Seed laws are also a reflection of government policy towards private seed enterprise and agriculture in general. The main purposes of seed legislation are to regulate the following aspects of the seed industry.

a. Cultivar listing
b. Seed production
c. Seed conditioning
d. Seed testing
e. Seed marketing

The major benefits of seed legislation are to:

1. Protect the farmer against the risk of buying poor quality seed.
2. Protect the seller when he is not at fault.
3. Safeguard the farmer against fraud, negligence, or accident.
4. Help raise agricultural productivity.
5. Regulate the seed industry and create healthy competition.
6. Ensure good germination ratios and normal stand establishment.
7. Ensure the purity of seed from visible and invisible contaminants.

By law, good seed should:

1. Be of a suitable cultivar.
2. Be of a satisfactory level of genetic and physical purity.
3. Contain a few or no weed seeds.
4. Be free from seed-borne diseases.
5. Have an acceptable level of germination.

6.6 Seed quality

Seed quality is the sum of all attributes contributing to seed performance. The quality of seed can decide whether a farmer's crop will be good, bad, or indifferent. Seed quality is determined by the following characteristics.

1. Genetic purity
2. Physical purity
3. Germination percentage or viability
4. Incidence of seed-borne diseases
5. Density (weight per volume or number)
6. Vigour
7. Moisture content
8. Storability

Genetic or cultivar purity is very important because it is through pure and true-to-type seed that farmers can reap the fruits of the breeder's efforts. Physical purity refers to the kind or variety in the mixture of a seed lot.[2] Seed lots contain impurities of various sorts, including other-crop seed, weed seed, and inert matter. Impure seeds when used by farmers result in poor crops and low income for the farmer.

Viability of seed is a measure of its ability to germinate and produce plants. A good quality seed must not only have a high viability ratio but also produce normal seedlings. Seed viability is affected by relative humidity, temperature, direct sunlight on the seed, kind of seed, number and kind of fumigations (if) done, seed treatment, and attack of insect or rodent pests.

The incidence of seed-borne diseases is an important and much neglected part of seed quality evaluation. If disease is not prevented or controlled in the early stage, a single diseased seed will produce numerous diseased seeds and may result in the failure of the entire crop. Seed must therefore be treated against such diseases before planting.

The seeds should be homogenous and preferably uniform in size and maturity. They should be large and heavy but not excessively moist. Abnormal moisture in the storage area invites moulds and fungi and results in heating up of the storage area. Therefore, the seed should be dried to the level necessary for safe storage.

In a broad sense, vigour is a measure of the physiological stamina or health of seed. Seed vigour can be defined as the emergence and

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[2]**Inert matter.** Inert matter includes fragments of seed or seedlike structures from both crop and weed plants and other non-seed matter, for example: (a) seeds of legumes, crucifers, and conifers with the seed coat entirely removed; (b) pieces of broken and damaged seed units, including those that are insect-damaged and half the original size or less. Also included are separated cotyledons of legumes irrespective of whether or not the embryonic axis and/or more than half of the seed coat is attached; (c) glumes and empty florets; (d) seed units with nematode galls or fungus bodies protruding from the tip of the seed unit. Also included are ergot and smut-filled caryopses; (e) fruit portions or fragments of monogerm beets and New Zealand spinach.

Pure seed. Pure seed includes all seeds of each kind and/or cultivar under consideration which are present in excess of 5% of the whole unless labelled as a component of the mixture. The following shall also be considered as pure seed. (a) Immature or shriveled seeds and seeds that are cracked or otherwise damaged. This does not include legumes, crucifers, and conifers with the seed coats entirely removed. (b) Pieces of broken and otherwise damaged seeds which are larger than one-half of the original size. (c) Insect-damaged seeds provided the damage is entirely internal or that the opening in the seed coat is not sufficiently large to allow the size of the remaining mass of tissue to be readily determined. (d) Seeds that have started to germinate. (e) Seeds of Cucurbitaceae and Solanaceae whether or not they are filled. (f) Intact fruits whether or not they contain a seed, of species of the following families: sunflower, mint, carrot, and other families in which the seed unit may be a dry, indehiscent, one-seeded fruit. (g) Seed units of the grass family as per rules for seed. (h) Seed units with nematode galls, fungus bodies, and spongy or corky caryopses which are entirely enclosed within the seed unit. (i) Seed units of beets, etc.; a seed unit is the structure usually regarded as a seed in planting practices and in commercial channels.

development of a normal seedling under prescribed conditions, which for the kind of seed in question are indicative of superior ability to produce healthy, productive plants under a wide range of field conditions. Speed of germination and rate of seedling growth may provide some evidence of vigour, but for accurate determination of vigour special tests are recommended.

