Programme-	B.Sc (Agriculture)
Course -	Field Crops-I
Course Code-	BSCAG-211
Semester -	III rd
Year-	2020-21
Unit-	1 (Part-5)
Торіс-	Cultivation of Redgram Crop
Sub-Topic-	Synonyms, Vernacular name, Importance, origin, History, Distribution, Botany, Climate, Soil, Season, Land preparation, varieties, Growth stages, Land Preparation, Seeds and Sowing, Nipping, Weed Management, Manure and Fertilizer Application, Growth Regulators, Water Management, Cropping Systems, Crop Protection, Integrated Pest Management Practices, Harvesting, Yield, Post Harvest Technology, Seed Storage, Utilization, Transplanting in redgram
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Cultivation of Redgram Crop Redgram - *Cicer arietinum* L.Millsp. Family= Fabaceae (Leguminoceae)

Synonyms: Cajanus indicus Spreng, Cajanus bicolor DC., Cajanus flavus DC.

Vernacular name: Redgram, Pigeonpea, Congo bean, Angola pea. No eye pea. Gungo pea, (English), Arhar. Tur (Hindi), Thovarai (Tamil) and Kandulu (Telugu).

Importance:India alone accounted for about 80% of total world production and 90% of total world consumption of Red gram. It is the second most important legume of India. Redgram is consumed as fresh green peas in Caribbean, Latin America, Puerto Rico, Trinidad, India, Kenya, Tanzania and Zambia. In India, late maturity types of vegetable red gram is grown in kitchen backyards or as bund crop. The top of the plants with fruit provide excellent fodder and are also made into hay and silage. Redgram is used as shade crop in cacao and turmeric as wind breaks and for anti - erosion purpose. The dried stalks are used for firewood, thatching and baskets.

Origin: India is the primary center of origin while Africa is the secondary center of origin of pigeonpea. Cajanus is derived from a Malay word *'katschang'* or *'katjang'* meaning pod or bean.

History: The Sanskrit word for redgram / pigconpea is adhaki as per Charaka (c. 700 BC) and Susruta (c.400 BC). Amarsimha (c. 200 BC), in his Amarkosa, has mentioned 'adhaki' and 'fuvarika' as names of pigeonpea. The word adhaki originated most likely from the word ardha, meaning **'one - half or split into two parts'.** Dry whole pigeonpea seed is rarely consumed; only the dhal is usually consumed. One of the two common names

used for pigeonpea in the Indian subcontinent is 'arhar' which has come from the word 'adhaki'. The second common name for pigeonpea is the Sanskrit, 'fuvara' or 'tubara' which means astringent. The green seed, which has been consumed in Gujarat for centuries, has an astringent taste. The word arhar is common in northern India, and tuvara (with variants tuvarika, furri, tur, etc.) in southern India.

Distribution: Redgram is widely cultivated in USA, Hawai, West Indies, India. Australia, Kenya, Uganda, Tanzania, Namibia and Malawi. In India it is mainly cultivated in Uttar Pradesh, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu.

Botany: Cultivated redgram is an annual, 0.6 to 1.5 m in height, deep tap root system. Pigeonpea with its deep root system (> 150 cm) can break hard pans in plough layer, and hence called 'biological plough'. Leaves are trifoliate and spirally arranged. Leaflets are lanceolate to narrow elliptic, hairy on both sides. Inflorescence is raceme 4 to 12 cm long, and has 3 to 4 seeds. Hundred seeds weight 11 to 13 gm. The flowers are self - compatible and usually self - pollinated and 20% cross pollination can occur due to the visit of bees and other insects. The majority of flowers open between 11 a.m. to 3 p.m. an often remain open for 6 hours. Rain at flowering reduces fertilization, it is essential to emasculate before 9 a.m. on the day before the flowers open and they may be hand pollinated at the same time for hybridization. Pod formation begins at 12 to 14 weeks in early varieties and they require 5 to 6 months to reach maturity while late varieties require around 9 to 12 months to reach maturity. The conversion ratio from fresh green pods to dried pods is about 3.3. Redgram has 3% out crossing at 14 m and 9 m guard rows can be provided as an adequate barrier. Redgram attains a height of 25 cm from ground in 30 days. Two botanical ecotypes have been recognized in redgram viz.,

- Cajanus cajan var. flavus is early maturing, shorter plants with yellow standards and green glabrous pods, which are light colored when ripe and are usually three seeded. These are Tur cultivars and are extensively cultivated in Peninsular India and
- Cajanus cajan var bicolor is perennial, late maturing, large, bushy, plants, with dorsal side of red or purple streaks and hairy pods blocked with maroon or dark colored with 4 -5 seeds. These are Arhar cultivars and are grown in north India.

In a fully developed bud, anthers surround the stigma and dehisce a day before the flower opens. Anthesis in pigeonpea starts from 0600 and continues till 1600. The peak anthesis period is between 0900 and 1000 hours. Fertilization occurs on the day of pollination. The extent of crosspollination ranges from 3 to 40%, with an average of 20%. A plant produces many flowers of which only 10% set pods. In the cotyledons, synthesis of starch and protein starts about 17 days after pollination and continues for 14 days. In each raceme 1 to 5 pods may mature, and rarely up to 10. Pods color may be green, purple, dark purple, or mixed green and purple. Pods with deep constrictions in shape are beaded, while others are somewhat flat. The number of seeds per pod range from three to five in cultivated varieties. The 100 - seed weight ranges from 2.8 to 22.4 g with the cultivated varieties ranging from 7.0 to 9.5 g.

