmentation	Absent	1	GHB 558, MIR 525-2	Stigma emergence (47)	
		Present	9	-		
9 (*)	Spike: anther color	Yellow	3	G 73-107, GHB 558	Anther dehiscence (50)	VG
		Brown	5	842B, ICMB 97111		
		Purple	7	PB 106, Kaveri Super Boss		
10 (*)	Plant: node pubescence	Absent	1	842 B, 843-22B	Dough grain -65	VG
		Present	9	841B		
11	Plant: number of nodes	Low (<11)	3	ICMH 356, GHB 538	Dough grain -65	MS
		Medium (11-15)	5	-		
		High (>15)	7	-		
12 (*)	Plant: node pigmentation	Whitish	1	G 73-107	Dough grain -65	VG
		Green	2	843-22 B, GHB 558		
		Brown	3	-		
		Red	4	-		
		Purple	5	ICMH 356, ICMB 88004		

S. no.	Characteristics	State	Note	Example variety/ line (new)	Stage of observation	Type of assessment
13 (*)	Plant: internode pigmentation (between third and fourth node from top)	Whitish	1	G 73-107	Dough grain -65	VG
		Green	2	843-22B, GHB 558		
		Brown	4	-		
		Red	6	-		
		Purple	7	ICMB 88004		
14	Spike exsertion	Incomplete	1	IP No. 4278, IP No. 14695	Dough grain -65	VS
		Partial	3	ICMB 94555, Nandi 61		
		Complete	5	ICMB 92777, GHB 538		
15 (*)	Spike: length (cm)		1	IP No. 2789, IP No. 8144	Dough grain -65	MS
			3	ICMA 88004, ICMR 356		
			5	81B, GHB 558		
			7	Kaveri Super Boss		
			9	IP No. 19628, IP No. 22888		
16 (*)	Spike: anthocyanin pigmentation of glume	Absent	1	RHRB 1B, GHB 558	Dough grain -65	VG
		Present	9	842B, ICMB 88004		
17	Spike: bristle	Absent	1	843-22B, GHB 558	Dough grain -65	VG
		Present	9	MPMH 17, HBL 11		
18. (*)	Spike: bristle color	Yellow	1	-	Dough grain -65	VS
		Green	2	-		
		Brown	3	RIB 3135-18, PB 106		
		Purple	5	-		
19	Spike: bristle appearance	Non-prominent (bristle length <2 mm from ear-head)	3	HHB 67 Imp., PB 106	Dough grain -65	VS
		Prominent (bristle length >2 mm from ear-head)	5	RBH 177		
20 (*)	Spike: girth at maximum point (excluding bristles) (cm)	Thin (<1.6)	3	IP No. 8128, IP No. 10402	Dough grain (65)	MS
		Medium (1.6-3.0)	5	842B, GHB 538		
		Thick (>3.0)	7	Nandi 61, Kaveri Super Boss		

S. no.	Characteristics	State	Note	Example variety/ line (new)	Stage of observation	Type of assessment
21 (*) (+)	Plant: number of productive tillers	Monoculm (<2)	1	IP No. 5075, IP No. 21156	Dough grain (65)	MS
		Low (2-3 tillers)	3	81B, J 2340		
		Medium (4-6 tillers)	5	RIB 3135-18		
		High (>6 tillers)	7	IP No. 3110, IP No. 3645		
22 (*)	Plant: height (including spike) (cm)	Very short (<101)		H 90/4-5, ICMB 94555	Dough grain (65)	MS
		Short (101-150)	3	ICMB 92777, J 2340		
		Medium (151-200)	5	ICMH 356, 86M86		
		Tall (201-250)	7	IP No. 4511, IP No. 10544		
		Very tall (>250)	9	IP No. 2670, IP No. 15537		
23 (*) (+)	Spike shape	Cylindrical	1	GHB 538	Maturity (75)	VG
		Conical	2	ICMB 88004, ICMH 356		
		Spindle	3	G 73-107, RHRB 1B		
		Candle	4	H 77/29-2, J 2340		
		Lanceolate	5	MPMH 17, GHB 558		
		Dumbbell	6	IP No. 7979, IP No. 7981		
		Club	7	IP No. 6057, IP No. 6069		
		Oblanceolate	8	IP No. 669, IP No. 12608		
		Globose	9	IP No. 2789, IP No. 8031		
24	Spike: tip sterility	Absent	1	842B, H 77/29-2	Maturity (75)	VS
		Present	9	841B, ICMB 02333		
25 (*)	Spike: density	Loose	3	RHRB 13B	Maturity (75)	VG
		Semi-compact	5	HHB 67 Imp., G 73-107		
		Compact	7	MPMH 17, H 90/4-5		