Storability of seed depends upon the kind of seed, its moisture content, temperature of the environment, and treatment of the seed. Some seeds will deteriorate more quickly than others even if kept under ideal conditions. Oilseeds are difficult to store for a long time. Some seeds are mechanically injured at the time of harvesting and processing. Such seeds are vulnerable to insect and mould attacks and, therefore, quickly lose the ability to remain viable in storage.

6.6.1 Seed health testing

Like that of other living things, the health of seed depends on the presence or absence of disease-causing organisms such as fungi, bacteria, viruses, worms, and insects. Physiological disorders and trace-element deficiency may also be involved in causing unhealthy seeds.

In order to get information on the health status of a given seed lot, seed health testing is recommended. Seed health testing is performed for the following reasons. (a) Introduction or import of seeds sometimes introduces new diseases to a region. (b) Seed-borne diseases spread in the soil, causing harm to other plants and reducing the market value of the crop. (c) Seed health testing may identify the causes of poor germination or poor establishment of field stand.

Methods of seed health testing. These methods can be discussed under the following three main headings: (1) examination without incubation; (2) examination after incubation; (3) serological procedures.

1. EXAMINATION WITHOUT INCUBATION. This procedure reveals the presence or absence of pathogens, but it does not show their viability. Once their presence is revealed, pathogens can be examined by one of the following methods.

a. *Dry seed examination*. The samples are examined with or without a stereoscopic microscope and are searched for fungal, viral, and bacterial symptoms as well as nematodes, insects, mites, inert matter, damage, and discolouration of seed.
b. *Wet seed examination*. The seeds are immersed in water, and after swelling are examined either superficially or internally, preferably with a stereoscopic microscope.
c. *Examination of organisms removed by washing*. The sample is immersed in water with a wetting agent or in alcohol and shaken vigorously to

remove fungal spores and nematodes, etc. adhering to the seeds. The excess liquid is then removed and the extracted material examined with a compound microscope.

2. EXAMINATION AFTER INCUBATION. Seeds are incubated for a specific time and then examined for the presence of diseases, pests, and physiological disturbances in seeds or on seedlings. Three types of media are commonly used for incubation: (a) blotter, (b) sand/artificial compost, and (c) agar plates.

Seeds are placed on moistened blotters at least 20 mm apart and placed in closed containers or rolled and incubated for a specific period. After this period the blotters are unrolled and studied under magnification. Sand and artificial compost, etc. can be used to detect certain pathogens. These media bearing untreated seed are placed in a safe and isolated place favourable for symptom expression. Pretreated seed can also be incubated on the surface of sterilized agar (2% malt extract) in 95 mm petri dishes. Characteristic colonies on the agar can be identified either macroscopically or microscopically.

3. SEROLOGICAL PROCEDURES. Specialised methods involving serological reactions have also been developed for the identification of viruses and bacteria. Two such procedures are (a) Ouchterlony agar–gel double diffusion test and (b) latex flocculation test (agglutination test). Both of these methods seem to be very promising for testing seed health.

6.6.2 Principles for regulating seed quality

Truth-in-labelling. According to this philosophy, no legal limits on seed are imposed, but the seed must be labelled with potential purchaser information (consumer right-to-know) according to the results of tests. The following are characteristics of this philosophy.

a. Enforcement consists of checking the correctness of stated information (labels) on quality.
b. Truth-in-labelling is suitable in countries where farmers can understand the information on the labels and are capable of judging quality.
c. High-quality seed is expected to drive poor seed off the market.

Restrictive legislation. Minimum standards are set for each label requirement and:

a. Seed that falls short of any standard is banned from sale.
b. An enforcement authority (inspector) checks whether or not standards are met.
c. Restrictive legislation is suited to situations when farmers are unable to understand the information given on the labels.

Crop standards. Minimum certification standards for maintaining genetic purity and seed quality have been established for different crops. These standards have been divided into two groups.