Climate: Redgram is cultivated between 30 ° N and 30 ° S up to an altitude of 1800 m from MSL although about 92 percent of total world production is in India. It can be grown between 14 ° N and 28 ° N latitude, with a temperature ranging from 26 ° to 30 ° C in the rainy season (June to October) and 179 to 22 ° C in the post - rainy (November to March) season. The amount of daily global solar radiation varies from 400 to 430 cal cm - 2 day- 'in the rainy season and 380-430 cal cm - 2 day in the post rainy season. Pigeonpea is very sensitive to low radiation at pod development, therefore flowering during the monsoon and cloudy weather, leads to poor pod formation. Mean annual rainfall ranges from 600 to 1400 mm, of which 80 to 90% is received in the rainy season. It is cultivated all over the country with exception of areas which are excessively wet or severe frost. It is intolerant of shade and tolerates only moderate competition. It does best in full sun on bare ground but can grow with side shade or broken shade from trees and a low cover of grass and forbs. Redgram is short day plant. The cardinal minimum, optimum and maximum temperature for redgram is 10 ° C, 24 to 29 ° C and 35 ° C respectively. Redgram is susceptible to frost damage at all stages of growth. Sowing of redgram should not be made at soil temperature less than 19 ° C. The germination and emergence is enhanced by soil temperature of 26 to 43°C and particularly 29 to 36 ° C. It prefers warm weather (max 30–40 ° C) during germination and pre -

flowering growth, and a lower temperature (max $25-30 \degree C$) during the flowering and pod filling stages. The optimum temperature for flowering and pod setting is $24 \degree C$. Temperature is the dominant factor influencing the number of days from emergence to floral initiation. The number of days from emergence to floral initiation is $24 \ days$ at a day / night temperature of $24/16 \degree C$ and 36 days at $32/24 \degree C$. The time from floral initiation to flower opening varried from 40 days under an 8 hour photoperiod at $24/16 \degree C$ to $22 \ days$ under 16 hour photoperiod at $32/24 \degree C$. Increased the day / night temperature regimes from $24/16 \degree C$ to $32/24 \degree C$ reduced the duration of floral bud development by 12 days under an 8 hours photoperiod and 9 days under a 16 hours photoperiod. Average annual rainfall of 600 mm to 1000 mm is most suitable for redgram growth and yield. High yields are obtained when there is good rainfall during the first 2 months of growth followed by a dry period during flowering and harvesting. It is a drought resistant crop with deep root system. Rainfall of 625 mm per year is adequate for good growth under semiarid conditions. Redgram is less suitable for wet tropics and sensitive to frost. It is fairly resistant to wind and is sometimes planted in double rows as a wind break. It is however sensitive to sea spray and does not thrive if planted near the seashore. Late maturity varieties are short day plants while early varieties are photosensitive plants.

Soil: Redgram can be grown on almost all soil types provided the soil is not markedly deficient in lime. It will not tolerate waterlogging. It thrives best on deep loamy soils free from excessive soluble salts. It tolerates pH from 4.5 to 8.4 and some varieties tolerate 6 to 12 mmhos / cm of salinity. It is extremely drought resistant crop. **Season:** Ten maturity groups have been identified under Indian conditions which have been combined into four categories: extra early (120 days), early (145 days), medium (185 days) and late - maturing (200 days) cultivars.

- North West Plain Zone (Punjab, Haryana, Western UP, Delhi, estern / Rajasthan): 2nd fortnight of May to Ist fortnight of June.
- North East Plain Zone (Assam, West Bengal, Bihar, Jharkhand, caster and central UP): Early: 1 "fortnight of June Late: 1" fortnight of July Pre - rabi: 1 "fortnight of September.
- Central Zone (Gujrat, Maharashtra, Rajasthan, MP): Rainfed: 1 "fortnight of July (onset of monsoon) Irrigated: 2nd fortnight of June.
- South Zone (Orissa, AP., Tamil Nadu, Karnataka): Onset of monsoon: 2nd fortnight of June.

Land preparation: Land preparation for redgram requires at least one plowing during the dry season followed by 2 or 3 harrowings. The summer plowing helps in minimizing the weed flora and to conserve moisture. Subsoiling on lands having hardpan permits both deep proliferation of roots and great infiltration of water to the deeper layers of the soil. The seedbed should have a moisture content of about 40 to 50% of the available water to ensure quick and adequate germination. Adequate provision for surface drainage is an important consideration in the seed bed preparation of redgram. Organic manure may be applied 2-4 weeks before sowing. In acidic soils 2-4 t ha - 1 of lime is included 3-4 weeks before sowing to neutralize the acidity.

Varieties: Pigeon pea varieties with salient features recommended for different states of India are furnished in Table 1.