S. no.	Characteristics	State	Note	Example variety/ line (new)	Stage of observation	Type of assessment
26 (*)	Seed: color	Whitish	1	IP No. 14683, IP No. 19349	After harvest (00)	VG
		Cream	2	WGI 52, WGI 148		
		Yellow	3	IP No. 8681, IP No. 20770		
		Gray	4	842B, GHB 538		
		Deep gray	5	Pratap		
		Gray brown	6	RIB 335/74		
		Yellow brown	7	HHB 67 Imp., MIR525-2		
27 (*) (+)	Seed: shape	Obovate	3	H 90/-5, RHRBI 1314	After harvest (00)	VG
		Elliptical	5	IP No. 3082, IP No. 11902		
		Hexagonal	7	ICMB 02333		
		Globular	9	842B, GHB 538		
28 (*)	Seed: weight of 1,000 grains (g)	Very low (<5)	1	IP No. 3089, IP No. 15352	After harvest (00) at 10% moisture content	
		Small (5.0-7.5)	3	H77/29-2, J 2467		
		Medium (7.6-10.0)	5	RHRBI 1314, G 73-107		
		Bold (10.1-12.5)	7	Proagro 9444, Nandi 61		
		Very bold (>12.5)	9	IP No. 10437, IP No. 22278		

MG = measurement by a single observation of a group of plants or parts of plants.

MS = measurement of a number of individual plants or parts of plants.

VG = visual assessment by a single observation of a group of plants or parts of plants.

VS = visual assessment by observation of individual plants or parts of plants.

** Characteristics that should be observed during every growing period on all varieties and should always be included in the description of the variety, except when the state of expression of any of these characteristics is rendered impossible by a preceding phenological characteristic or by the environmental conditions of the testing region. Under such exceptional situations, an adequate explanation should be provided.*

+ Please refer to characteristics in the descriptor.

Source: 1. Pearl millet descriptor: https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Descriptors_for_pearl_millet__Pennisetum_glaucum__L._R._Br._157.pdf

2. Protection of Plant Varieties and Farmers Rights' Authority. 2015. Revised guidelines for the conduct of test for distinctiveness, uniformity and stability on pearl millet (Pennisetum glaucum L.). Protection of Plant Varieties and Farmers Rights' Authority (PPV & FRA), Government of India, 51 p.

Pearl millet field

PLANT DESCRIPTION

Pearl millet is an annual highly tillering C4 plant, which can grow to a height of 1-4 m, depending on the cultivar. The leaves are long, scabrous, rather slender, and may be smooth or have a hairy surface. Inflorescence is a cylindrical spike that varies in length from a few centimeters to more than a meter depending on the cultivar. It is densely packed with groups of spikelets varying in number from two to five but generally two. The spikelets are surrounded by an involucre of bristles. Each spikelet can contain two flowers or florets, partly protected by glumes. The lower floret is staminate (male) and the upper floret is bisexual.

Pearl millet is a naturally cross-pollinating species, which is achieved through protogyny. In the spike, in all flowers, stigmas exsert first over a 1-3-day period, progressing on either side from the upper two-thirds of the spike. Anthesis occurs 1 to as many as 4 days later, in the same sequence. Some self-pollination can occur upon stigma emergence on later-flowering tillers that overlap with the anthesis of earlier heads on the same plant. About 20% selfing is normal. Seeds are small and their shape can range from globular to conical. Seed color varies from ivory to purplish black, with light to deep gray being the most common color.

Pearl millet seeds

LAND PREPARATION

- Choose fields that were not under millet cultivation during the previous two years to
- decrease risk of volunteer plants.
- Fields should have good drainage. Excessively high or low soil moisture content can harm seed production plot
- Hard pan and compaction restrict root development.
- Land preparation should ensure that all crop residues, crop volunteers, and weeds are completely buried. Soils seriously infected with witch-weed (Striga sp.) must be avoided.
- Prepare the land to a fine tilth by deep ploughing, followed by three to four harrowings.

FERTILIZER APPLICATION:

1. Nitrogen (N): @ 100 kg/ha in three splits:
   a. Basal dose at the time of sowing @ 30kg/ha
   b. First top dressing @ 40 kg/ha 30-35 days after sowing
   c. Second top dressing @ 30 kg/ha (1/3rd) at the time of booting/just before flowering

Urea is better option for the top dressings

2. Phosphorus (P_2O_5): Basal dose @ 60 kg/ha
3. Potassium (K_2O): Basal dose @ 40 kg/ha
4. Zinc (as $ZnSO_4$): Basal dose @10-15 kg/ha in Zn deficient soils

ISOLATION

Because pearl millet is a highly cross-pollinated crop, the seed crop must be sufficiently isolated from the same or other contaminating crops. For open-pollinated varieties, the minimum isolation distance is as below for different grades of seeds.