1. FIELD STANDARDS: Include field history; isolation; inspections; estimation of diseases, off-types, and other crop plants; damage caused by lodging, insects, and pests.

2. LABORATORY STANDARDS: Every country has developed its own seed standards. These standards are established on the basis of laboratory tests of harvested seed samples in quantitative terms for the following factors.

1. Seed purity (minimum)
2. Inert matter (maximum)
3. Other crop seed (maximum)
4. Weed seeds (maximum)
5. Noxious weed seeds (maximum)
6. Germination (minimum)
7. Moisture content (maximum)

Minimum field and laboratory standards for certified and labelled seed of different crops are given in Tables 6.1 and 6.2. These standards have been established by the Federal Seed Certification Department.

Table 6.1 Minimum field standards for certified seed of major crops

CROP	ISO (m)	OT (%)	OCP (%)	WP (%)	SBD (%)	VD (%)
Wheat	3	0.10	0.05	0.02	0.20	NA
Rice (paddy)	3	0.10	NA	0.02	0.10	NA
Maize (hybrid)	200	0.50	NA	NA	NA	NA
Maize (composite and open pollinated	200	1.00	NA	NA	NA	NA
Sorghum (open pollinated)	3	0.10	0.05	0.02	0.10	NA
Pearl millets (hybrid open polli nated, composites and synthe- tics)	200	0.20	NA	None	0.10	NA
Cotton	10	0.20	NA	NA	NA	NA
Jute	20	1.00	NA	0.05	NA	NA
Berseem/alfalfa	50	1.00	NA	0.05	NA	NA
Sorghum and Sudan grass	200	0.05	NA	0.05	0.10	NA
Groundnut	10	0.50	NA	NA	NA	NA
Rape and mustard	200	0.20	NA	0.01	0.20	NA
Safflower	200	0.01	.03	0.01	NA	NA
Sesame	25	0.20	NA	NA	NA	NA

CROP	ISO (m)	OT (%)	OCP (%)	WP (%)	SBD (%)	VD (%)
Soybean	10	0.50	NA	NA	NA	NA
Sunflower (hybrid and open pollinated)	800	0.10	NA	NA	NA	NA
Cowpea	20	0.50	NA	NA	1.00	NA
Gram	10	0.50	NA	NA	1.00	NA
Mash/mung/*moth*	3	0.10	0.01	NA	NA	NA
Lentil (*masoor*)	10	0.10	0.01	NA	NA	NA
Cabbages (cauliflower, broccoli, Chinese cabbage, knol kohl)	1000	0.50	NA	NA	0.50	1.00
Cucurbits*	400	0.20	NA	None	0.20	0.50
Brinjal	200	0.20	NA	NA	0.50	NA
French bean	20	0.50	NA	NA	1.00	NA
Okra	250	0.20	NA	NA	NA	NA
Pepper	200	0.30	NA	NA	0.50	0.20
Tomato	10	0.50	NA	NA	0.50	0.20
Pea	20	0.50	NA	NA	NA	1.00
Coriander	500	0.20	NA	NA	NA	NA
Fenugreek	25	0.20	NA	0.10	0.20	NA
Lettuce	25	0.20	NA	0.10	0.20	NA
Spinach	300	0.20	0.10	None	NA	NA
Carrot	1000	0.20	NA	NA	NA	NA
Garden beet and sugar beet	1000	0.20	NA	NA	NA	NA
Radish	1000	0.20	NA	NA	0.20	0.20
Turnip	1000	0.20	NA	NA	0.20	0.20
Onion	800	1.00	NA	NA	NA	NA
Tobacco	400	0.10	NA	NA	NA	NA

* Ash gourd, white gourd, bitter gourd, bottle gourd, cucumber hybrid, long melon, muskmelon, pumpkin, squash gourd, red gourd, ridged gourd, sponge gourd, tinda, vegetable marrow, and watermelon.

ISO = Isolation distance
OT = Off-type
SBD = Seed-borne diseases
OCP = Other-crop plants
WP = Weed plants
VD = Viral diseases

Source: Adapted from Ahmad (1989b).

