AGR 401 AGRONOMY OF FIELD CROPS - II 2+1

THEORY

Agronomy of field crops – Economic importance - origin - soil and climatic requirement - area, production and productivity in World, India and Tamil Nadu – System of cultivation – crop management - season - varieties - seed rate - seed treatment - sowing - density and geometry - growth stages - critical stages - nutrient, irrigation, weed management - after cultivation - harvest and processing - cropping systems – yield estimation – byproducts utilization.

Oilseeds	Groundnut, Sesame, Sunflower ,Rapeseed and Mustard, Castor, Safflower, Niger and Linseed
Sugar crops	Sugarcane, Sugarbeet, Sweet sorghum
Fibre crops	Cotton, Jute, Mesta, Sunnhemp, Agave
Narcotics	Tobacco

LECTURE SCHEDULE

THEORY

1. Importance of oilseeds, sugar crops, fibres and narcotics in trade and utility
2. Area, production and productivity of oilseeds (groundnut, sesamum, rapeseed and mustard, sunflower, safflower, castor, niger and linseed)
3. Groundnut - importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing under irrigated and rainfed condition - plant density
4. Groundnut - manures and manuring - weeding – irrigation- cropping system - after cultivation, harvest and storage - Rainfed groundnut cultivation
5. Sesame - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring - weeding - irrigation – cropping system - after cultivation, harvest - Rice fallow and rainfed sesamum cultivation.
6. Rapeseed and Mustard - importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring – weeding - irrigation - cropping system - after cultivation, harvest and post harvest technology

7. Sunflower – importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring – weeding - irrigation
8. Sunflower – cropping system - after cultivation - techniques to improve seed setting – harvest and post harvest technology– Rainfed sunflower cultivation.
9. Safflower - importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring - weeding - irrigation - cropping system - after cultivation, harvest and post harvest technology.
10. Castor - importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring - weeding - irrigation - after cultivation - cropping system- harvest and post harvest technology.
11. Niger - importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring - weeding - irrigation - after cultivation - cropping system- harvest and post harvest technology.
12. Linseed - importance - origin and distribution - soil and climatic requirements, season - varieties - field preparation - sowing - manures and manuring - weeding - irrigation - after cultivation - cropping system- harvest and post harvest technology.
13. Area, production and productivity of Sugar crops (sugarcane, sugarbeet and sweet sorghum)and fibre crops (cotton, jute, mesta and agave) in India and Tamil Nadu
14. Sugarcane – economic importance - origin and distribution - soil and climatic requirements, season - important varieties
15. Sugarcane - main field preparation - preparation of setts for planting - sett treatment - methods of planting – manures and manuring - crop logging
16. Sugarcane - weed management – irrigation - after cultivation – cropping system
17. Mid-Semester examination
18. Sugarcane – time of harvest - juice extraction and post harvest technology (sugar and jaggery manufacture) and management of ratoon sugarcane.
19. Sugarbeet – economic importance - season - varieties - sowing / planting - manures and manuring - weeding – irrigation - after cultivation,- cropping system- harvest and post harvest technology.
20. Sweet sorghum - economic importance – origin and distribution – soil and climatic requirements -season - varieties - sowing - manures and manuring - weeding - irrigation – after cultivation - cropping system- harvest and post harvest technology.
21. Cotton – economic importance - origin and distribution - soil and climatic requirements, season - species / varieties - field preparation - methods of sowing
22. Cotton – manures and manuring - seed rate - seed treatment - sowing - weeding - irrigation – after cultivation - cropping system - harvest
23. Rice fallow cotton - season - important varieties - field preparation - seeds and sowing - seed treatment - manures and manuring - weeding - after cultivation - harvest

24. Problems in cotton cultivation - terminologies associated with cotton- post harvest technology- quality characters - cotton seed oil - utility - importance
25. Jute – economic importance - origin and distribution - soil and climatic requirements, season – field preparation - sowing - manures and manuring - weeding and after cultivation
26. Jute – irrigation- cropping system- harvest and post harvest technology- fibre extraction (retting)
27. Mesta and sunnhemp – economic importance - season - varieties - sowing - manures and manuring - weeding - after cultivation - irrigation – cropping system- harvest and post harvest technology- fibre extration
28. Agave –economic importance –origin and distribution- climatic requirements – season- varieties/ types - cultural practices – harvest and post harvest technology - fibre extraction
29. Tobacco – economic importance - origin and distribution - area, production and productivity in India and Tamil Nadu - soil and climatic requirements - season - varieties - nursery preparation - seed rate - seed treatment and sowing
30. Tobacco - main field preparation - planting - manures and manuring - weeding - irrigation - after cultivation -
31. Tobacco – cropping system -harvest and post harvest technology and curing of tobacco
32. Yield estimation – pertaining to oilseeds viz., Groundnut, Sesame, Sunflower , Rapeseed and Mustard, Castor, Safflower, Niger and Linseed
33. Yield estimation – pertaining to sugar crops (sugarcane and sugarbeet), fibre crops (cotton, Jute, Mesta, Sunhemp and Agave) and narcotics (Tobacco
34. Byproduct utilization from oilseeds, sugar crops, fibres and narcotics

PRACTICAL

Visit to crop cafeteria - Identification of crop plants - varieties and seeds - Acquiring skill in different operations for various crops - nursery preparation - sowing - seed treatment - preparation of main field - method and depth of sowing / planting - use of sowing equipment - maintenance of plant density and geometry, time and method of application of manures and fertilizers - irrigation, weed management - after cultivation - assessment of maturity - harvest and processing. Cost of cultivation and economics - Observations on growth and yield estimation - Topping in cotton. Detrashing and propping of sugarcane. Topping, desuckering and curing in tobacco. Study of jaggery manufacture and visit to sugar factory / Ginning factory / Tobacco curing centres.

