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JOWAR OR SORGHUM
Botanical Name- *Sorghum bicolor*
Family- Poaceae
2n=20

It belongs to family Poaceae and genus sorghum. Sorghum is one of the major food crops of the world, particularly Africa and Asia. In India, it ranks third in major food crop, especially central and peninsular India. It is used in various forms, similar to rice as cooked food, malted, flour for dosai and making chapatti or rotti, popped, semolina etc. It is a very good dry and green fodder and a good concentrate feed for cattle and poultry. Raw material is used for starch Industries. It is used in production of alcohol similar to corn and used for preparation of sorghum syrup (20–25% sugar) from sweet sorghum varieties. It is also used for production of Jaggery. It contains high amount of aconitic acid, which prevents the crystallization of sugar. It contains 72.6% carbohydrate, 10–12% protein, 3% fat, 1.6% mineral and contains more of fibre. It has the capacity to withstand drought or excess moisture (92% of sorghum is grown under rainfed). It comes up well even in marginal soil under moisture stress. It does well in low rainfall areas. It makes comparatively quick growth than maize. It is dormant during stress condition and it resumes its growth, when optimum condition occurs.

❖ **Undesirable qualities:** It contains high amount of Niacin, which interface with the synthesis of Tryptophane, which is the precursor for synthesis of IAA. “**Pellagara**” is nutritional disorder due to presence of high amount of Leucine: iso-leucine ratio (3.4). When it is reduced, yield is also reduced. This disease is common in Africa. It contains considerable amount of oxalic acid, which interface with absorption of Ca and metabolism of Ca. Phytin ‘P’ is not utilized due to high oxalic acid. Oxalic acid also affects the Fe uptake. Low digestibility and low palatability is due to presence of phenolic compounds and glycosides, tannin and lignin. Sorghum contains “cynogenic glucoside” called ‘Dhurin’. This glucoside is converted into HCN in the stomach of ruminants. It causes bloating and reduce the transfer of O₂ to the blood steam and causes death of the animal. It is called “**sorghum poisoning**”/(**sorghum effect**). HCN content is more than 100 ppm in the early stage. Critical level is 50 ppm. It (50 ppm) normally occurs during 60-65 DAS or at heading stage. If it is harvested earlier, it should be dried and fed to cattle. “**Sorghum injury**”—Sorghum stubbles/roots have high C:N ratio (50:1), i.e., it contains low amount of ‘N’. Hence, microbes take the soil ‘N’ for decomposition than from the decomposed stubble, which causes temporary immobilization of soil ‘N’. Hence, succeeding crop after sorghum is affected due to N deficiency in the early stage called sorghum injury. Succeeding crops need higher N.

❖ **Origin:**

Warth (1937): Africa and Decandolle (1984): Abyssinia.

❖ **Classification:** Harlen and De-Wet (1971), gave a modified and simple classification based on spikelet type.

➤ **Basic races:**

1. Bicolor, 2. Guinea, 3. Caudatum, 4. Kafir, 5. Durra. Now cultivated sorghum is Sorghum biclor.

➤ **Hybrid races:**

Guinea bicolor, Caudatum bicolor etc.

❖ **Climate:**

It is a short day C₄ plant. Long day condition delays flowering and maturity. It is a warm weather plant and is grown even in 1500 m from MSL. It can tolerate high temperature throughout their life cycle, better than any other cereal. It is highly resistant to desiccation. It can tolerate water logging. Low temperature at flowering affects the seed set. Rainfall at maturity affects the quality of grain. Low temperature with cloudy weather at flowering induces sugary disease.

❖ **Soil:**

It is grown under variety of soil. Soil with clay loam or loamy texture having good water retention is best suited. It does not thrive in sandy soils, but does better in heavier soils. It does well in pH range of 6.0–8.5 as it tolerates considerable salinity and alkalinity. The black cotton soils of Central India are very good for its cultivation.