State	Туре								
Mary Mary Carlow Control	Early (120-150 days)	Medium (150-180 days)	Late (> 180 days)						
UP (Central & Western)	PA 3, T 21, Prabhat, UPAS 120, Pusa 84, Pusa 74, Manak, Pusa 33, Pusa 993, Pusa 855, TT 5, ICPL 151	MA 6, Mukta, Paras, Sharda, Pant A 3	T 7, T 17, NP (WR) 15, Pusa 33, Pusa 55, Bahar (1258), MAL 13, KA 32-1 (Amar), Narendra Arhar-1, Pusa 9, Gwalior 3, Azad,						
Punjab, Haryana, Delhi	PA 1, T 21, Prabhat, UPAS 120, Pusa 84, Pusa 74, Manak, ICPH 8, Sagar (H 77-208), Pusa 33, Pusa 992, Pusa 855	Mukta, Paras, Sharda	NP (WR), Pusa 55						
Bihar, Jharkhand, Eastern UP	Prabhat, UPAS 120, Pusa Ageti, Pusas 74, Pusa 84	Mukta, ICPL 85063, BR 65, BR 183, MA 6, Birsa Arhar 1	T 7, T 17, NP (WR) 15, AS 71-77, MAL 13, Azad (K91-25), Pusa 9, DA 11 (Sharad), Bahar, Basant						
West Bengal, Orissa & Assam	T 21, Prabhat, Pusa Ageti, Pusa 74, Pusa 84, TT 5, BS 1	BR 65, BR 183, Mukta, ICPL 85063, C 11, WB 20 (105)	Sweta (B7), Chuni (B 517), T 7, T 17, NP (WR) 15, MAL 13, Pusa 9, Bahar						
Rajasthan	T 21, Prabhat, UPAS 120, Manak, Pusa Ageti, J 9-19, Pant A 1, Pant A 2, Sagar, Pusa 74, Pusa 33,	Sharda, Mukta, Paras	NR (WR) 15, Gwalior 3						
Madhya Pradesh and Chattisgarh	T 21, Prabhat, UPAS 120, Pusa Ageti, Vishakha 1, J 9-19, Pusa 33	Sharda (S 8), No. 148, Mukta, MA 3, KM 7, BDN 1, BDN 2, C 11, Paras, ICPL 87119, JA 3, JA 4	T 7, T 17, NP (WR) 15, Kanke-3						
Gujarat	T 21, Pusa Ageti, Prabhat, Vishakha 1, TAT 10, J 9-19, Pusa 84, Pusa 74	Sharda, Mukta, ICPL 87119, BDN 1, BDN 2, C 11, ICPL 871, GTH 1	NP (WR) 15, Gwalior 3						
Maharashtra	T 21, Pusa Ageti, Prabhat, Vishakha 1 (TT 6), TAT 10, J 9-19, AKT 8811	Sharda, Mukta, No. 148, BDN 1, BDN 2, C 11, ICPL 87119, BSMR 175, BSMR 736, MA 3, Malviya Vikalp, KM 7	NP (WR) 15, Gwalior 3,						

Table 1 Pigeon pea varieties recommended for different states of India

Maruthi, ICPL-8863, TS-3R	Wilt	Central and South India
BSMR-736, Asha (ICPL-87117)	Wilt + SMD + PSB	Central and South India
C-11	Wilt	All zones
PDA 89 - 2E, PDA 92 - 3E	Pod fly	U.P., Maharashtra and M.P.
PDA-93 - 1E	Pod borer	U.P., Maharashtra and M.P.
PDA-88 - 2E	Pod fly	Orissa, Maharashtra and M.P.
MA-91 – 2	Pod fly	Orissa, Maharashtra and M.P.
Mukta	Pod fly	U.P., West Bengal, A.P., T.N, and Gujarat
UPAS 120	Pod borer	U.P., Maharashtra and M.P.
JA-3 & JA-4	Pod borer	Central India

Table 5 Pigeon pea varieties tolerant to diseases

Specific trait	Varieties
Wilt	BDN 1, BDN 2, C 11, TT 6 Maruthi, BSM 6736, Sharda, Amar, Narendra Arhar, Asha BSMR, 736, BSMR 853, JKM 7, Maruti, C11
Sterility mosaic disease (SMD)	Bahar, HY 3C, Pusa 9, Azad, ICPL 366, ICPL 87051, Amar, BSMR 175, BSMR 763, BSMR 736, BSMR 853, MA 3, Pusa 9, Co 5, MA 6, MAL 13, NDA 1, Asha,
Wilt + Sterility mosaic disease (both)	Narendra Arhar 1, Asha (ICPL 87119), DA 11, BMSR 853, MA 3, Amar, Asha BSMR 736,
Alternaria blight	WB 20 (105), Pusa 9, DA 11, DA9
Phytopthora blight	KM 7, DA 11, Pusa 9, Narendra Arhar 1
Short duration	UPAS 120, PUSA 992, VLA1, Co 7, PAU 881