PRACTICAL SCHEDULE

1. Maintenance of crop cafeteria involving oilseeds, sugar crops, fibre crops and tobacco for identification of crops and to acquire skill in various operations.
2. Acquiring skill in field preparation, sowing and manuring of oilseeds under pure and intercropping situations
3. Acquiring skill in field preparation, preparation of setts, planting and manuring of sugarcane and ratoon cane management
4. Acquiring skill in field preparation, sowing / planting and manuring for sugarbeet and sweet sorghum
5. Visit to nearby sugar mill for observing juice extraction, quality assessment, sugar manufacture and byproducts
6. Acquiring skill in different seed treatment techniques for oilseeds, fibres, sugar crops and narcotics
7. Nursery preparation and management in tobacco
8. Visit to tobacco field and observing operations on topping, desuckering and different curing methods
9. Estimation of plant population per unit area for various oilseeds, fibres, sugar crops and narcotics
10. Observations on growth and yield parameters and estimation of yield of various oilseeds and sugar crops
11. Observations on growth and yield parameters and estimation of yield of various fibre crops - visit to ginning factory
12. Acquiring skill in after cultivation practices in cotton - earthing up - topping
13. Acquiring skill in after cultivation practices in sugarcane - earthing up - detrashing, propping
14. Observation on harvest symptoms of oilseeds, sugar crops, fibres and narcotics and assessment of maturity
15. Cost of cultivation and economics of important oilseeds and sugar crops
16. Cost of cultivation and economics of important fibre crops and narcotics
17. Practical examination

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GROUNDNUT

`Origin and History

The word *Arachis hypogaea* (groundnut) has been derived from two Greek words, Arachis meaning a legume and hypogaea meaning below ground (referring to the formation of pods in the soil). Groundnut has never been found in the wild state anywhere and its origin has, therefore, been a matter of considerable speculations and even controversy. There are tow school of thoughts about its origin-one supporting the view that groundnut had originated in Africa and the other tracing its origin to Brazil in South America. According to some literatures it is clear that from the beginning of the sixteenth the west cost of Africa an naturally they introduced it from Brazil into Africa. De Gandolle (1825) stated its origin to be in Brazil (South America). Its introduction in India is considered to be through Jesuit Fathers (Missionaries) who followed Vasco De Gama shortly after his first landing in India i.e. in the first half of the 16th century.

Ecological requirements

Groundnut is a tropical crop which requires a long and warm growing season while high rainfall, drought and cold weathers are extremely detrimental for better crop growth. Normally it needs about 70-90°F temperature during its growing period with cold nights at maturity. It can be grown well in tracts which receive an annual well distributed rainfall of 50-125 cm.

The best type of soil for groundnut cultivation is the one which is well drained, light coloured, loose, friable, sandy loam, well supplied with calcium and moderate amount of organic matter. Soils with poor drainage high acidity or alkalinity must be avoided for groundnut cultivation. A soil pH over 5.0 or below 8.5 is supposed to be an

ideal for groundnut production. In U.P. it is grown in alluvial sandy to loam soil while in M.P., Maharashtra, Gujarat, Andhra Pradesh and Karnataka the crop is taken in black cotton and red soils. Heavy clay is not fit for groundnut production because soil becomes very hard during drought which restricts pod formation and development. Even peg penetration becomes difficult.

Land preparation

For good germination and higher pod yields it is essential to get a weed free well pulverised, open and aerated seed-bed for sowing the crop. The field must be thoroughly leveled to avoid water logging in any part of the field. A required tilth may be obtained by ploughing twice with mould board plough followed by two harrowings and plankings. If the field is infested with white grubs, chemicals like Heptachlor or Chlordane should be drilled at the rate of 25 kg per hectare before the final harrowing. Organic manures, if to be applied, should be spread and mixed well in the soil at least 15-20 days before sowing.

Application of manures and fertilizers

Groundnut, being a leguminous crop, does not require very high doses of nutrients. In general, it needs about 10-20 kg N, 40 kg P_2O_5 and K_2O/ha under rainfed conditions while under irrigated conditions an application of about 20-40 kg N, 40-90 kg P_2O_5 and 20-40 K_2O/ha is sufficient. It is observed that Andhra Pradesh soils are deficient in B and molybdenum whereas North Indian soils are deficient in sulphur, zinc and calcium. These deficiencies may be corrected by appliction of 5 kg Borax, 1.0 kg Ammonium molybdate, 15-20 kg of zinc sulphate and 200-500 kg of gypsum at per hectare rate. Of these, Borax and Ammonium molybdate should be applied as basal

while gypsum should be band placed near roots 30 days after sowing. These nutrients should be applied in the zone of pod development as they are directly absorbed by the developing pods.

The crop responds well to application of F.Y.M. or compost at the rate of 6.25 tonnes under rainfed and 12.5 tonnes/ha under irrigated conditions. But under unavailability of organic manures the above mentioned NPK may be met with inorganic fertilizers. So far as sources are concerned it is always better to apply ammonium sulphate/calcium ammonium nitrate, single super phosphate and muriate of potash. In case of very light soils the nitrogen should be applied in two split doses i.e. half at sowing and half (top dressing as band placed) 30 days after sowing or at the time of last intercultivation.