❖ **Area, Production and Productivity:**

The World production is 147 m.t. and it is cultivated in USA, Brazil, Argentina, China and India. In India, it is staple food crop of north Karnataka, Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh and Rajasthan. In India, it is cultivated in an area of 11.5 m.ha. with a production of 11.08 m.t. and a productivity of 950 kg/ha. In India, 92.0% of the area is under rainfed. It is mainly grown as kharif crop and smaller extent as rabi crop in Maharashtra, Karnataka, Andhra Pradesh and Madhya Pradesh. In Maharashtra, Karnataka, Madhya Pradesh and Andhra Pradesh, sorghum is grown in both kharif and rabi. The area under cultivation is high in Maharashtra followed by Karnataka, Madhya Pradesh and Andhra Pradesh. At present, Maharashtra has the largest area accounting 43% of Indian area under sorghum and 51% of total production. In Tamil Nadu, it is cultivated in an area of 5.06 lakh ha with a production of 4.86 lakh t and productivity of 960 kg/ha and it is largely grown in Trichy, Coimbatore, Salem, Dharmapuri, Madurai, Tirunelveli, Vellore and Erode districts. In Tamil Nadu, 85% of area is under rainfed and 15% is irrigated.

➤ **Rainfed Sorghum**

• **Rainfall:**

Average and well distributed rainfall of 250–300 mm is optimum for rainfed sorghum.

❖ **Season:**

• **SWM:** Entire north India, it is grown as “Kharif crop” (June-July)

• **Rabi:** North India (October)

❖ **Field preparation:**

Field has to be prepared well in advance taking advantage of early showers. FYM @) 12.5 t/ha is applied at last ploughing. Chiselling is recommended to break hardpan once in three years. Depending on the rainfall and soil type, different land shaping methods may be adopted for conservation of the moisture. Black soil having high rainfall areas, formation of broad bed and furrow is recommended. In black soils having low rainfall, form compartmental bunding or sow the seeds in flat bed and form furrows between crops during inter cultivation or during third week after sowing for both the soil types or form dead furrow at 3 m interval.

❖ **Varieties:**

All India Co-ordinated sorghum Improvement Project (AICSIP) developed 15 sorghum varieties (CSV 1 to CSV 15) and 18 hybrids (CSH 1 to CSH 18 R). CSH 1, CSH 6 and CSH 9 are best for kharif season. CSH 15 R and 18 R is best for rabi season. The hybrids and varieties recommended for different parts of rainfed region in India are given in Table 1

Table 1. Hybrids /Varieties Recommended

Hybrids/Varieties	Season	Grain yield	Dry fodder (t/ha)	Duration (days)
Hybrids				
CSH-1	Kharif (June-July)	3.0		95–100
CSH-6		3.4		95–100
CSH-9		3.9		105–110
CSH-11		4.1		105–110
CSH-13		3.9		105–110

CSH-16		4.2		110
CSH-17		4.2		103
CSH-18		4.1		112
Varieties				
CSV 11	Kharif (June-July)	3.2		110–115
SPV 462–CO		3.3		110–115
CSV 15		3.6		107–112
Hybrids				
CSH 13R CSH	Rabi (October-November)	3.2	5.4	113
		3.2	5.6	110
Varieties				
CSV 14R	Rabi (October- Novemb	2.3	5.5	117
CSV 8R		2.2	4.8	120
Swati		2.2	5.3	117

Table 2. Variety Details

Variety	Duration (days)	Grain yield (t/ha)	Fodder yield (t/ha)
CO 26	105–110	4.5	14.00
K10	110–115	1.6	16.00
CO 25	115–120	3.68	13.25
K tall	90	3.75	11.25
K 8	85	2.4	7.30
APK 1	105–110	2.60	8.00
BSR 1	105–110	3.00	7.20

❖ **Seed rate:** The seed rate is 15 kg/ha.