Variety	Yield (q/ha)	Suitability	Major characteristics
UPAS 120	11-15	Punjab, Haryana, North Rajasthan, West U.P.	Indeterminate. Semi-spreading, synchronous in maturity, tolerant to pod borer
Bahar	25-30	U.P., Bihar, W.B.	Compact, resistant to sterility mosaic
Amar (KA 32-1)	16-20	Uttar Pradesh	Compact, resistant to SMD
Narendra Arhar 1	20-22		Resistant to SMD and tolerant to wilt and phytophthora blight
Pusa 9	22-26	U.P., Bihar, W.B.	Indeterminate, resistant to SMD and Alternaria, suitable for Pre-rabi also
MAL 13	2465	U.P., Bihar, W.B.	Tolerant to wilt, PB, SME
NDA 98-1 (NDA2)	2443	U.P., Bihar, W.B.	Resistant to wilt
MA 6	2281	Bihar, U.P.	Resistant to wilt and SMD
Paras (H 82-1)	15-20	Haryana	Indeterminate
AI 201	15-16	Punjab	Indeterminate
PUSA 992	14-18	Delhi, Punjab, Haryana	
TJT501	18.60	MS, Guj. & MP.	Tolerant to pod borer, pod fly
Malviya Vikalp (MA 3)	20-22	M.P., Gujarat, Maharashtra	Spreading, constricted pod resistant to pod fly
Jawahar (JKM 7)	18-20)	M.P., Gujrat, Maharashtra	Tolerant to wilt and Phytophthora blight
BSMR 175	11-12	Maharashtra	White seeded, wilt and sterility mosaic resistant
JA 4	16-18	Madhya Pradesh	Pod borer tolerant
Asha (ICPL 87119)	16-18	M.P., Gujarat, Maharashtra	Indeterminate, spreading, bold seeded, bold seeded, wilt and SMD resistant

Table 2 Pigeonpea varieties features in different states of India

Growth stages: When sown under optimal moisture and temperature ($29 \circ C - 36 \circ C$), the seed testa splits open near the micropyle on the 2nd day. The tip of the radical elongates and emerges from the seed coat. On the 3rd day the hypocotyl appears as an arch and continues to grow upward. The hypocotyl turns light purple. The seedling epicotyl elongates 3-7 cm before the first trifoliate leaf emerges. Growth is moderately slow during the first 2 to 3 months of life during which time seedlings are not competitive with grass and weeds: subsequently redgram competes well with vegetation equal or lower in height. Seed development is visible 7 days after pollination. A pod is formed 15-20 days after fertilization. Seeds reach physiological maturity in 30 days and are ready for harvest at lower moisture content in 40 days. There is little or no shattering of mature pods in the field. Redgram requires 65-80 days to flower and 50-75 additional days to create mature seeds.

Growth stages of long and short duration redgram varieties

Туре	Days to 50% flowering	Days to 75% flowering	Days to maturity
Long duration	100	107	150
Short duration	83	93	125

Land preparation: A deep ploughing with a mold - board plow followed by two to three cross - harrowings, and proper leveling should be done to ensure uniform irrigation and good drainage. The entire basal dose of fertilizer should be mixed in top 15 cm of soil during land preparation.

Seeds and Sowing: Seeds are sown either by broadcasting, line sowing or dibbling. Dibble the seeds with recommended spacing. The seed rate and spacing varies with varieties, hybrids and cropping systems.

Quantity of seeds required for different redgram varieties

varieties	Vamban 2	LRG 41	Co(Rg) 7	VBN (RG) 3	APK 1
Long duration	8	8	15	15	15
Short duration	3	3	5	5	5
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[BSR 1 (Bund planting) 50 g / 100 metre]

Spacing for sole, inter crop and bund crop for different redgram varieties

varieties	Spacing for pure crop	Spacing for intercrop
Co 2	45 cm x 30 cm	
Co 3	45 cm x 30 cm	
Co 4	45 cm x 30 cm	
Co 5	45 cm x 30 cm	
Co 6	90 cm x 30 cm	240 cm x 30 cm
SA 1	90 cm x 30 cm	140 cm x 30 cm
BSR 1, Sa 1		60 cm

Treat the seeds with Carbendazim or Thiram @ 2 g / kg of seed 24 hours before sowing (or) with talc formulation of Trichoderma viride @ 4g / kg of seed (or) Pseudomonas fluorescens @ 10 g / kg seed. Fungicide treated seeds should be again treated with a rhizobium culture. There should be an interval of at least 24 hours after fungicidal treatment for giving biocontrol agents / rhizobium culture treatment. Bio-control agents are compatible with biofertilizers. First treat the seeds with biocontrol agents and then with rhizobium. Fungicides and bio-control agents are incompatible. Three packets of rhizobial culture are sufficient for treating seeds required for one ha. The culture slurry may be prepared with 500 ml of rice gruel. 10% of sugar / gur / jaggery solution is made by adding 50 gm of sugar or gur to 500 ml of water. Boil the solution for 15 minutes to dissolve the sugar in water. Cool the sticky solution to room temperature. Mix three packets of rhizobial culture into the cooled sticky solution thoroughly. The slurry solution helps rhizobium stick to the seed surface and also enhances the survival of rhizobium. Dry the bacterial culture treated seeds in shade for 15 minutes before sowing. The inoculated seeds should not be exposed to sunlight. Seeds after inoculation with rhizobium should be sown as soon as possible preferably on the same day. Inoculated sown seed should be covered with soil. The inoculated seeds should not be allowed to come in direct contact with chemical fertilizers. If the seed treatment is not carried out apply 10 packets (2 kg) of Phosphobacteria (Bacillus egaterium) and 10 packets (2 kg) of Pseudomonas fluorescens with 25 kg of FYM and 25 kg of soil before sowing. In very acid soils, it is advisable to sow the inoculated seeds along with lime, dolomite or neutralized super phosphate. Sowing of redgram can be

done on ridges when soil internal drainage is poor which leads to waterlogging. Seeding depths of 2.5 to 5 cm are recommended. The seeds take nearly five days for germination and the seedlings begin to appear above the ground by the fifth day under favorable conditions.