Seed selection and seed treatment

To ensure good stand, uniform maturity, high yield and better quality produce one has to be careful about the seed quality. The seed must be pure, viable uniform in size and free from the seed bone diseases. The seeds should not be broken or damaged by any means. It is better to use hand shelled kernels but if large area is to be sown, groundnut sheller may be used. The germination of the seed should be checked and the seed not having over 90 per cent germination should be selected for sowing . It is observed that the germination in case of bunch type is always higher (90-95 per cent) than the spreading type (85-90 per cent).

To ensure the freedom of seed from seed borne diseases the kernels must be treated with captan 75 per cent dust or Thiram 75 per cent. W.D. P. (Slury made by

mixing 125 g Thiram / 100 kg kernal in 500 ml of water) or Difolotan dust at the rate of 2.5g and 1.25 g and 2.0 g/kg and 2.0 g/kg of groundnut kernel respectively.

It is observed that some of spreading varieties have a dormancy of 60-75 days before they germinate. Therefore, in case of the freshly harvested kernels are to be used for sowing within the dormancy period, the kernels should be treated with some germination promoting hormones like G.A. etc.

It is advised that, when groundnut is to be introduced in some new areas where it was never grown the kernels should be treated with *Rhizobium* culture for better nodulation, growth and development of the crop. The *Rhizobium* culture treatment may be done as under:

For 50 kg of kernels, prepare 10 per cent solution of gum Arabic in water, add gur (Jaggary) to make a solution of 5%. When it is dissolved, add 2-3 packets (200 g each) of peat based culture, pour the groundnut kernels and agitate the content to make a slurry. When all the kernels have had an uniform coating of the slurry, spread them out on newspaper sheets in the shade. Reject the left over slurry after use and sow the seeds when they have dried completely.

Sowing

Time of sowing. In north India groundnut is grown as a kharif season crop where sowing is done between April-July under irrigated conditions and between June 20 to July 31, under rainfed conditions. In Tamil Nadu the crop is sown from May to July where as in Andhra Pradesh and Gujarat, it is sown between January to March.

Seed rate. The seed rate depends upon boldness, spacing and germination percentage of seeds. On average the seed rate of spreading type comes to 60-70 kg/ha

while for bunch type it is about 85-90 kg/ha. In case of very bold seeded variety like T-64 it would be about 200 kg/ha.

Method of sowing. Groundnut is sown either by dibbling the seeds behind the plough or by suing a seed drill. In case of irrigated crop it is better to prepare ridges and furrows with a country plough and dibble the seeds on ridges as this helps in inter cultivation and in better pod setting of groundnut. In case of rainfed light soils the crop is sown of flat beds. For good germination depth of seed sowing is another important aspect which needs due attention. Usually groundnut seeds should be sown at a depth of 5-8 cm in light soils and 4-6 cm in case of moderate to heavy soil types. To ensure a good and proper germination a light covering with soil is required over the seed.

Sometimes rodents and crows are noticed to take away the seeds from the field, therefore, use of some repellants like pinetar and kerosene for seed treatment are recommended to keep the industries away. But care should be taken to avoid any injury to the kernels.

Spacing. This varies according to irrigation facilities and type of the seed. In case of bunch type and rainfed crop the spacing ranges between 20-30 cm from row to row and 8-10 cm from seed to seed. The spacings in case of semi-spreading and spreading types with irrigation facilities range between 30-40 cm x 10-15 cm and 50 cm x 15-20 cm respectively..

Irrigation

Generally groundnut is grown as a rainfed crop during kharif season though its water requirement varies from 500-700 mm but if crop is caught in a long spell of drought, especially at the pod formation stage, supplemental irrigation is given. In case

of irrigated crop the frequency of irrigation depends upon soil texture and the interval between the irrigations ranges between 8-12 days. The critical stage for irrigation is branching, flowering and pod formation. There should be sufficient moisture at the sowing time in the field, thus if the crop is to be sown before onset of monsoon the field should be given one light pre-sowing irrigation for better germination of the seeds. The winter and summer crops are always grown under assured irrigation. The irrigation must be stopped about 20-25 days prior to maturity.

Weed Management

Weeds result in a severe competition with the crop and cause a considerable reduction in the yield to the extent of 20-40 per cent based on nature of weed infestation in the field. To kept the soil loose and friable and the field free from weeds the crop should be given a hand weeding 20-25 days after sowing and one or two hoeings--the first at the time of weeding and second about a fortnight later. The intercultural operations should be stopped after the pegs have started going into the soil. The bunch and semi spreading types should be given a light earthing to facilitate the maximum penetration of the pegs into the soil.

For an integrated approach to the weed control problem it is advised to apply TOK-E-25 or Lasso at the rate of 5 litres of commercial material dissolved in 500 litres of water as pre-emergence soil spray within two days of sowing. The chemical weed control should be combined with above mentioned mechanical control measures to take care of the weeds effectively. But on top of everything it is essential to sow the seed in a completely weed-free seed-bed.

Mixed Cropping

The groundnut crop may successfully be growing mixed with several erect growing crops like bajra, arhar, castor, sesamum, cotton, maize, sunflower etc. The number of groundnut rows between two rows of any of the said crops depends upon their inter-row spacing and type groundnut, *i.e.* bunch, semi-spreading or spreading to be grown.