❖ **Seed treatment:**

For seed hardening, the seeds are soaked in 2% KH_2PO_4 or 500 ppm of CCC/cycocel for six hours and shade dried for 5 hrs. Using 350 ml of solution is sufficient for soaking 1 kg of seed. It is a method by which drought tolerance is induced in plants by soaking the seeds in weak electrolytes or salt solution. Seed treatment is done with Azospirillum and phosphobacteria each 3 packets (600 gm). In main field, application of 2 kg of Azospirillum and 2 kg of phosphobacteria with 25 kg of FYM + 25 kg of soil is recommended. Then, the seeds are treated with Thiram/Bavistin @ 2 g/kg of seeds. If possible, the seed is palletized with 15 g of chlorpyriphos in 150 ml of gum before sowing and seeds are dried.

❖ **Sowing:**

The seeds are sown before onset of monsoon at 5 cm depth with seed cum fertilizer drill or by seed drill or by country plough. Pre monsoon sowing/dry seeding i.e., sowing a week or 2 weeks before on set of monsoon.

❖ Spacing:

The spacing for sole crop of sorghum is $45 \times 15/10$ cm (1,80,000 plants/ha) and $60/30 \times 15$ cm for intercropping and paired row system.

❖ Manuring:

Application of FYM or compost at 12.5 t/ha during last ploughing is recommended. Application of NPK at 40:20:0 kg/ha is recommended. 'P and K' is applied basally as enriched FYM. 'N' may be applied in two splits viz., 50% basal and 50% at 25 DAS depending upon the rainfall. In high rainfall areas of north India where sorghum is grown during SWM (kharif season), the recommended NPK is: 80:40:40 kg/ha where 50% N, and entire P and K should be applied as basal, remaining 50% N as top dressing at 25–30 DAS depending on the rainfall. During rabi season, the recommended application of NPK is 40:20:0 kg/ha. Entire fertilizer is applied as basal by drilling method.

❖ Growth stages:

There are five growth stages.

1. Seedling stage : 1–15 days
2. Vegetative stage (Grand growth (30–40)) : 16–40 days
3. Flowering/Reproductive stage : 41–65 days
4. Maturity : 66–95 days
5. Ripening : 96–105 days

❖ Weed management:

Keeping the sorghum fields free of weeds from 2nd week after germination till 5th week is good. If sufficient moisture is available, spraying atrazine @ 500 g/ha (atrazine 0.25 kg/ha) as pre-emergence within three days after receipt of soaking rain followed by one late hand weeding/inter cultural operation may be done. For sorghum based intercropping system with pulses, pre-emergence application of pendimethalin (Stomp 30 EC) at 3.0 lit/ha followed by one hand weeding at 35 DAS is recommended.

➤ Striga:

There are three species of striga viz., *Striga asiatica*, *S. lutea*, *S. hermonthica* (witch weed). It is a semi-root parasite in sorghum and reduces the yield markedly. The control measures for striga in sorghum are as follows:

- ✓ Post emergence application of 2,4-D Na salt at 2.0 kg/ha at 25–30 DAS.
- ✓ Intercropping with red gram.
- ✓ Crop rotation with trap crops like cotton, sunflower, groundnut, cowpea, etc., which induce germination of weed seeds, but they are not themselves parasitized.
- ✓ Heavy application of N and FYM and flooding the field.
- ✓ Spraying Urea 10% solution on 25–30 DAS.
- ✓ Using germination stimulants like Strigol and ethylene gas.

❖ Cropping system:

The important intercropping systems in Tamil Nadu are given below:

Southern districts	Sorghum + cowpea (2:1); sorghum + black gram (2:1) Coimbatore Sorghum + green gram (4:2); sorghum + sunflower (4:2)
Aruppukottai	Sorghum + fodder cowpea (1:1)
Dharmapuri	Sorghum + lab-lab (4:1); sorghum + red gram (3:1) In north India, the

important systems during kharif season (SWM) are given below:

Sorghum + red gram at	3:1 ratio
Sorghum + soybean at	4:2 ratio
Sorghum + green gram at	4:2 ratio.