Seed hardening will help redgram to tolerate drought stress. Calcium chloride 20 g per liter (c. 0.2%) is to be prepared. One kg of seeds per liter should be immersed for one hour and dry it under shade for 7 hours to harden the seeds. Dry the seeds under shade for seven hours. Treat the seeds with 100 g rhizobium, 100 g PSB and 4 g trichoderma per kg seed by sprinkling jaggery solution and then microbial powder on the seeds.

Nipping: Nipping off 5-6 cm top growth in red gram at 20-30 days after transplanting (DAT) will allow side branches which in turn increase pods yield.

Weed management: Redgram is very sensitive to weed competitions in the first 60 days of growth. When protected in this period, the crop makes rapid growth and weeds do not affect its growth thereafter. Spray Fluchloralin 1.5 lit per ha or Pendimethalin 2 lit per ha three days after sowing mixed with 900 liters of water which is followed by irrigation. Post emergence application of Imazethapyr @ 60 g ai / ha on 15 DAE of weeds (2-3 leaves stage of weeds) and quizalofop ethyl @ 50 g ai / ha on 20 DAE of weeds (2-3 leaves of weeds) are recommended for controlling broad leaved and grassy weeds respectively. At the time of herbicide application, there should be sufficient soil moisture. Then one hand weeding may be given on 30 to 35 days after sowing. If herbicide is not applied, two hand weeding are given on 20 and 35 days after sowing.

Manures and fertilizer application: Farm yard manure / Compost @ 12.5 t/ha or Vermi-compost @ 5.0 t / ha is applied as basal dressing. Application of 12.5-25-0 and 25-50-0 kg of N, P, Os and K20 per ha is recommended for rainfed and irrigated conditions respectively. Seedlings in early stages depend on soil - nitrogen and do respond to a starter dose of 15 to 20 kg N / ha. In the later stages of plant growth, most of the nitrogen requirement is derived from fixation in nodules. Soil application of 25 kg of sulphur as gypsum (110 kg ha) or 2% urea in two sprays at flower commencement and 15 days after may be given. At the time of first appearance of flowering, spray DAP @ 2% and a second spray is given 15 days after the first spray.

Growth regulators: Apply 40 ppm NAA (40 mg / liter) at flower initiation. This may be advantageous when mixed with urea and sprayed. NAA can be mixed with fungicide and insecticide. Use of TIBA @ 150 ppm (150 mg / liter) as a foliar spray at flowering initiation is effective in increasing grain yield.

Water management: Water requirement for redgram crop is 400 mm which yields about 910 kg of grain per ha. Though it is a drought tolerant crop, it responds well to irrigation during summer seasons. Irrigate the crop immediately after sowing, third day after sowing, bud initiation, 50% flowering and pod development stages. 50% increase in grain yield with irrigation at 60% depletion of available soil moisture compared to irrigation at 100% depletion of available moisture. Water stagnation should be avoided. Ridge planting has proved advantageous as it ensured quick disposal of rain water allowing no stagnation. In general, redgram is grown as rainfed crop and the rains received during the growing season itself are sufficient to allow the crop to complete its life cycle without water stress. The moisture stored in the soil profile during monsoon (rainy) period is used by the crop in the post - monsoon period.

Cropping systems: The promising sole and intercropping system of redgram is presented in Table. Early - maturing (100-120 days) genotypes are grown as a sole crop. It is generally grown during the kharif season (June - July) either as sole crop or as an intercrop with cereals, like sorghum, pearl millet or oilseeds like groundnut. The practice of mixed cropping has been common with long duration varieties of Redgram under rainfed conditions. It can be one of the alternate crops grown in rabi (post rainy season to utilize the residual soil moisture and nutrients. The optimum plant populations for the rabi crop is three to four times higher than that normally used in kharif season because of the influence of low temperature and short photoperiod. Intercropping of redgram + groundnut in 1: 6 ratios is recommended during kharif season. Multitier cropping of agathi (Sesbania grandiflora) with $1x \ 1 \ m$ spacing forms first tier, redgram with 45 cm x 20 cm forms second tier, cotton with 45 x 20 cm forms third tier and blackgram with 30 cm x 10 cm forms fourth tier is recommended for rainfed black soil areas recording more than 300 mm rainfall during the cropping period.