Use of hormones in groundnut production

Use of hormone was not very much practical in the past but with the advancement of the production technology now application of certain hormones has become a common practice. Seeding the growth behaviour of the crop we find that groundnut usually suffers from two drawbacks--the first is that the crop being non-determinate keeps on flowering and production of pegs simultaneously uptil maturity and the second is that the pods start germinating at once after reaching physiological maturity, if they get water. As a result and effective pods germinate if there is rain or irrigation. Thus both the conditions lead to very poor yield and quality of the crop.

Application of L-NAA in the form of planofix (manufactured by May & Baker Ltd.) and Vaardhak (manufactured by Paushak Ltd.) at the time of flowering have been found to reduce the excessive vegetative growth and flowering period which ultimately increases the number of effective pods / plant, test weight and the yield/unit area. However, their positive effect on quality is not established. It has also been observed that their two applications at lower concentration are better than one application at higher concentration. The most ideal time for hormone application in groundnut is 40 and 80 days after sowing and the best concentration is 20 ppm.

It has also been noticed that application of MH (Maleic hydrozide) near maturity results in inducing dormancy in the pods for about 20-30 days which checks the germination of matured pods even if they get water. Thus it helps in easy harvesting of the crop. If the soil has dried the field may be irrigated and the crop can easily be harvested by the help of plough, harrow or cultivator. However, the chemical being very expensive is not commonly applied.

Harvesting and after use

Yellowing of leaves is the prominent symptom of maturity. The leaf yellowing is associated with leaf shedding (particularly, the older ones), development of proper colour of shell and a dark tint on the inner side of the shells. Usually the crop takes about 120 to 140 days time to mature depending upon the variety and the harvesting is done in the month of October-November accordingly. At maturity the crop is badly damaged by crows, jackals, pgis etc. which need vigilance. After maturity the bunch and semi-spreading types are generally harvested by hand pulling at an appropriate soil moisture, while the spreading types are harvested by digging out the plants with the help of khurpi, spade or by polughing the field. The left out pods in the soil are collected by hand, later. The pulled out plants are stacked in a safe place for a few days to dry and are stripped afterwards. The stripped pods are cleaned nicely and dried to a safe moisture content of not more than 5 per cent before they are stored because dampness will cause fermentation of pods and allow to develop the poisonous moulds like *Aspergillus flavus* in the kernel. These moulds lead to contamination with aflatoxin which create a health hazard to both human and cattle who consume the kernels.

Drying

Generally moisture % in pods is found to be around or excess of 40% (on wet basis) depending upon stage of maturity at harvest. The pods must be dried to 5-10 % moisture for safe storage. Drying rapidly prevents molding and other forms of deterioration. Perfect drying helps in maintenance of the desirable flavour, texture, germination and viability of kernels etc.

Yield

The pod yield is controlled by several factors like climate, soil and varietal potentiality. In general, the irrigated groundnut crop produces about 30-35 quintal pods / hectare and rainfed about 15-20 quintal pods/ha. The yield of haulms is usually two to two and half times of pods' yield. The shelling percentage ranges between 70-75% and the kernels have on an average 45 to 50% oil in them.

Storage

All the damaged or injured pods must be sorted out before they are stored. Well cleaned and dried pods to 5% moisture level should be stored after filling in gunny bags. These gunny bags are stacked in a store room in tiers comprising not more than ten bags in each tier. The tiers must be staked on wooden planks in such a way that the air keeps on circulating to avoid damage from dampness, rate etc. The room should be inspected periodically and proper control measures of rats and pests should be taken. The store should be fumigated, if needed and made airtight. The groundnut should be stored in the form of pods rather than kernels but the broken and damaged pods must be taken out and discarded. Apart from this the undersized / underdeveloped and unfilled pods (pop-pods) should also be discarded because their presence reduces the market price.

Sesame

The crop may be grown on plain as well as on hills. It is mostly grown rainfed in areas receiving an annual rainfall of 50-70 cm but it cannot stand frost, continued rain or prolonged drought. The crop may be grown on a variety of soil types ranging from sandy loam to heavy black soils, with a pH ranging between 5.5. to 8.2.

In northern parts of the country the crop is mostly grown during kharif and some places during summer season but in central parts of India sesamum is grown in three seasons like kharif, semi-rabi and summer. Kharif and semi- rabi crops are completely rainfed but summer crop is grown under assured irrigation for which it is sown in May/June. Aug-Sept. and Feb./March respectively. Due to washing of pollens the kharif crop bears less number of capsules and hence it gives poor seed yield.

The seed rate varies from 3 to 5 kg/ha which is mixed with sand for proper distribution and drilled at a row to row spacing of 25-35 cm during summer but during kharif season a spacing of 35-45 cm between rows and 12-15 cm between plants is kept. To check the fungal diseases it is essential to treat the seed with Captan or Thiram at the rare of 3 g/kg of seed. Mostly it is grown on residual fertility but in case of poor soils the crop may be fertilized with 25-30 kg N, 20 kg of P_2O_5 and K_2O per hectare. The crop should be given a hand weeding about 20 days after sowing or it may be given a pre-emergence application of Lasso at the rate of 3 litres a.i./ha for control of weeds. Normally the crop is grown as rainfed during kharif but the rabi and summer crop need irrigation. The crop should be irrigated twice in rabi season (at flowering and grain filling) whereas summer crop needs 3 irrigations. The physiologically matured crop having leaves still green should be harvested by cutting the plants with sickles, which are

carried to threshing floor and stacked for a week. Later the plants are well shaken by holding upside down or by beating with stick to take out the seeds.