❖ **Thinning:**

Thinning should be completed 10–15 days after emergence leaving one plant per hill.

❖ **Harvesting and Threshing:**

Most of the high yielding varieties and hybrids mature in about 100–115 days. The right stage for harvest is, when the grain becomes hard having less than 25% moisture. Do not wait for stubble and leaves to dry, because hybrid sorghum appears green even after the crop is matured. Harvest may be done at physiological maturity. Harvesting is done by cutting the entire plant or removing the ear heads first and cutting down the plants later and is allowed to dry for 2–5 days. Threshing is done with the help of thresher or beating the ear heads. The threshed grain is dried in the sun for a week to bring the moisture content to 10–12% for safe storage.

❖ **Yield:**

The grain yield varies from 2–3 t/ha under rainfed conditions and the dry stover yield varies from 8–10 t/ha.

➤ **Irrigated Sorghum**

It is raised by either direct seeding or transplanting. Irrigated transplanted crop has advantages like main field duration is reduced by 10 days; shoot fly attacks will be economically controlled in the nursery; seedlings which show chlorotic and downy mildew symptoms can be eliminated; optimum population can be maintained as only healthy seedlings are used and seed rate is reduced by 2.5 kg/ha.

➤ **Varieties:**

CO 25 (115–120 days, grain yield of 6.0 t/ha, straw yield of 17.5 t/ha), **CO 26** (105–110 days, grain yield of 6.0 t/ha, straw yield of 19.0 t/ha), **BSR 1** (105–110 days, grain yield of 6–6.5 t/ha, straw yield of 9.6 t/ha).

✓ **Hybrids:** **CSH 5** (100 days, grain yield of 4.5 t/ha, straw yield of 12.5 t/ha), **COH 4** (105–110 days, grain yield of 6.5 t/ha, straw yield of 20.0 t/ha), **COH 5** (100 days, grain yield of 6.8 t/ha, straw yield of 19.0 t/ha).

✓ **Seed rate:** The seed rate for direct sowing is 10 kg/ha and 7.5 kg/ha for transplanting.

❖ **Nursery**

✓ **Preparation:** For planting one ha, about 7.5 cent (300 m²) nursery area is required, near the water source. Application of 750 kg of FYM or compost for 7.5 cent nursery is done and another 500 kg for covering the seeds after sowing is used. Forming raised beds of 2 m × 1.5 m with 30 cm spacing to a depth of 15 cm is done. Pre treatment of seeds for both direct seeded crop and raising in the nursery is must. The seeds are treated 24 hours before sowing with carbendazim/ captan/thiram @ 2 g/kg of seed. And then, the seeds are treated with 2% KH₂PO₄ for 6 hours and shade dried for 5 hours. The seeds are treated with 3 packets of Azospirillum (600 g/ha) using rice kanji as binder.

✓ **Sowing:** Forming rills using fingers, broad casting the seeds and covering with 500 kg of FYM is done.

❖ **Irrigation:** Irrigations are given immediately after sowing, 3rd day, 7th day, 12th day and 17th day (Totally five irrigations).

❖ **Transplanting:** Age of seedling is 15-18 days. The seedlings are dipped in Azospirillum solution (5 packets -1000 g) dissolved in 40 lit. of water) for 15-30 minutes. Planting at 45 × 15 cm spacing at a depth of 3–5 cm with one seedling per hill on the side of ridge is done.

❖ **Main field preparation (direct seeded and transplanted crop):**

Sorghum does not require fine tilth. The field is ploughed with an iron plough once and twice with a country plough. To overcome the sub soil hard pan in Alfisol, chiseling the field at 0.5 m interval to a depth of 40 cm on both the direction of the field followed by disc ploughing once and cultivator ploughing twice is done. Application of 12.5 t FYM or compost/ha with 2 kg of Azospirillum (10 pockets/ha) is recommended. Ridges and furrows are formed at 45 cm apart using ridge plough.