SOWING

As pearl millet tillers profusely, rows should be spaced

Pearl millet panicle

Contaminants	Minimum distance (m) Foundation seed	Certified seed
Fields of other varieties	400	200
Fields of the same variety not conforming to varietal purity requirements for certification	400	200

75-90 cm apart with 15-20-cm spacing between plants within the row. The required seed rate varies from 3 to 9 kg/ha depending on spacing. Pearl millet can be sown directly or transplanted. Seed drills can be used for direct sowing. Seeds should be sown approximately 2 cm deep. Sowing equipment should be thoroughly cleaned to avoid contamination between cultivars. For transplanting, seeds are sown on a raised nursery bed, usually at 10 cm to facilitate safe uprooting of seedlings for transplanting. Seeds are sown in rows approximately 15 cm apart. Seedlings are transplanted in the field at 18-20 days. Transplanting of seedlings older than 20 days might result in less effective tillers.

Harvested spikes of pearl millet

ROGUING

This is a regular exercise in all crops for seed production and has been mentioned in an earlier section in detail.

HARVESTING

Seed moisture content is a good indicator of the optimum time of harvest. It is advisable to allow moisture content to fall to 15% before harvest. Pearl millet is susceptible to sprouting in the ear and harvest should not be delayed if the weather is likely to be unfavorable. Larger fields can be harvested by combines. Combines must be adjusted to properly thresh the small seed of pearl millet. For smaller areas, hand harvesting is common.

PEARL MILLET SEED STANDARDS

Factor	Standards for each class	
	Foundation seed	Certified seed
Pure seed (minimum)	98.00%	98.00%
Inert matter (maximum)	2.00%	2.00%
Other crop seed (maximum)	10/kg	20/kg
Weed seed (maximum)	10/kg	20/kg
Ergot sclerotia, seed entirely or partially modified as sclerotia, broken sclerotia, or ergot in seed (maximum)	0.02% (by number)	0.04% (by number)
Germination (minimum)	75%	75%
Moisture content (maximum)	12.00%	12.00%
For vapor-proof containers (maximum)	8.00%	8.00%

SEED YIELD

Average seed yield varies from 1,000 to 1,500 kg/ha.

SEED PRODUCTION OF SORGHUM *(SORGHUM BICOLOR)*

Seed production procedures for all crops have to strictly follow standard seed production techniques and certification; however, procedural variation for specific crops happens in view of the technical requirements of specific crops due to floral variation and behavior. The detailed requirements for producing quality sorghum seed follow.

CLIMATE AND SOIL

Sorghum requires warm temperatures throughout growth. Temperatures from 25 to 30 °C are best suited for seed production. Low temperatures (<15 °C) or high temperatures (>35 °C) during flowering and seed formation lead to poor seed set, problems with ripening, and diminished yield. Avoid areas where rain is likely to occur during seed maturation before harvest as molds develop on ripening heads and discolor the seeds. Sorghum is a short-day plant, but day-neutral varieties exist. Sorghum can be grown on a wide range of soils: from clay to light sand, but light- to medium-textured soils are best suited for sorghum cultivation. The soil should preferably be well aerated and well drained. Although optimum pH for production is 6.2-7.8, satisfactory growth and acceptable yield can be obtained in soil with pH from 5.0 to 8.3. Sorghum is relatively tolerant of short periods of waterlogging.

DUS TRAITS FOR SORGHUM

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
1 (*)	Leaf sheath: anthocyanin pigmentation	Absent	1	AKMS 14B	Fifth leaf (15)	VS
		Present	9	Pant Chari 4		
2	Leaf: midrib color (fifth fully developed leaf from bottom)	White (RHS 155-N 155)	1	SPV462, JJ 1041	Fifth leaf (15)	VS
		Yellow-green (RHS 144-144N)	2	CS 3541		
		Grayed yellow (RHS 162)	3	IS 18541, IS 2060		
		Grayed purple (RHS 183-N187)	4	IC 568372		
		Brown (RHS 199-N199)	6	SPV 2018		
3 (*)	Plant: time to 50% flowering (50% of plants with 50% anthesis)	Very early (<56 days)	1	GFS 4	Panicle emergence (60-68)	VG
		Early (56-65 days)	3	CSH 14		
		Medium (66-75 days)	5	CHS 16		
		Late (76-85 days)	7	Pant Chari 5		
		Very late (>85 days)	9	SSV 84		