The crop is attacked by leaf-eating caterpillar (*Antigastra catalaunalis* Dup.) and gall-fly (*Asphondylia sesami* Felt) which may be controlled by spraying of Carbaryl 0.2% or Endosulfan (0.5 kg a.i./ha) on 40th day and 60th day after sowing. Seed treatment with Captan at the rate of 3 g/kg seed controls the stem root rot diseases while three sprayings of 100 ppm Agrimycin at 15 days interval control the bacterial leaf spot disease. Spraying of 0.05% of any Phosphomidon or Dimethoate or Dichlorovas kills the insect vectors responsible for spread of phyllody and leaf-curl in sesamum crop.

A Good kharif crop gives about 200 to 500 kg seed yield/ha while semi rbi and summer crop yield about 300-600 kg seed/ha.

VARIETIES

State wise list of varieties

Andhra Pradesh	:	Gowri (C. 1036), T 85
Gujarat		Mrug-1, Purva-1, Patan-64, Patan-65
M.P.	:	G-5, T-4, G-35, N0-128, N-32
Maharashtra	:	D. 7-11-1, N.58-2, N.128, T.85 and Chanda-8.
Orissa	:	Vinayka, Kalika, Kanak
Rajasthan	:	Pratap (C-50), T.13
Tamil Nadu	:	TMV-1, TMV-2, TMV-3, KRR-1 and KRR-2
U.P	:	T. 4, T. 10, T. 12, T.13, T 22
Bihar	:	Kanke white, M-3-1, M-2-3, M-3-3-.

Characteristic features of some important varieties

Type-4. It matures in 100 days and produces 6-7 q/ha. It has reddish white flowers, seeds are white & have 52% oil.

Type-10. It matures in 80-90 days, seeds are white and have 50-52% oil. It s a selection from varanasi local

Kalika. It is improved from Vinayak and recommended for kharif and zaid sowing. It may produce 8-9 q/ha during kharif and 13-14 q/ha during summer season.

Kanak. It is selection from Vinayak and T.4 and has grey seeds. The variety is recommended for Orissa.

Kankie white. This has white seeds, matures in 120 days and can produce 4-6 q/ha. The oil % in seeds is 50%.

M-3-1. Recommended for Bihar, it has black seeds, matures in 142-150 days and can produce 3-6 q seeds/ha.

M-3-2. It is similar to M-3-1 and is recommended for Bihar.

Pratap. Recommended for Rajasthan, this variety matures in 95-100 days, has white seeds and can produce 5-10 q/ha. The seeds have about 48% oil in them.

Newly identified varieties for release

Rt-46. It matures in 75 days, is white seeded resistant to diseases, it can produce about 6 q/ha and is found suitable for Jammu and Kashmir, H.P., Punjab, Haryana, Rajasthan and Western U.P.

Improved Selection 5. It matures in 80-85 days, seeds are reddish brown in colour, it is resistant to stem rot, bacterial leaf blight, tolerant to leaf spot, phyllody and powdery mildew. It can produce 6-7 q/ha and is recommended for W.B., Bihar, Orissa, M.P. and Western U.P.

Sunflower

Helianthus annus L. has three sub-species viz., H. annus var. macrocarpus (DC), H. annus var. lenticularis (Dough) and H. annus var. jaegeri (Heiser) which are cultivated ones while following are the wild sp.:

Wild Species of Sunflower collected at Bangalore Centre

H. anomalus, H. orgophllus, H. bolanderi, H. deblis sp. Bedlis, H. deserticola, H. neglectus, H. riveus sp. Conesceus, H. paradoxus, H. periolasis, H. praccex sp. (hirtus, praecox, runyonii), H. mutalli (All having no. = 17 chromosomes) and H. tuberosus (having no. = 51 chromosomes).

Sunflower cultivars vary greatly in plant height, time of maturity, no., diameter and colour of heads; size, shape, colour, oil and husk content of seeds & suitability for different climates. Thus the cultivars may be divided into following types:

1. **Giant types.** Plants 180 to 420 cm tall, late maturing heads 30-35 cm in diameter, seeds large white or grey with lower oil content, variety 'Mammonth Russian'.
2. **Semi Dwarf types.** Plants 130-180 cm tall early maturing, heads 18 to 24 cm in diameter; seeds smaller, black, grey, higher oil content, variety 'Pole Star', Jupiter.
3. **Dwarf types.** 60 to 130 cm tall, early maturing, heads 12 to 17 cm in diameter, seeds small, highest oil content. Variety 'advance', 'sunrise' etc.

Generally sunflower is grown as a rainfed crop in kharif, hence to make use of rain water, it is necessary to plough the land once by a mould-board plough followed by harrowing soon after the onset of the rains. The crop prefers deep fertile soil adequately

supplied with moisture without producing water logged conditions that adversely affects the germination of seed.

After leveling the land, fertilizer @ 60-40-20 kg/ha of NPK respectively for low fertility and 40-30-20 kg/ha of NPK respectively for high fertility soils should be applied and mixed properly with the soil. The Indian Agricultural Research Institute however, recommends 40-60 kg/ha NPK respectively. To increase the efficiency of nitrogen, 60% of nitrogen may be applied as basal and the remaining top dressed 40 days after sowing. Increase in yield and oil content have been reported by application of gypsum and sulphur specially in saline and alkaline soils.