❖ **Fertilizer management**

- ✓ **Transplanted crop:** If soil test recommendation is not available, the blanket recommendation of 90:45:45 kg NPK/ha is recommended. 50% N and entire P and K should be applied basally before planting and remaining 50%N is applied on 15 DAS.
- ✓ **Direct seeded crop:** Blanket recommendation of 90:45:45 kg NPK/ha is followed. Application of 50% N, and entire P and K should be applied basally and the remaining 50% N on 25–30 DAS.
- ✓ **Micronutrient:** For Zn deficient soils, 25 kg ZnSO₄/ha is applied at the time of sowing/transplanting. If ZnSO₄ is not applied basally and if Zn deficiency is noticed, ZnSO₄ at 0.5% concentration is sprayed.
- ✓ For Fe deficient soils, 50 kg FeSO₄ is applied at sowing or at planting. If FeSO₄ is not applied basally, FeSO₄ 1% concentration at 2 or 3 stages is sprayed.

❖ **Spacing:**

The spacing is 45 × 15 cm (1,48,000 plants/ha) for both direct and transplanted crop. For raising intercrop and paired row system, a spacing of 60/30 × 15 cm may be adopted. Raising one row of pulses in between 60 cm row spacing is common.

❖ **Thinning and gap filling:**

In the direct sown crop, thinning one seeding per hill and gap filling the thinned out seedlings is done on 10–15 DAS, maintaining a spacing of 15 cm between plants.

❖ **Weed management:**

Sorghum is slow growing in the early stage and is adversely affected by weed competition. Keeping the fields free of weeds up to 45 days is good. Pre-emergence herbicide Atrazine 50 WP at 500 g/ha (atrazine 0.25 kg/ha) on 3 DAS using high volume sprayer followed by one hand weeding on 30–35 DAS is recommended. If pulse crop is raised as intercrop, do not use atrazine. If herbicide is not used, for transplanted crop, two hoeing and weeding on 10 and 30–35 DAS should be done. In the case of direct seeded crop, two hand weeding on 15–20 DAS and 35–40 DAS should be done.

❖ **Water management:**

Total water requirement is 450–500 mm. Irrigation at 50% depletion of available soil moisture or 0.6 IW/CPE ratio is sufficient. There are four critical stages viz., (1) seedling, (2) vegetative, (3) flowering, (4) dough stages. Stress at one week before and one week after flowering is very critical. Under moisture stress condition, 5 irrigations are sufficient. For normal condition, 8 irrigations are to be given i.e. on 1st day, 4th day, 15th, 28th, 40th, 53th, 64th, 76th and 88th days. Irrigation should be stopped after 88–90 DAS. As contingent plan, spraying 3% Kaolin (30 g in one litre of water) during periods of stress will mitigate the ill effects.

❖ **Harvesting and processing:**

When the crop matures, leaves turn yellow and the grains are hard and firm and moisture content will be less than 25%. At this stage, the earheads are cut separately and dried for 2–3 days and threshing using mechanical thresher is done and the grain is dried to 12% moisture for safe storage. The straw is cut after a week and allowed it to dry and then stacked for fodder.

❖ **Cropping system**

Sorghum–Wheat

Sorghum–Pea

Sorghum–Wheat-Moong

Sorghum–Potato-Wheat

❖ **Intercropping**

The sorghum crop is intercropped with Cowpea and Green gram.

❖ **Ratoon Sorghum**

It is highly amenable for ratooning. The varieties suited for ratooning are CO 25, CO 26, CSH 5 and K.Tall.

❖ **Ratooning technique:**

The main crop is harvested leaving 15 cm stubble in the field and first formed two sprouts are removed from the main crop and allowed only the latter formed two sprouts to grow. Two tillers per hill are allowed.

❖ **Hoeing and weeding:**

The weeds are removed immediately after harvest of main crop. Hoeing and weeding is done on 15th and 30th day after cutting.