Inter crop	Sowing pattern	Ratio of component crops
Cereal combinations		
Sorghum + Pigeonpea	Paired rows at 30:30:60 cm.	2:1
Pearl millet + Pigeonpea	Paired rows at 30:30:60 cm.	2:1
Maize + Pigeonpea	Paired rows at 40:40:80 cm. or Uniform rows at 60 cm.	2:1
Pigeonpea + upland Rice	Uniform rows at 60-75 cm.	2:2
Legume combinations	and the second state of th	St. and and
Pigeonpea + Groundnut	Uniform rows at 75-90 cm.	2:2
Pigeonpea + Soybean, Mung Bean or Black Gram or Chickpea	Uniform rows at 75 cm. or Uniform rows at 50 cm.	2:1
Long duration redgram varieties (one row) + groundnut (six row)	Rainfed condition	1:6
Short duration redgram varieties + groundnut	Rainfed condition	1:4

Table 10 Particulars of redgram based cropping systems

Crop protection: Among insect pests gram pod borer (Helicoverpa armigera) and pod fly (Melanagromyza obtusa) cause severe damage and associated yield losses across pigeon pea growing regions of the country. Pod fly causing 2.5 to 86.8% of grain losses in different parts of the country was notable. The estimates of avoidable losses due to pod borer complex, mainly pod fly and H.armigera are 43.5 and 30.2%, respectively. Among diseases, Fusarium wilt (Fusarium udum) in Central and Southern states followed by sterility mosaic (virus transmitted by criophyid mite Aceria cajani), and SMD and Phytophthora blight (Phytophthora drechsleri /.sp.cajani) diseases in the North East plain (Uttar Pradesh) cause substantial yield losses to the crop. Unchecked weeds also cause 21-97% yield loss in pigeon pea.

Integrated Pest Management practices:

- Grow trap crops such as marigold (Chrysanthemum spp.) On the border and in between rows as an inter crop.
- ▶ Use of neem seed kernel extract 5% against pod borer in SDP and ESDP is quite effective.
- Spray HNPV (nuclear polyhedrosis virus that infects H. armigera) 250 LE (larval equivalent) ha 1 on noticing egg and first instar larva of H. armigera (2-3 eggs or 1 larva per 5 twigs of plants, which is the economic threshold level).
- Installing bird perches (a) 50 / ha for attracting insectivorous birds that feed on larvae of Helicoverpa pod - borer.
- Sprays of monocrotophos 36 EC (0.04%) (Iml L 1 water) followed by Nimbicidine (0.3%) was best for the control of pigeonpea pests. Cypermethrin (0.004%), and endosulfan 35EC (0.07%) (2 ml / 1 water) are also effective for pod borers. Spraying should be done @ 600-1000 liters of water ha- with knapsack sprayer or 200-300 liters of water ha - 1 with power sprayer.
- Seed dressing with Ridomil MZ @ 3g kg 1 seed. Two foliar sprays of Ridomil MZ at 15 days intervals starting from 15th day after germination, if there is continuous rain (high humidity), and risk of infection to control Phytophthora blight.

- Spray acaricides Kelthane or Morestan or Metasystox at 0.1% to control the mite vectors in the early stages of plant growth which favors the spread of Sterility mosaic disease.
- > Pheromone traps for Helicoverpa armigera 12 / ha.
- Apply any one of the following insectcides viz. , Azadirachtin 0.03% WSP 2500 5000 g / ha, Bacillus thuringiensis serovar kurstaki (3a, 36,3c) 5% WP 1000-1250 g / ha, Dimethoate 30% EC 1237 ml / ha, Emamectin benzoate 5% SG 220 g / ha, Indoxacarb 15.8% SC 333 ml / ha, Chlorantraniliprole 20 E 150ml / ha, NPV of H. armigera 2% as 250-500. Spinosad 45% SC 125-162 ml / ha, NSKE 5% twice followed by triazophos 0.05%, Neem oil 2%, Phosalone 0.07%, (Spray fluid 625 ml / ha) etc., to control pod borers, plume moth, pod fly, pod bug.
- Gram pod borer management practices includes.
- Setting up of pheromone traps @ 5 traps / ha before the initiation of flowering and collection and destruction of moths caught in the traps.
- Spray application of phosalone 0.07% or endosulfan 0.07% or profenofos 0.05% or cypermethrin 0.005% or the combination with Bacillus thuringiensis var. kurstaki three times at fortnightly interval commencing from flowering affords protection,
- Dusting of endosulfan 4% or carbaryl 10% dust @ 25 kg / ha once at initiation of flowering controls the pest on Bengal gram and,
- Spray application of HaNPV at dusk @ 250 larval equivalent / ha.
- Plume moth may be controlled with spray application of phosalone 0.07% or endosulfan 0.07% or profenofos 0.05% to control
- Spray Methyl demeton 25 EC 500 ml / ha or Dimethoate 30 EC 500 ml / ha to control aphids.
- Apply P. fluorescens (or) T. viride 2.5 kg / ha + 50 kg of well decomposed FYM or sand at 30 days after sowing to control wilt.
- Drenching with Carbendazim @ 1 gm / lit to control root rot. Rogue out the infected plants in the early stages of growth.
- Spray Fenazaquin @ 1 milit on 45 and 60 DAS as prophylactic spray to manage sterility mosaic.
- Seed treatment with Pseudomonas fluorescens and Trichoderma viride (5g + 5g) and Soil application of Pseudomonas fluorescens or Trichoderma viride @ 2.5 kg ha at the time of sowing to control Cyst nematode.