Varietal improvement

The interspecific hybridization between wild sp. of North American origin and the best Soviet varieties produced 182 varieties and 2,000 inbred lines in USSR. Out of these four varieties--Progress, Novinka (Novelty), Oktyabr (Octover) and Yubileinyl. 60 (Jubilee 60) have been found promising. In India, heterosis breeding was initiated in early seventies over better parents for yield and yield components involving CMS lines and restorers Hybrid 1 (BSH 1) and BSH 2 evolved at Bangalore showed yield stability under various agroclimatic zones of the country. Subsequently 1980 BSH 1 was released for commercial cultivation. The hybrids have following advantage over open pollinated varieties:

1. Hybrids have high yield potential and are responsive to higher inputs
2. They are superior in their seed filling ability and are comparatively more self fertile.
3. They are more tolerant to diseases and pests.

4. They have higher drought tolerance.
5. They have higher drought tolerance.

Sunflower, being photo and thermo non-sensitive, can be grown thrice in a year i.e. rabi crop in Oct./Nov., zaid crop in Ja./Feb. and kharif crop in June/July. The seed must be treated with Captan, Dithane, Thiram or Brasicol @ 2 g/kg of seed before sowing.

Seed dormancy and Viability

The sunflower seeds (achenes) remain dormant upto 40-45 days of harvesting however, the dehusked seeds may germinate from 10th day after harvest. Exogenous application of ethrel, benzyl adevine and gibberellic acid promotes germination of achenes. Pre-soaking of dormant seeds with ethrel solution (25 ppm) equivalent to 40% by volume of seeds has been found to be optimum. The soaking period may vary from 6 hours to 24 hours. The achenes should be dried in shade and then may be sown directly.

Usually sunflower seeds remain viable for 10-12 months but under hot humid conditions the seeds lose viability quickly. At 50 to 85% relative humidity, seeds lose viability even under high humidity conditions. Short-terms seed hardening treatment given to 6 month old seeds extends viability upto 10 months.

Seeds having over 70% germination and 80 g test weight (wt. Of 1,000 seeds) would be sown at 8-10 kg/ha rate in rows 45-60 cm apart. The spacing between the platns (within the rows) should be around 20-25 cm. In order to have a stand of 80,000 healthy plants/ha thinning or gap filling is required during early stage of crop growth.

Weed control

The crop should be kept weed free up to 45 days of sowing failing which yield reduction from 35 to 50% has been observed. Mechanical weeding twice at 20-25 and at 30-35 days after sowing has been found to be most effective in controlling weeds however, pre-emergence application of TOK-E-25 @ 1.5-2 kg a.i./ha, Prometryne @ 1.0 kg a.i/ha or Alachlor @ 1.5 kg a.i/ha have been found to be more economical and efficient in controlling weeds.

The crop being drought resistant, may very well be grown under rainfed conditions. However, under irrigated conditions one or two irrigations are required to increase the yield, although germination, flowering and dough stages are critical for irrigation.

The crop does not have serious insect-pest and disease problems at present. However, according to a report from Coimbatore centre, the attack of grass hoppers at seedling stage and green bug at flowering stage are serious. They can be controlled by dusting 10% B.H.C. @ 30 kg/ha. Use of 10% sevin is recommended where leaf-eating caterpillars are noticed. Sunflower is essentially a cross-pollinated crop. In view of this, selection of suitable insecticide that is not harmful to pollinators needs to be made through investigations. Birds are a menace during seed formation stage and constant vigilance to scare them away is necessary.

Hand-pollination

Sunflower is a self-incompatible and depends on insects (mainly bees) for cross-pollination and seed-set, therefore, it is essential that adequate pollinators are present in the field, for pollen movement and seed-set. Otherwise the heads bear chaffy and

partially filled seeds resulting into drastic reduction in yield and quality of the produce. Keeping bee hives in the field increases crop yield. Hand-pollination gives an increase in the crop yield to the extent of 18 to 25%. Hand-pollination could be done by gentle rubbing of the sunflower heads with palm or with soft muslin clothes during flowing period between 7 to 11 A M on alternate days for about two weeks.

The crop is found to be attacked by leaf spot, rust and head rot which could be controlled by spraying of Bavistin or Mancozeb (0.2%).

At maturity the back of the floral heads and outer bracts turn yellow and then to brown colour respectively. The heads harvested from the plants and seeds are separated. Seeds when harvested at 8-10 % moisture level, have better keeping quality and higher oil content. The stalks may be used as fuel or for making high quality compost. One hectare should yield 20-25 quintals sunflower seed. The seeds should be bagged at 6% moisture level for better keeping quality and germination.

The oil must be extracted within 90 days of harvesting otherwise it becomes bitter in taste especially when stored under damp conditions. Such seeds also lose their viability.

Advantage of taking sunflower in high intensity cropping system

1. Being a short duration, it can be well suited as catch crop.
2. It is a drought, frost and salt tolerant crop.
3. There is very slow degeneration in seed quality hence the same seed can be sued for sowing upto 4-5 years.
4. Being thermo and photo insensitive it can be grown any time in the age, year, in any part of the country and under any type of cropping system.

5. Sunflower is a useful crop for apiculture (bee keeping) at it attracts the bees and provides them nectar.
6. The rainy season sunflower is mostly grown as rainfed crop in which few crops like groundnut (2: 6); ragi (2 :5); cowpea or blackgram (2 : 3) may be successfully intercropped.