❖ **Application of fertilizers:**

Application of 100:50:0 kg NPK/ha is recommended. N is applied in two splits doses viz., 1st dose on 15th day after cutting and second on 45th day after cutting. P₂O₅ is applied along with first application of N.

❖ **Pest and disease management:**

Since the ratoon crop invites pests and diseases in early stages, plant protection measures have to be resorted to.

❖ **Water management:**

Irrigation is given immediately after cutting the main crop. Irrigation should not be delayed for more than 24 hours after cutting. Then, irrigation is given 3rd or 4th day after cutting and subsequent irrigations are given once in 7–10 days. Irrigation is stopped 70–80 days after ratooning.

❖ **Harvest:**

Similar to sown crop but duration is 10–15 days lesser than main crop.

❖ **Yield:**

Yield is equal or slightly higher than sown crop.

PEARL MILLET (BAJRA)

Botanical Name- *Pennisetum americanum* Leeke

Family- Poaceae

2n=14,18

It is a staple food crop of about 100 million peoples in rural areas of India and Sub Saharan Africa. Roti or Chapatti, which are unleavened flat breads prepared using pearl millet flour are common in Asia. Porridges and cooked grains are also used. In northern India, it is prepared during winter while wheat becomes common in summer diet. It is also used for fried preparations, foods such as fermented products and beer. Varieties of pancakes are prepared using pearl millet flour in Africa and pearl millet beer is used throughout Africa. Fura or cheese is the traditional African snacks prepared using steamed pearl millet flour and cream. It is used as fodder in Africa and Asia. Oxalic acid content is very high. So it is not relished by cattle. It is rich in protein (12.6%) and fat (5%), fibre (1.2%) and 60–70% of Carbohydrate. It is normally rich in Ca, Vitamin Riboflavin and Carotenoids. In Central America, it is mainly cultivated for forage purpose. It is also grown as pasture grass. 150 sps. of *Pennisetum*,

P. glaucum is the cultivated species for grain and *P. purpurea* is the forage species.

❖ **Origin-** Africa

❖ **Area, Production and Distribution:**

It is largely grown in India. The important pearl millet producing countries are India, Africa, Pakistan, China, Sudan and Egypt. In India, it is cultivated in an area of 10 m.ha with a production of 7.9 m.t and productivity of 791 kg/ha. Area under cultivation is high in Rajasthan, followed by Maharashtra, Gujarat and Uttar Pradesh. The production is more in Rajasthan, followed by Maharashtra, Gujarat, Tamil Nadu and Uttar Pradesh.

❖ **Stages:**

There are four crop stages namely seedling stage (1–18 days), Tillering stage (19–35 days), Flowering phase (36–55 days) and Maturity phase (56–85 days)

❖ **Climate:**

It is a rapid growing, warm weather crop and it has resistance for drought. The best temperature is between 20 and 28°C. It can withstand even desiccation. It is highly suitable for the areas having rainfall ranges from 400–750 mm. Even 150 mm of rainfall is sufficient. Rainfall during vegetative phase is highly favourable, while rainfall at flowering is not conducive, as it washes off the pollen and there is a poor seed setting. The crop grows better in light showers followed by bright sunshine. Usually bajra is grown, where it is not possible to grow sorghum because of high temperature and low rainfall. It is grown as kharif crop in Northern India, while in Tamil Nadu, Karnataka and Punjab, it is grown under irrigated condition during summer.

❖ **Soil:**

It is grown in a wide variety of soils, but being sensitive to water logging. It grows well in well drained sandy loams. It is sensitive to acidic soil. It is grown successfully in black cotton soil, alluvial soils and red soils of India.

❖ **Time of sowing:**

In India, it is grown in three seasons viz., kharif (rainfed-June–October), winter (rainfed–November–February) and summer (rain fed–March–June). During summer, it is grown in Tamil Nadu, Karnataka, Punjab and Gujarat as an irrigated crop.