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
4 (*)	Flag leaf: coloration of midrib	White (RHS 155-N 155)	1	PVK 400, Co-S-28	Panicle emergence (60-68)	VS
		Yellow Green (RHS 144-144N)	5	27B		
		Brown (RHS 199-N199)	7	SPV 2018		
5 (*)	Lemma: arista formation	Absent	1	CS 3541	Flowering (68)	VS
		Present	9	296B		
6 (*)	Stigma: yellow coloration	Absent	1	CS 3541	Flowering (68)	VS
		Present	9	27B		
7 (*)	Stigma: length (mm)	Short (<1)	3	AKMS14B	Flowering (68)	MS
		Medium (1-2)	5	IMS 9B		
		Long (>2)	9	MAN T1		
8 (+)	Flower with pedicel: length of flower	Short	3	-	Flowering (68)	VS
		Medium	5	CS 3541		
		Long	7	27B		
		Very long	9	SSG 59-3		
9	Anther: length (mm)	Short (<3)	3	C 43	Flowering (68)	MS
		Medium (3-4)	5	27B		
		Long (>4)	7	-		
10	Stem/leaf sheath: waxy bloom (epicuticular wax at upper one-third height of plant)	Absent	1	RS 647	Flowering (68)	VG
		Present	9	296B, 2077B		
11 (*)	Stigma: anthocyanin coloration	Absent	1	CS 3541	Upper portion of panicle at completion of anthesis (74)	VS
		Present	9	SSG 59-3		
12	Anther: color of dry anther	Yellow-orange (RHS 14-23)	1	2219B	End of flowering (75)	VG
		Orange (RHS 24-29)	2	CS 3541		
		Orange-red (RHS 30-35)	3	-		
		Grayed orange (RHS 163-177)	5	CSH 16		

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
13 (*) (+)	Glume: color	Yellow-white (RHS 157-158)	2	2077B	Physiological maturity (105)	VG
		Grayed yellow (RHS 160-162)	3	Pant Chari 5		
		Grayed orange (RHS 163-177)	4	UPMC 503		
		Grayed red (RHS 178-182)	5	IC 585210, IC		
		Grayed purple (RHS 183-N187)	6	Pant Chari 4		
14 (*)	Plant: total height (cm) at maturity (including panicle)	Very short (<76)	1	IS 40107, IS 3920	Physiological maturity (105)	MS
		Short (76-150)	3	2219B		
		Medium (151-225)	5	RS 673		
		Tall (226-300)	7	GJ 39		
		Very tall (>300)	9	IS 3828, IC 333381		
15	Stem: diameter (at lower one-third height of plant) (cm)	Small (<2)	3	CS 3541	Physiological maturity (105)	MS
		Medium (2-3)	5	2077B		
		Large (3.1-4.0)	7	IS 2806, IC 568477		
		Very large (> 4)	9	-		
16	Leaf: length of blade (third leaf from top, including flag leaf) (cm)	Short (< 40)	3	IC 596016	Physiological maturity (105)	MS
		Medium (40-60)	5	2219B		
		Long (60.1-80.0)	7	CS 3541		
		Very long (>80)	9	CSH18		
17	Leaf: width of blade (third leaf from top, including flag leaf) (cm)	Narrow (<4)	3	GFS 4	Physiological maturity (105)	MS
		Medium (4-6)	5	IS 965, IS 1025		
		Broad (6.1-8.0)	7	CSV 17		
		Very broad (>8)	9	CSH 16		
18 (*)	Panicle: length without peduncle (cm)	Very short (<10)	1	IC 568440, IS 1067	Physiological maturity (105)	MS
		Short (10-20)	3	SSV 84		
		Medium (20.1-30.0)	5	CS 3541		
		Long (30.1-40.0)	7	IMS 9B		
		Very long (>40)	9	SSG 59-3		
19	Panicle: length of branches (middle third of panicle) (cm)	Short (< 5)	3	Surat 1	Physiological maturity (105)	MS
		Medium (5-10)	5	CS 3541		
		Long (10.1-15.0)	7	2077B		
		Very long (>15)	9	SSG 59-3		

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
20 (*)	Panicle: density at maturity (ear-head compactness)	Very loose	1	SSG 59-3	Physiological maturity (105)	VG
		Loose	3	Pant Chari 4		
		Semi-loose	5	CHS 16		
		Compact	7	C 43		
		Very compact	9	Surat 1		
21 (*) (+)	Panicle: shape	Reversed pyramid	1	IC 585172, IC 585175	Physiological maturity (105)	VG
		Panicle broader in upper part	2	JJ741		
		Symmetric	3	CSH 9		
		Panicle broader in lower part	4	MAN T1		
		Pyramidal	5	SSG 59-3		
22 (*)	Neck of panicle: visible length above sheath (cm)	Absent or very short (<5)	1	296B	Physiological maturity (105)	MS
		Short (5-10)	3	JJ 1041		
		Medium (10.1-15.0)	5	Pant Chari 4		
		Long (15.1-20.0)	7	GJ 37		
		Very long (>20)	9	CSH 16		
23 (+)	Glume: length	Very short (25% of grain covered)	1	CSH 9	Physiological maturity (105)	VS
		Short (50% of grain covered)	3	CSV 15		
		Medium (75% of grain covered)	5	2219B		
		Long (100% of grain covered)	7	SSG 59-3		
		Very long (longer than the grain)	9	IC 585147, IC 585155		
24	Plant: pigmentation (at lower one-third height of plant)	Tan	1	C 43, CSV 15	Physiological maturity (105)	VG
		Non-tan	9	M 35-1, CSV 18		
25 (+)	Grain: threshability	Freely threshable (<10% unthreshed grain)	1	C 43	Maturity (110)	VG
		Partly threshable (11-50% unthreshed grain)	5	MR 750		
		Difficult to thresh (51-70% unthreshed grain)	7	SSG 59-3		
		Very difficult to thresh (>70% unthreshed grain)	9	IS 11, IS 12, 1S 37		