Problems in growing sunflower

1. Greater menace of the birds specially of crows and parrots.
2. Poor filling of seeds specially of disc florets.
3. Unavailability of ideo-types and their superior seeds.
4. Poor viability and lesser keeping quality of seeds
5. Poor market and acceptability of raw and fresh oil by the customers.
6. Oil becomes bitter if not extracted within 90 days of harvesting.
7. Plant protection (chemicals cannot be used as they kill the pollinators).
8. Rains at maturity destroys the seed quality.

Castor *(Ricinus Communis* L.)

Believed to be originated in Eastern Africa, probably in Ethiopia castor is grown for oil yielding seeds which contain 35 to 58% oil in them (on an average 57% oil). The oil acts as the best lubricant for high speed engines, aeroplanes, manufacturing soaps, transparent papers, prining-inks, varnishes, linoleum and plasticizers etc. Its sgreen leaves are fed to eri silkworms for producing eri silk. Castor occupies 4.4. lakh hectares and produces about 1.4 lakh tones of seed in India. The main castor producing states include Andhra Pradesh (67.2% area), Gujarat (12.7%), Karnataka (7.1%) and Orissa (5.8%) while rest 10% area is shared by other states.

The crop is sown during June/July in furrow (drilling) or dibbled at 90 to 120 cm x 45-60 cm spacing which requires about 8-10 kg seed /ha (treated with thiram @ 3 g/kg seed as it protects crop from root-rot and alternaria blight). The crop should be fertilized with N40P40K20 kg/ha and weeds should be taken out before earthing the crop. The crop requires 150-180 days to mature and produces around 400 kg to 950 kg seeds/ha depending upon variety and production technology.

Castor Varieties

Andhra Pradesh	-	HC-6, HC-8, Aruna, Bhagya, Sowbhagya
Bihar	-	E.B. 16 A
Gujarat	-	GCH-3, J-1, GAUC-1, GAUCH-1
Haryana	-	Punjab Castor No.1
Karnataka	-	Rosy, MC-1
Tamil Nadu	-	TMV-1, TMV-2, TMV-3, SA-1, SA-2
Uttar Pradesh	-	T-3, Tarai-4, Kalpi-6
West Bengal	-	B-1

Safflower *(Carthomus tinctorius* L.)

Safflower, originated in India, Afghanistan and Ethioopia (Vavilov) or Arabia (Decandole), is grown for seed to extract oil or to be eaten after roasting. It contains 24 36% oil in seeds which may be used for culinary purposes or for making soap. In India it occupies about 0.59 m. hectares and produces about 0.13 m. tones. Around 98% of the total cropped area lies in Maharashtra (64.4%), Karnataka (26.0%) and Andhra Pradesh (8.0%) while about 2% area is adopted by U.P., M.P., and part of Bihar. Safflower is grown mixed with wheat barley, gram and rabi jowar (after every 9 to 12 rows of main

crop). It acts as guard crop as it protects main crop against cattle trespass. Sometimes it is taken as a pure crop in marginally fertile soils. The crop is sown in September / October by using 5 to 12 kg seeds/ha under mixed crop or pure respectively at a spacing of 45 cm between the rows if grown as pure crop. A good crop can be raised by applying 20-40 kg N/ha. Crop needs topping when plants have developed apical flower to promote branching, flowering and seed yield. It takes about 120-150 days to mature and produces 400-500 kg seed/ha when taken as a pure crop where as 100-150 kg/ha when grown mixed.

Varieties

Karanataka	-	A-1, A-300
Madhya Pradesh	-	No.7
Maharashtra	-	N. 62-8, Nag. 7, Tara
Tamil Nadu	-	K 1
Andhra Pradesh	-	Manjira (C-438)

Linseed

Climatic requirements

It needs colder climate and accordingly it is grown during rabi season in India. The oil seed crop needs about 25-30°C during germination and about 15-20°C during seed formation but the fibre crop (flax) requires still lower temperature and high humidity. It is fairly resistant to drought and grows well temperature and high humidity. It is fairly resistant to drought and grows well in areas receiving an annual rainfall of about 45-75 cm. High rainfall and cloudy weather during growing period is very harmful

for the crop. It requires high temperature, low moisture and fairly dry weather during its maturity.

Soil and land preparation

It may be grown on a variety of soil types, however, it does very well on deep cotton soils of central India and alluvial loam soils of north India. The soil must be well drained and nearly free from soluble salts, though it may tolerate moderate acidity and salinity.

Linseed needs a weed free and fine textured seed bed. Termites and cutworms usually attack the crop, therefore, BHC 10% or Aldrin or Chlordane 5% dust should be mixed in the soil at the rate of 25 to 30 kg/ha at the time of last ploughing.

Seed and sowing

In rainfed areas the crop is sown earlier in last week of September or mid of October when the rains have stopped so that best use of residual moisture of rains be made but in case of irrigated areas the crop may be sown little later in October-November by giving one light pre-sowing irrigation for ensured moisture supply to germinating seeds. In Bihar and eastern parts of U.P. the linseed is sown broadcast in standing rice crop as relay crop during September - October.

Broadcasting of the seeds should be avoided and it should be sown in lines either behind the country plough in shallow furrows or by the seed drill. Sometimes it is also sown broadcast in case of relay cropping in standing rice crop (this system of sowing is called as paira or Utera cropping) which occupies nearly 25% of total area under linseed crop but in case of mixed cropping of linseed with wheat, gram and barley it is won in rows after every few lines of aforesaid crops. In case of pure crop of linseed a row to row

spacing of 20-30 cm is given and a seed rate of 20-30 kg/ha in case of line sowing and 35-40 kg/ha in case of broadcasting is required.