❖ **Hybrids:**

Under All India Co-ordinated Research project, many hybrids have been developed. Using Cytoplasmic male sterile line (CMS line), five hybrids have been developed. Among them, HB-3 is the best. But all hybrids are susceptible to downy mildew. To overcome the downy mildew, CMS line MS.5071 was used and five New Hybrid bajra were developed. Among them, NHB.5 is the best for disease resistance and wide adaptability besides giving higher yield. In Tamil Nadu, using CMS line MS 5141 A, two hybrids X 6 and X 7 were evolved and are recommended for cultivation.

X6: 90–100 days, irrigated crop yields 3236 kg/ha and rainfed crop yields 2394 kg/ha. It is resistant to downy mildew.

X7: 90 days, irrigated crop yields 3295 kg/ha and rainfed crop yields 2513 kg/ha. It is resistant to downy mildew.

❖ **Composite:** WCC 75 (World Cumbu Composite developed at ICRISAT, Hyderabad) is suited for both irrigated and rainfed. Duration is 95 days. Irrigated crop yields 3.0 t and rainfed crop yields 2.0 t/ha.

Variety: CO 7–90–100 days duration. Rainfed crop yields 2.5 t/ha and irrigated crop yields 3.5 t/ha. It is resistant to downy mildew.

K3: 85 days duration.

❖ **Method of Raising**

✓ **Irrigated condition:** (a) Raising seedling in the Nursery and transplanting. (b) Direct sowing.

✓ **Rainfed crop:** Direct seeding either broadcasting or sowing behind country plough.

❖ **Seed Rate and Seed Treatment**

The seed rate for direct sowing is 5 kg/ha and for transplanting, it is 3.75 kg/ha. Ergot affected seeds are removed using salt solution (1 kg of NaCl in 10 lit of water), to prevent primary infections and shade dried. Seed treatment is done with fungicides-captan or thiram 2 g/kg of seed, followed by Azospirillum seed treatment (3 pockets or 600 g/ha seed rate).

❖ **Transplanted Crop**

✓ **Nursery preparation:** Nursery area required is 7.5 cents (300 m²) for one ha. The land is ploughed in such a way to bring fine tilth. Application of 750 kg of FYM or compost is done and incorporated. Raised beds of 3.0 m × 1.5m with 30 cm channel are formed. Small rills not deeper than 1 cm on the raised bed are opened. About 3.75 kg of seeds is sown in 7.5 cents at 0.5 kg/cent and 500 kg of FYM or compost is used for sprinkling for covering the seeds.

Irrigation	Light soil	Heavy soil
1st	immediately after sowing	immediately after sowing
2nd	3rd DAS	3rd DAS
3rd	7th day	9th day
4th	12th day	16th day
5th	17th day	

❖ **Field preparation for both irrigated and rainfed crop:**

Deep ploughing with Iron plough and country plough is to be done twice to bring fine tilth. If there is hard pan, chisel ploughing is done. About 12.5 t/ha of FYM or compost is applied during last ploughing. Application of Azospirillum to the soil is done @ 10 packets/ha (2 kg).

❖ **Land Shaping:**

For irrigated crop (transplanting), either ridges and furrows at 45 cm apart or beds of convenient size depending upon the water availability are formed. For rainfed crop, flat sowing is followed. For rainfed crop, Pora method of sowing is better than Kera method.

❖ **Transplanting:**

Pull out of the seedlings is recommended when age of seedling is 15–18 days. A spacing of 45 × 15 cm for all the varieties except CO 7 is adopted. For CO 7, spacing is 35 × 15 cm (similar row spacing is adopted for rainfed crop also). Dipping the roots in bio-fertilizer Slurry (dis- solve 5 packets of Azospirillum in 40 lit. of water) for 15–30 minutes may be done. Planting one seedling/hill to a depth of 3–5 cm is recommended.