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
26 (*)	Grain: color after threshing	White (RHS 155)	1	MAN T1	After threshing (00)	VG
		Grayed white (RHS 156)	2	Pant Chari 4		
		Yellow-white (RHS 158)	3	Pant Chari 5		
		Yellow-orange (RHS 14-20)	4	27B		
		Grayed orange (RHS 163-173)	5	UPMC 503		
		Grayed red (RHS 178-182)	7	Paiyur 2, IS 3163		
		Black (RHS 202-203)	9	IS 25040		
27 (+)	Grain: weight of 1,000 grains (g)	Very low (< 16)	1	SSG 59-3	After threshing (00)	MG
		Low (16-25)	3	2219B		
		Medium (25.1-35.0)	5	C 43		
		High (35.1-45.0)	7	IS 62, IS 3457		
		Very high (>45)	9	IS 3589, IS 22361		
28 (*) (+)	Grain: shape (in dorsal view)	Narrow elliptic	1	SSG 59-3	After threshing (00)	VG
		Elliptic	2	2219B		
		Circular	4	27B		
29 (+)	Grain: size of mark of germ	Very small	1	-	After threshing (00)	VG
		Small	3	RS 29		
		Medium	5	296B		
		Large	7	C 43		
		Very large	9	DSV 4		
30 (*)	Grain: texture of endosperm (in longitudinal section)	Fully vitreous (100% corneous)	1	IS 67, IS 74, IS 1059	After threshing (00)	VG
		Three-fourths vitreous (75% corneous)	3	IS 158, IS 190		
		Half vitreous (50% corneous)	5	AKMS 1B		
		Three-fourths farinaceous (25% corneous)	7	296B		
		Fully farinaceous (0% corneous)	9	IS 60, IS 170, IS 206		
31	Grain: color of vitreous albumin	Grayed yellow (RHS 160-162)	1	AKMS 14B	After threshing (00)	VG
		Grayed orange (RHS 164-166)	2	SSG 59-3, UPMC 503		
		Grayed purple (RHS 187-N187)	3	Pant Chari 4		

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
32 (*)	Grain: luster	Non-lustrous	1	296B	After threshing (00)	VH
		Lustrous	5	CS 3541		
		Highly lustrous	7	M 35-1		

In addition to the above 32 characteristics, the following characteristics are to be assessed in case of candidate varieties of forage or sweet sorghum types.

APPLICABLE TO FORAGE SORGHUM ONLY

S. no.	Characteristics	State	Note	Example variety/line	Stage of observation	Type of assessment
33	Plant: tillering ability	No tillers	1	Pant Chari 5	45 days after emergence -45	MS
		Few tillers (1-4)	3	Pant Chari 23		
		Many tillers (> 4)	5	SSG 59-3		

APPLICABLE TO SWEET SORGHUM ONLY

S. no.	Characteristics	States	Note	Example variety/line	Stage of observation	Type of assessment
34 (+)	Stem: juice brix (%)	Low (12-15)	1	IS 3076, IS 10284	Physiological maturity (105)	MS
		Medium (15.1-18.0)	3	SSV 84		
		High (18.1-21.0)	5	SPSSV 30		
		Very high (>21)	7	IS 19303, IS 1481		

MG = measurement by a single observation of a group of plants or parts of plants.

MS = measurement of a number of individual plants or parts of plants.

VG = visual assessment by a single observation of a group of plants or parts of plants.

VS = visual assessment by observation of individual plants or parts of plants.

** Characteristics that should be observed during every growing period on all varieties and should always be included in the description of the variety, except when the state of expression of any of these characteristics is rendered impossible by a preceding phenological characteristic or by the environmental conditions of the testing region. Under such exceptional situations, adequate explanation should be provided.*

+ Please refer to characteristics in the descriptor.

Source:

1. Sorghum descriptor (https://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-sorghum-sorghum-bicolor-l-moench/).

2. Protection of Plant Varieties and Farmers Rights' Authority. 2015. Revised guidelines for the conduct of test for distinctiveness, uniformity and stability on sorghum (Sorghum bicolor (L.) Moench.). Protection of Plant Varieties and Farmers Rights' Authority (PPV & FRA), Government of India, 25 p.