Table 6.2 Minimum laboratory standards for certified (C) and labelled (L) seed classes

Crop	PS %		IM %		OCS %		WS %		NWS %		G %		MC %
	C	L	C	L	C	L	C	L	C	L	C	L	
1. CEREALS AND MILLETS													
Wheat	98	97	2	2	.05	.01	5/kg	.1	NA	.05	85	75	12
Rice	98	97	1.5	2	NA	0.2	NA	.2	NA	.05	80	75	12
Barley	98	97	2	2.1	.10	0.1	.05	.1	NA	.05	85	75	12
Triticale	–	97	–	2	–	0.1	–	.1	–	.05	–	75	12
Sorghum	98	97	2	2	.10	0.1	.10	.1	NA	.05	80	70	–
Maize (hybrids)	98	97	2	2	NA	NA	NA	NA	NA	NA	90	75	12
Maize (composite and open pollinated)	98	97	2	2	NA	NA	NA	NA	NA	NA	90	70	12
Pearl millets (hybrid)	98	97	2	2	.02	0.1	.05	.1	NA	NA	70	75	12
Pearl millets (open–pollinated, composite and synthetics)	–	97	–	2	–	0.1	–	.1	NA	0.05	–	70	–
Swank, cheena, kangni	–	96	–	3	–	.2	–	.2	–	.1	–	60	–
Tobacco	96	–	4	–	.02	–	.05	–	NA	–	80	–	10
2. FIBRE CROPS													
Cotton	98	96	2	2	NA	.2	NA	.2	NA	.01	75	65	NA
Jute	97	96	3	2	0.1	0.2	0.1	.2	NA	0.1	75	70	9
3. FORAGE CROPS													
Berseem/alfalfa	98	97	2	2	.5	.1	.2	.1	.05	NA	80	70	10
Sorghum (forage and Sudan grass)	98	96	2	3	.08	.1	.1	.1	NA	.05	80	70	10
Guara		97		2		.1		.1		.05		65	–
Indian clover (*senji*)		97		2		.1		.1		NA		60	–
Lucerne		97		2		.1		.1		NA		70	–
Napier grass		97		2		.1		.1		.05		70	–
Oat		97		2		.2		.2		.05		70	–
Teosinte		97		2		.2		.2		.05		70	–
4. OILSEEDS													
Castor (hybrid)		97		3		NA		NA		NA		70	–
Castor		97		3		NA		NA		NA		70	–
Groundnut	96	96	3	3	NA	NA	.01	NA	NA	NA	80	70	9
Rape and mustard	98	97	2	2	.2	.2	35/kg	.2	.01	.01	80	70	8
Linseed		97		3		0.2		.2		.01		70	–
Taramira		97		3		0.2		.2		.01		70	–
Safflower	98	97	2	2	.03	.02	.01	.01	.01	.01	75	70	12
Sesame	96	96	4	3	.1	.02	.02	.02	NA	.01	75	70	9
Soybean	98	96	2	3	NA	0.2	.05	.02	NA	.05	80	70	12