❖ **Direct sown crop:**

Soaking the seed in 2% potassium chloride or 3% NaCl for 6 hours followed by shade drying for 5 hours is done. As in transplanted crop, a spacing of 45 × 15 cm for all varieties except CO 7 and for CO 7, 35 × 15 cm row spacing is adopted. If pulse is intercropped, a spacing of 35 × 15 cm for cumbu and 30 × 10 cm for cowpea and other pulses is adopted. Seed rate is 5 kg/ha.

❖ **Fertilizer management:**

If soil test recommendation is not available, the blanket recommendation is followed as given below:

- ✓ **Irrigated crop:**

Hybrids	80: 40: 40 kg N: P ₂ O ₅ : K ₂ O/ha.
Varieties	70: 35: 35 kg N: P ₂ O ₅ : K ₂ O/ha.
- ✓ **Rainfed crop:** 40: 20: 0 kg N: P₂O₅ : K₂O/ha.

Application of 50% N and 100% P and K is recommended as basal at 5 cm depth and the remaining 50% N at 15 days after planting for transplanted crop and 30 DAS for direct sown crop is applied. It removes about 90 kg N, 20–25 kg, P₂ O₅ and 160 kg K₂O. For Zn deficient soil, application of ZnSO₄ at 25 kg/ha is done. Iron deficiency occurs in saline and calcareous soil. Based on the level of deficiency, 12.5–25 kg of FeSO₄ is recommended. If it is not applied basally, foliar application of 1% FeSO₄ at vegetative phase is recommended.

❖ **Water management:**

It is a highly drought tolerant crop and water requirement is 300–350 mm. Irrigation at available soil moisture of 50% or optimum IW/CPE ratio 0.4 is sufficient. The critical stages are tillering and flowering. Normally 5 irrigations are recommended for the stages viz., tillering, panicle initiation, flag leaf, flowering, dough stages in addition to sowing irrigation. Under limited moisture conditions, three irrigations can be recommended for panicle initiation, flag leaf and flowering in addition to sowing irrigation.

❖ **Thinning and gap filling:**

In the direct sown crop, after 1st weeding at the time of irrigation, gap filling and thinning is done to a spacing of 15 cm between plants. In rainfed crop, thinning should be done 10-15 DAS.

❖ **Weed management:**

Weed reduces the yield by 50%. Crop weed competition is up to 35 days. Pre-emergence application of atrazine at 500 g/ha followed by hand weeding on 30–35 days after transplanting or sowing. If the herbicide is not used, weeding is done on 15th day and again between 30 and 35 days after transplanting. For direct sown crop, hoeing and weeding may be done on 20–25 DAS and second weeding on 35–40 DAS. Atrazine should not be used for intercropping systems.

❖ **Cropping system:** Some of the important crop rotations are:

- | | |
|-------------------|-------------------------------------|
| 1. Bajra – Barley | Intercropping system in North India |
| 2. Bajra – Wheat | Bajra + Groundnut |
| 3. Bajra – Gram | Bajra + Black gram |
| 4. Bajra – Pea | Bajra + Green gram |

❖ **Harvesting and Threshing:**

When the leaves turned yellow colour and when the seeds become hardened and having 20% moisture, harvesting is done by removing the earheads first and cutting down the plants latter on. The ear heads after harvesting should be dried well in sun before threshing. The grains are separated either by beating the ear heads by sticks or by trampling by bullocks. If mechanical thresher is available, thresh it or spread it and drag a stoneroller over it. The threshed grain should be cleaned and dried in the sun to bring the moisture to 12–14% for safe storage.

Yield	Grain yield (t/ha)	Stover yield (t/ha)
Irrigated	3.0–3.5	10.0
Rainfed	1.2–1.5	7–7.5

Reference Books

1.	Modern techniques of raising field crops	Chhidda Singh.
2.	Kharif crops.	Omprakash and Ahlawat
3.	Crop production	Nazir M. S.
4.	Principles of field crop production	Reddy, S.R.