Sorghum field

PLANT DESCRIPTION

Sorghum is a highly diverse crop, varying markedly in height, leaf size, panicle shape, seed color, and a host of other traits. The leaves are relatively broad and are covered with a waxy layer. Sorghum inflorescence varies from a compact to an open panicle, ranging from 7.5 to 50 cm in length and up to 15 cm in width. Spikelets usually occur in pairs, one being sessile and the second borne on a short pedicel. The sessile spikelet contains a perfect flower and the pedicellate spikelet is usually sterile. Flowering starts in the uppermost panicle branches and progresses downward. It may take 6-9 days for all flowers in the panicle to finish blooming. Stigmas become receptive 1-2 days before flowering. Seeds are more or less spherical to somewhat flattened on the side and range in color from white to red.

CLIMATE AND SOIL REQUIREMENTS

Sorghum requires warm temperatures throughout growth. Temperatures from 25 to 30 °C are best suited for seed production. Low temperatures (<15 °C) or high temperatures (>35 °C) during flowering and seed formation lead to poor seed set, problems with ripening, and diminished yield. Avoid areas where rain is likely to occur during seed maturation before harvest as molds develop on ripening heads and discolor the seeds. Sorghum is a short-day plant, but day-neutral varieties exist. Sorghum can be grown on a wide range of soils, from clay to light sand, but light- to medium-textured soils are best suited for sorghum cultivation. The soil should preferably be well aerated and well drained. Although optimum pH for production is 6.2-7.8, satisfactory growth and acceptable yield can be obtained in soil with pH from 5.0 to 8.3. Sorghum is relatively tolerant of short periods of waterlogging.

FIELD PREPARATION

Select fields in which sorghum was not grown in the previous year. The field should have good drainage and be free from weeds at the time of sowing. Prepare the land to a fine tilth by deep ploughing, followed by three to four harrowings.

FERTILIZER APPLICATION:

1. Nitrogen (N): @ 150 kg/ha in three splits:
   a. Basal dose at the time of sowing @ 60kg/ha
   b. First top dressing @ 45 kg/ha at tillering stage
   c. Second top dressing @ 45 kg/ha at the time of booting/just before flowering

Urea is better option for the top dressings

2. Phosphorus (P_2O_5): Basal dose @ 60 kg/ha
3. Potassium (K_2O): Basal dose @ 50 kg/ha
4. Sulphur (S): S-deficient soils (<10 ppm available S), the application of 40-60 kg S/ha is advantageous
5. Organic fertilizers (Compost or Farmyard Manure): An application of 15-30 t/ha well-decomposed organic matter suffice the crop's nutrient requirements

ISOLATION

Sorghum is generally a self-pollinating crop but cross-pollination up to 5-6% can occur, depending on the variety and environment. Therefore, isolation of the seed crop is necessary. The recommended isolation distances for open-pollinated sorghum follow.

Contaminants	Minimum distance (m)	
	Foundation seed	Certified seed
Fields of other varieties	200	100
Fields of the same variety not conforming to varietal purity requirements for certification	200	100
Forage sorghum with high tillering and grassy panicle	400	400

SOWING

The crop should be sown in rows. For optimum light interception, 100,000 to 150,000 plants/ha are recommended. Accordingly, rows can be 45-75 cm apart (with wider spacing where water is in short supply), with plant-to-plant distance about 15 cm in the row. The depth of sowing should be 3-4 cm. The required seed rates vary from 12 to 15 kg/ha, depending on spacing.

ROGUING

This is a regular exercise in all crops for seed production and has been mentioned in an earlier section in detail.

HARVESTING

Harvesting should be done when the seed hardens and moisture content falls below 15%. Sorghum is very prone to sprouting on the ear in wet weather, so harvest the crop at the first opportunity. Sorghum can be harvested by hand if the fields are small. The heads are cut and left to dry before threshing on a clean drying floor. Heads dried on a drying floor should not be spread more than 20 cm deep and should be turned frequently. The ear-heads are often threshed manually using wooden sticks or mallets to separate the seeds. Tractor wheels or metal-disk threshers can also be employed. Winnowing against wind separates the glumes and ear-head chaff. Large areas are harvested by combine. This method is particularly suitable for the more uniform and short-statured cultivars.

Sorghum seeds

Sorghum panicle

SORGHUM SEED STANDARDS

Factor	Standards for each class	
	Foundation seed	Certified seed
Pure seed (maximum)	98.00%	98.00%
Inert matter (maximum)	2.00%	2.00%
Other crop seed (maximum)	5/kg	10/kg
Weed seed (maximum)	5/kg	10/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Ergot (Claviceps spp.), sclerotia, seed entirely or partially modified by sclerotia, broken sclerotia, or seed with ergot (Sphacelia sorghi McRae and Claviceps spp.) (maximum)	0.02% (by number)	0.04% (by number)
Germination (minimum)	75%	75%
Moisture content (maximum)	12.00%	12.00%
For vapor-proof containers (maximum)	8.00%	8.00%

SEED YIELD

A good yield under irrigation is 3.5-5.0 tons/ha. Under rainfed conditions, with little or no rainfall, yield varies from 800 to 1,300 kg/ha.