Harvest: Redgram should be harvested when 75 to 80% of the pods are at physiological maturity. It can be harvested about 40 days after anthesis when pods turn brown and are dry and when the dry mass of the seed is low and moisture content is between 20 and 24. Sometimes, the whole crop is cut down when about two - thirds or three quarters of the pods are matured. Traditionally the crop is harvested by cutting the stem at the base, with an ax or sickle. The harvested plants are tied in bundles and transported to a threshing floor. The plants are stacked in upright bundles to dry. The pods and grain are separated by beating the dry plants with sticks or by using a thresher. Hand picking of the mature pods can also be done. This allows the crop to flower and pod for a second or sometimes a third harvest. Hand picking may not be economical beyond a second flush. When hand picking of pods is not feasible, the upper branches with mature pods are cut (good for determinate types). The seeds and chaffs separated by winnowing.

Yield: Red gram may yield 1.0-1.5 tonnes (kharif), 2.0-2.5 tonnes (rabi) of grain / ha, 5.0-6.0 tonnes of sticks, 0.8-1.0 tonnes of dry leaves and 0.2-0.3 tonnes of pod husk / ha. Crop residue yield is ranging from 20-25 quintal per ha. In general, early - maturing (100–120 days) genotypes have a higher harvest index with an average of 34% compared to medium maturing genotypes at 24%.

Post - harvest technology: After threshing and winnowing, the seeds are cleaned and thoroughly dried to a moisture content of 10% before being stored. The ripe dry seeds are boiled and eaten as pulse. In India, the ripe dry seeds are split and made into dhal, which may be prepared either by a dry or wet method. In the dry method, the dry seeds are placed in the sun for 3 to 4 days and are then split in a mill and this process is repeated for 3 to 4 times. In the wet method, the seeds are soaked in water for 6 to 10 times mixed with red earth overnight, then

dried in the sun, after which the red earth is removed by sieving and the seeds are finally split into 'dhal' in a hand mill. The split 'dhal' is then cleaned by repeated winnowing and sieving to remove the hulls and broken pieces and is then treated with castor or sesame oil to preserve its quality, prevent insect attack and give it an attractive appearance. The yield of dhal 'is about 66% by the dry method and 80% by the wet method.

Redgram is susceptible to insect infestation during storage and periodic fumigation of the storage chamber with carbon bisulphide, phosphine, ethylene dibromide or methyl bromide is recommended. Slurry treatment of the seeds with carbendazim @ 2g using 5 ml of water kg of seed (or) dress the seeds with halogen mixture (Pure CaOCl2 + CaCO3 + leaf powder (arappu) of Albizzia amara at (5: 4: 1) ratio) @ 3g / kg of seed (or) treat the seeds with neem oil / groundnut oil or leaf powder of tobacco / notchi / neem / Albizzia amara (arappu) or fruit rind powder of Sapindus laurifolius (Poochi kottai) or Acacia concinna (Soapnut powder) @ 1: 100 ratio. Treat the seeds with turmeric rhizome powder (or) neem leaf powder @ 1:50 powder to seed ratio against bruchid infestation as eco - friendly seed treatment.

Seed Storage: The seeds can be stored in gunny or cloth bags for short term storage (8-9 months) with seed moisture content of 8 to 9% in polylined gunny bag for medium term storage (12-15 months) with seed moisture content of 8 to 9% and in 700 gauge polythene bag for long term storage (more than 15 months) with seed moisture content of less than 8%. Many factors such as sced moisture, relative humidity, temperature and infestation by stored grain pests influence the viability of seed during storage and reduce the quality of seed. The seeds damaged by bruchids do not germinate well resulting in poor plant stand and consequently yield, and economic loss. The seed can also be solarized for couple of days before storing them in shade. High temperatures (-65 ° C) in polythene bags due to sunrays will kill any living insect pest. Use new gunny bags lined with fenvelrate 20 EC. Dip the old gunny bags in this solution for 10-15 minutes and dry properly in shade before storing seed. Grain earmarked for sowing should be mixed with 5% malathion dust at 250 g 100 - kg - seed. In case of insect attack, fumigate the seed in store with aluminum phosphide (30g celphos t-seed or 7-10 tablets of celphos 28 m-?) For a period of one week. Seed can also be treated with 7.5 ml rapeseed oil or groundnut oil per kg of seed. By this way, the seed can be kept safe for 8-9 months.

Utilization: Pigeon pea is cultivated either as a food crop (dried pea or vegetable pea). cover crop, forage crop, green manure crop, nurse crop, a windbreak hedge, as a host for lac insects, and as food for silk worms. When it is used as pulse, the dried seeds are used as human food. When used as a vegetable, redgram should be harvested when the seeds are fully grown but just before they lose their green color. The stalks are used for fuel, thatch, and basketry. Redgram is mainly eaten in the form of split pulse as' dal 'or'dhal'. The outer covering of its seed together with part of the kernel provides a valuable feed for milch cattle. The husk of pods and leaves obtained during threshing constitute a valuable cattle feed.