Crop	PS %		IM %		OCS %		WS %		NWS %		G %		MC %
1. CEREALS AND MILLETS	C	L	C	L	C	L	C	L	C	L	C	L	
Sunflower (hybrids)	98	97	2	2	.02	.1	NA	.1	NA	NA	80	70	12
Sunflower (open pollinated)	–	97	–	2	–	0.2	–	0.2	–	NA	–	70	–
5. PULSES													
Cowpea	98	97	2	2	NA	0.2	NA	.2	NA	.01	75	70	9
Mash/mung/*moth*	98	97	2	2	.01	.2	0.1	.2	NA	.01	70	70	10
Lentil (*masoor*)	98	97	2	2	.01	0.2	.1	0.2	NA	.01	70	70	10
6. VEGETABLES													
Cabbages	98	97	2	2	.1	.2	.2	.2	NA	.01	70	65	7
Cucurbits	98	97	2	2	0.1	NA	NA	NA	NA	NA	60	70	7
Brinjal	98	97	2	2	NA	NA	NA	NA	NA	NA	70	60	8
Brinjal hybrid	–	98	2	–	–	–	–	–	–	–	–	65	–
French bean	98	97	2	2	NA	0.2	NA	.2	NA	.01	75	70	9
Capsicum (chili)	–	97	–	2	–	0.2	–	.2	–	.05	80	70	–
Okra	98	97	2	2	.05	.1	NA	.1	NA	.01	65	60	10
Pepper	98	–	2	–	.1	–	.1	–	NA	–	65	–	8
Tomato	98	97	2	2	.01	NA	NA	NA	NA	NA	70	60	–
Tomato (hybrid)	–	98	–	2	–	NA	–	NA	–	NA	–	60	–
Pea	98	97	2	2	NA	.1	NA	.1	NA	.01	70	65	9
Celery	–	96	–	3	–	.2	–	.2	–	.01	–	60	–
Coriander	96	96	4	3	.2	.2	.2	.2	NA	.02	60	60	9
Fenugreek	98	96	2	3	.1	.2	.1	.2	.1	.01	65	60	8
Lettuce	98	97	2	2	NA	0.2	0.1	.2	NA	0.1	70	65	8
Parsley	–	97	–	2	–	.2	–	.2	–	.01	–	60	–
Spinach	96	94	3.5	5	.1	.2	.2	.2	NA	.01	65	60	9
7. ROOT CROPS													
Carrot	95	94	5	5	.1	.2	.1	.2	NA	.01	60	65	8
Carrot, hybrid	–	97	–	2	–	NA	–	NA	–	NA	–	65	–
Garden and sugar beet	96	95	4	4	.2	.2	.2	.2	NA	.01	65	65	9
Radish	98	97	2	2	.1	.2	.1	.2	NA	.01	70	70	60
Radish, hybrid	–	98	–	2	–	NA	–	NA	–	NA	–	70	–
Turnip	98	97	2	2	.1	.2	.1	.2	NA	.01	70	70	6
Turnip, hybrid	–	97	–	2	–	NA	–	NA	–	NA	–	70	–
8. BULBS AND TUBERS													
Onion	98	97	2	2	.1	.2	.2	.2	NA	.01	70	60	8

Garlic (labelled seed). The average diameter of the bulb shall not be less than 25 mm or 25 g in weight. The seed material should be reasonably cleaned. Cut, bruised, cracked, immature bulbs, or those damaged by insects, slugs, or worms shall not exceed more than 2% by weight.

Potato (labelled seed).

1. The size of the seed potato shall be 30/60 mm.

2. The tuber shall be reasonably clean, healthy, and firm—with colour and shape distinct for variety.
3. 3% admixture of other varieties shall be permissible.
4. Mechanical damage, i.e cuts, bruises, injuries, and cracks shall be permissible only up to 5% level.
5. The following maximum percentage of diseases shall be permitted on the basis of visible symptoms: *Rhizoctonia*–2%, wart–none, brown rot–none, powdery scab–0.5%, common scab–2%, blackleg–1%, wet rot–1%, late blight–2%, *Fusarium* and *Verticillium* spp–2%.

PS	Pure seed	NWS	Noxious weed seed
IM	Inert matter	G	Germination
OCS	Other crop seed	MC	Moisture content
WS	Weed seed	NA	Not applicable

Source: Adapted from Ahmad (1989b).

6.7 Seed processing

Seed processing refers to a set of operations (drying, presorting, cleaning, size-grading, and treatment) undertaken to obtain pure and high-quality seed of different crop species.

6.7.1 Drying

Drying means lowering moisture content to levels safe for storage. Seeds have maximum viability and vigour at physiological and functional maturity, and if harvested at this stage have a moisture content ranging from 35 to 45%. Harvesting seed at such an unsafe moisture content will result in heating of the seed and rapid deterioration, particularly in storehouses. This makes drying to a moisture content level of 10–12% or less compulsory for safe seed storage. There are two methods of drying seed: (1) sun drying (natural drying), and (2) forced-air drying (artificial drying).

Sun drying. In dry climates, crops are harvested when they have fully dried in the field. After harvesting and threshing, the seed is spread out in the sun on a clean drying floor or roof of a building and turned frequently. In the rainy season, the seed is brought inside and spread out in a well-ventilated building, where it takes longer to dry. The advantage of this practice is that no additional expenditures or special installations are involved. The disadvantages include risk of weather damage and the possibility of admixture if several varieties are spread on the same threshing floor.

Forced-air drying. In recent years traditional methods of drying (sun drying) have become cumbersome, inefficient, and ineffective. This is due to the increased use of fertilizers, greater plant populations, improved crop varieties, and large acreages. Increased yields demand more efficient and effective seed drying methods which can provide temperature and air circulation to the storage area according to the requirements of the kind of seed