SEED PRODUCTION OF COWPEA *(VIGNA UNGUICULATA)*

Seed production procedures for all crops have to strictly follow standard seed production techniques and certification; however, procedural variation for specific crops happens in view of the technical requirements of specific crops due to floral variation and behavior. The detailed requirements for producing quality cowpea seed follow.

CLIMATE AND SOIL REQUIREMENTS

Cowpea is well adapted to many areas of the humid tropics and temperate zones. It thrives from 20 to 35 °C but not lower than 15 °C. Cowpea tolerates heat and dry conditions. However, temperatures above 38 °C can adversely affect fertilization and pod-set. Cowpea performs well on a wide range of soils and soil conditions, but performs best on well-drained sandy loams or sandy soils where soil pH is in the range of 5.5-6.5. Seeds will decay if sown in cool and wet soils.

Each variety is rogued throughout its growth stages based on the specific DUS characteristics linked with that specific variety. Cowpea has a lot of DUS traits that can be found in this article (https://www.ijcmas.com/abstractview.php?ID=8281&vol=7-6-2018&SNo=134). However, details for all of the traits can be found in its descriptor *(https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Descriptors_for_cowpea_377.pdf)*.

PLANT DESCRIPTION

Cowpea is an important crop in many arid and semi-arid regions because of its tolerance of drought. Plant types are often categorized as erect, semi-erect, prostrate (trailing), or climbing (viney). The leaves are trifoliolate and smooth and vary in size and shape, depending on the cultivar. Cowpea generally is day-neutral. Flowers are borne in multiple racemes on long flower stalks (peduncles) that arise from the leaf axil. Two or three flowers per peduncle are common. The pods are smooth,

Cowpea plants

15-25 cm long, cylindrical, and generally somewhat curved. Pod color becomes tan or brown with drying.

FIELD PREPARATION

Select fields in which cowpea was not grown in the previous season. The fields should be prepared well by deep ploughing and one or two harrowings, followed by leveling. Cowpea emergence can be adversely affected by soil crusting.

FERTILIZER APPLICATION:

Cowpea is a leguminous crop hence need nitrogenous fertilizer only at the initial development stage of plant. Later the root nodules make the sufficient nitrogen needed by plant through biological nitrogen fixation.

Contaminants	Minimum distance (m)	
	Foundation seed	Certified seed
1	2	3
Fields of other varieties	10	5
Fields of the same variety not conforming to varietal purity requirements for certification	10	5

Cowpea seeds

1. Nitrogen (N): Basal dose @ 30 kg/ha
2. Phosphorus (P_2O_5): Basal dose @ 30 kg/ha
3. Potassium (K_2O): Basal dose @ 45 kg/ha

ISOLATION

Cowpea is a self-pollinating crop; therefore, less isolation distance is required for genetic purity of varieties. Details on the spatial isolation required for different grades of varieties are as follows.

SOWING

Cowpea should be seeded in rows spaced 45-60 cm apart. The optimum distance between plants within a row is 10-15 cm. Seed should be planted 2-4 cm deep. In climbing and prostrate cultivars, seed is sown in rows 75 cm apart and at approximately 15 cm within rows. Climbing types require support of 2 m high. The recommended seeding rates range from 20 to 25 kg/ha for climbing and prostrate types and from 45 to 50 kg/ha for the others.

ROGUING

This is a regular exercise in all crops for seed production and has been mentioned in an earlier section in detail.

HARVESTING

Cowpea pods are ready for harvest when they turn yellowish brown and seeds become firm. Fruiting extends over a long period of time. Therefore, hand picking of pods is common. Depending on the span of maturity of the cultivar, more than two pickings may be necessary. Cultivars that mature relatively uniformly can be cut and left in windrows for further drying. Crops left in windrows can either be picked up with a combine or taken to a stationary thresher. Care must be taken during threshing to minimize mechanical damage to the seeds.

DRYING AND STORAGE

Seed requires drying if the moisture content is above 13%. This can be done on a drying floor. The air temperature should not exceed 35 °C when seed is artificially dried. The seed moisture content should be further decreased to 8-10% for longer-term storage in vapor-proof containers.

Pods of cowpea

SEED YIELD

Average seed yield varies from 1.5 to 2.0 t/ha.