Transplanting in redgram:

- Seedling preparation: seeded rate is 3.0 kg / ha to prepare red gram plants for one hectare land. To raise the seedlings, polythene bags of size 15 cm x 10 cm (1 x b) with 200 y guage should be used. At lower side of bags three four holes are to be opened for draining of excess water. Polythene bags can be filled with FYM / Vermicompost, Soil and Sand in 1: 1: 1 ratio. Sow the seeds @ 2 / poly bag at 1 cm depth and keep the bags under partial shade and watering should be done at regular intervals. The age of seedlings for transplanting is 30 to 40 days. Plant hardening is essential before transplanting. Seedlings can also be raised in the field to avoid transportation cost.
- Transplanting of seedling in main field: Under water logging condition, form furrows before digging pits. Apply inorganic fertilizers @ 25:50:25 kg NPK / ha at 20-30 days after planting as urea, DAP and potash around the seedlings After deep ploughing and tilling, pits of 15 sq cm size should be opened at 5 x 3 ft in deep medium soils (2904 plants per acre) for sole crop under irrigated condition or 6 x 3 ft in deep soils (2420 plants per acre) for inter crop under irrigated condition. And 5 x 3 ft in deep soil (2904 plants per acre) for sole crop under irrigated condition. Fill the pits with soil and compost in equal proportion before 15 days of transplanting. Transplant one seedling per pit. In intercrops, prior to

transplanting sow the crops (black gram / green gram / soybean) then red gram plants have to be transplanted into pits (as said above). By opening ridges and furrows with 5 and 6 ft interval in sole and intercrop, respectively. Separate the bag before transplanting. Transplanting is done with 25-30 days old polybag seedlings in pits prepared using power tiller operated post whole auger. Irrigation is given immediately after transplanting. The advantages of transplanting the seedlings are viz. , i) reduced main field duration, ii) adequate plant population and iii) increased yield per unit area.

- Layout for Drip Fertigation: The recommended lateral spacing is 150 cm and plant spacing is 90 x 60 cm for long duration for drip fertigation while the lateral spacing is 100 cm and plant spacing is 60 x 30 cm for short duration. Power tiller operated heavy duty auger digger can be used to dig holes for planting seedlings. Nipping (removal of top 5 cm) the plants may be done on 20 DAT which is equivalent to the seedling age of 50 DAS to arrest the terminal growth and to enhance branching in the plant.
- Manures and fertilizer application: Farm yard manure / Compost @ 12.5 ton / haar vermicompost @ 5.0 ton / ha should be added three weeks before transplanting. By this, water holding capacity and microbial population increases due to which nitrogen fixation will also occur at faster rate. Application of zinc sulphate 5 kg / ha mixed with farm yard manure @ 100 kg / ha / vermicompost @ 50kg / ha is recommended to control zinc deficiency while gypsum @ 200 kg / ha to overcome sulphur deficiency. DAP and MOP application should be made at 20-30 DAT in ring method. Soil application of sulphur @ 20kg / ha through SSP. gypsum or pyrite enhances seed yield, fertilization schedule (drip irrigation once in 3 days at 100% CPE) is given on 14, 21, 28, 35, 42, 49, 56, 63, 77, 84, 91, 98, 105, 112, 119 DAS. Bio fertigation using liquid bio-fertilizer, rhizobium and azophosmet each @ 750 ml / ha, TNAU pulses tonic @ 1% once at peak flowering and humic acid @ 2 liters per irrigation and sea weeds extract @ 2.5 lit can be given for first five irrigations. The fertigation schedule for redgram 100% dose with water soluble fertilizer are furnished in table 1 and 2.

	1999		Fertilizer grade			Dose	Total Oty kg/	Nutrients (kg/ha)		
Stage	Duration	Fertilizer Form	N	P	K	/day	ha	N	Р	K
15-45 DAT	30	МАР	12	61	0	1.57	47	5.64	28.67	0
Carlos Are		UREA	46	0	0	0.33	10	4.6	0	0
46-75	30	MAP	12	61	0	1.17	35	4.2	21.35	0
- Area la - a - a	- Leike	UREA	46	0	0	0.33	10	4.6	0	0
76-105	30	SOP	0	0	50	0.83	25	0	0	12.5
1 En Eliza	Britshing	UREA	46	0	0	0.33	10	4.6	0	0
106-135	30	SOP	0	0	50	0.83	25	0	0	12.5
and some and	30	UREA	46	0	0	0.17	5	23	0	0

Table-1 Fertigation schedule for redgram 100% dose with normal fertilizers:

Table-2 Fertigation schedule for redgram 100% dose with water soluble fertilizers:

		C. S. Street	Fertilizer grade			Dose	Total	Nutri	ents (k	g/ha)
	Duration	Fertilizer Form	N	Р	K	/ ha / day	Qty kg/ha	N	Р	K
Stage	30	MAP	12	61	0	1.33	40	4.8	24.4	0
15-45 DAT	50	UREA	46	0	0	0.33	10	4.6	0	0
	20	MAP	12	61	0	0.90	27	3.24	16.47	0
46-75	30	DE	19	19	19	0.83	25	4.75	4.75	4.75
105	20	DE	19	19	19	0.83	25	4.75	4.75	4.75
76-105	30	SOP	0	0	50	0.60	18	0	0	9
	20		46	0	0	0.27	8	3.68	0	0
	30	SOP	0	0	50	0.47	14	0	0	7
106-135			46	0	0	0.17	5	2.3	0	0

Yield: The average redgram yield is 700 kg / ha. The achievable redgram yield under drip fertigation is 1500 to 1750 kg / ha while the per plant yield ranges from 125 to 250 grams depending on the duration of varieties.

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.				