COWPEA SEED STANDARDS

Factor	Standards for each class	
	Foundation seed	Certified seed
Pure seed (minimum)	98.00%	98.00%
Inert matter (maximum)	2.00%	2.00%
Other crop seed (maximum)	None	10/kg
Other distinguishable varieties (maximum)	None	10/kg
Weed seed (maximum)	10/kg	10/kg
Germination (minimum)	75%	75%
Moisture content (maximum)	9.00%	9.00%
For vapor-proof containers (maximum)	8.00%	8.00%

SEED PRODUCTION OF BUFFEL GRASS *(CENCHRUS CILIARIS)*

Buffel grass growing in a field

Seed production procedures for all crops must strictly follow standard seed production techniques and certification; however, procedural variation for specific crops happens in view of the technical requirements of specific crops due to floral variation and behavior. The detailed requirements for producing quality buffel grass seed follow.

CLIMATE AND SOIL

Buffel grass is a short-day plant. The distributional range of the species has average annual temperatures from 12 to 28 °C. Optimal temperature for growth is 35 °C and the minimum is from 5 to 16 °C. Buffel grass often occurs in the wild on sandy soils, but is also well adapted to a wide range of other soils. Although slow to establish on hard and heavy clay soils, once established, it grows well. The optimum soil pH is 7-8, but it can grow on soils with pH as low as 5.5. It does have moderate tolerance of salinity (threshold of 4.0 dS/m), but not as good as that of Rhodes grass.

ISOLATION DISTANCE

Contaminants	Minimum distance (m)	
	Foundation seed	Certified seed
Fields of other varieties of the same species	20	20
Fields of the same variety not conforming to varietal purity requirements for certification	20	20
Fields of another Cenchrus sp. known to cross or suspected of being able to cross	200	100

PLANT DESCRIPTION

Buffel grass is a perennial grass growing to 20 to 120 cm tall. The leaves are linear, 3 to 25 cm long and 4 to 10 mm wide. The flowers are produced in a panicle 2 to 14 cm long and 1.0 to 2.6 cm wide. Good details of buffel grass description can be found at *https://wildlife.lowecol.com.au/wp-content/uploads/sites/25/PIRSABuffelGrassIdentification.pdf.*

LAND PREPARATION

Establishment can be poor on overprepared, very fine seedbeds and on hard-setting soils. On well-prepared seedbeds, the seed is broadcast onto the surface and covered by soil to a maximum depth of 10 mm by light harrowing. It can also be sown through a grass air-seeder, modified fertilizer spreader, or modified combine. Mixing with fertilizer, cracked grain, or using

Buffel grass panicle

Buffel grass seeds

pelleted seed improves distribution through air-seeders and combines. Buffel grass germination relies on good soil moisture after planting. The seed must maintain contact with wet soil for 4-5 days to produce a seedling. In dry areas, irrigation may be required. Buffel grass can also be established vegetatively from "splits."

Buffel grass seed threshing with a rubbing board

FERTILIZER APPLICATION:

Buffel grass has very high fertilizer requirement especially for nitrogen and phosphorus to attain maximum yield potential.

1. Nitrogen (N): Basal dose @ 150 kg/ha followed by subsequent dose of 50kg/ha after 8 and sixteen weeks of establishment.
2. Phosphorus (P2O5): Basal dose @ 100 kg/ha

SOWING

Buffel grass is usually sown using the broadcasting method. For row planting, the row-to-row and plant-to-plant distance should be 50 cm.

ROGUING

This is a regular exercise in all crops for seed production and has been mentioned in an earlier section in detail.

HARVESTING

Buffel grass cultivars with purple seed heads are best harvested when the heads begin to lighten in color. For other cultivars, a good test for harvest is to draw the head downward between the fingers. If the seed is stripped reasonably easily, it is mature. Once the head turns almost white, the seed detaches too easily and a high proportion is blown away by wind.

In small plots, harvesting can be done by hand by stripping mature seed heads into paper bags. To extract seeds, seed heads can be placed on a piece of plywood lined with corrugated rubber floor matting and a rubbing board also covered with corrugated rubber moved back and forth across the seed heads. The threshed seed usually contains trash, which can be removed by winnowing or using air/screen cleaners.

STORAGE

Fresh seed often has a high level of dormancy. Germination rate can be improved with storage of 6-18 months after harvest or by separating caryopses from glumes. Total live seed content is commonly 30-50%.

SEED YIELD

Depending on growing conditions and variety, seed yield ranges from about 10 to 60 kg/ha.

Seed cleaning

BUFFEL GRASS SEED STANDARDS

Factor	Standards for each class	
	Foundation seed	Certified seed
Pure seed (minimum)	98.00%	98.00%
Inert matter (maximum)	2.00%	2.00%
Other crop seed (maximum)	10/kg	20/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Weed seed (maximum)	10/kg	20/kg
Germination (minimum)	85%	85%
Moisture content (maximum)	12.00%	12.00%
For vapor-proof containers (maximum)	8.00%	8.00%

For more information, please contact us at:

PO Box 14660, Dubai, United Arab Emirates
+971 4 336 1100
+971 4 336 1155
icba@biosaline.org.ae
www.biosaline.org

ICBAAgriculture