Seed treatment. In order to protect the crop from seed and soil borne diseases it is advisable to treat the seed from Bavistin/Topsin @ 2 g/kg seed or Agrosan GN or Thiram @ 3g/kg of seed before sowing.

Fertilizer application

Normally the crop is grown rainfed under unfertilized condition of residual fertility or under very poor fertilizer doses. The experimental findings indicate that the application of fertilizers in linseed crop can increase the yield significantly. In case of rainfed crop the placement of 20-30 kg each of nitrogen and phosphate but in case of irrigated crop a dose of 30-40 kg of each of nitrogen and phosphate per hectare had been recommended. When linseed is to be sown as relay cropping in standing rice crop, top dressing with only 10-15 kg nitrogen per hectare would be enough. In irrigated condition, top dressing with half of the required nitrogen is more beneficial.

Weed control

The crop suffers from a very severe weed competition upto 25 days of sowing and crop growth is badly suppressed by the presence of weeds which reduces the crop yield, therefore, it is essential to provide two hand weedings- once after 21 days and second after 35-40 days of sowing.

Irrigations. Under irrigated conditions the crop should be given two light irrigations--first 35 days and second 65 days after sowing.

Plant protection measures

Linseed crop gets attacked by gall midge and a severe damage to the crop is observed. The insect may be controlled by spraying of any insecticide like Metasystox, dimecron or rogor at 0.3% concentration. The spraying should be done two-three times at 10 days interval starting from appearance of the insect in the crop.

Amongst the prevalent diseases wilt and rust are most commonly occurring ones for which resistant varieties like R-552, K-2, LC-54, LC-185 as wilt resistant and R-7, R-17, R-552, LC-54, K-2, LC-185 as rust resistant should be selected and grown. Early sowing of short duration varieties and seed-treatment can reduce the incidence of insect-pest and diseases and a good crop yield can be obtained thereform. The powdery mildew and alternaria blight may be controlled by spraying of sulphur (0.3%), Karathane (0.2%) or aulfex (0.2%) over the crop.

Harvesting, yield and storage

The crop should be harvested at red ripe stage but when fibre and grains both are to be taken from the same crop then harvesting at physiological maturity o pod maturity should be done when the plants are little green. The crop is traditionally harvested by the help of sickles and threshing is done by beating the plants with wooden mallets or by trampling them under bullocks feet. On hectare crop usually produces about 4-5 quintals under mixed cropping but the yield is about 10-12 quintals/ha when grown as pure crop.

The seeds possess about 36-42 per cent oil in them and they may be stored at a moisture of 10-12% in a moisture proof store.

VARIETIES

Improved varieties recommended for various states

U.P. - Neelam, Hira, Mukta, T 397 and K-2

Punjab & Haryana - LC-185, K-2, Himalini

M.P. - JLS(J)-1, Jawahar-17, Jawahar-552, Jawahar-7, Jawahar-18, T 397

Bihar - T397, Mukta

Rajasthan - T 397, Himalini, Chambal

Himachal Pradesh - Himalini, K-2, LC-185

Characteristic features of the improved varieties

K-2. It is resistant to rust and powdery mildew. It matures in 140-170 days and produces 10-12 q/ha. The variety is suited to rainfed culture also.

L.C.54. It is resistant to rust, wilt and powdery mildew. The plants mature in 155-160 days and the crop produces 12-15 seeds/ha. This needs irrigation.

Himalini. The variety is resistant to all the diseases, matures in 150-175 days and produces 12-15 q/ha.

Jawahar-7. It is resistant to rust but susceptible to wilt and can be grown rainfed. It matures in 115-125 days, bears blue flowers and produces 8-10 q seeds/ha.

Jawahar-7. It is resistant to rust but susceptible to wilt. It matures in 128 days, can be grown rainfed and it may yield 7-8 q/ha.

Chambal. It may be grown rainfed. The crop matures in 130 days and yields 8-9 q/ha. It is moderately tolerant to rust, wilt and powdery mildew.

Neelam. This is resistant to rust and wilt diseases and matures within 125-150 days time. A yield of 15-20 q/ha is obtained with 43 per cent oil in the seeds. It is well adapted U.P. conditions under both irrigated and rainfed.

Mukta. It is recommended for U.P. which matures within 130 days and yields about 15-18 q/ha seeds with 45 per cent oil in them.

Hira. It is resistant to rust and wilt diseases. It takes about 135-140 days for maturity and yields about 15-18 q/ha. The seeds contain about 45% oil.

T-397. It is fairly resistant to rust but moderately resistant to wilt. It takes about 145 days to mature and yields about 12-18 q/ha. The seeds contain 43 per cent oil in them.

LC-185. It is resistant to wilt, rust and also tolerant to frost. It takes about 170 days to mature and yields about 10-18 q/ha seeds with 46% oil in them.

Niger (*Guizotia ayssinica L.f. Cass)*

It is believed to be originated in tropical Africa probably in in Ethiopia. The crop is grown for seed to yield oil ranging between 37 to 43% of the seed weight. The oil is used for culinary purposes and manufacturing paints and soft soaps. In India it is grown in about 4.8 lakh hectares which produces about 1.2 lakh tones of seed. It is grown in Madhya Pradesh, Bihar, Maharashtra, Orissa and Tamil Nadu and partly in Uttar Pradesh also. The niger is a kharif crop which should be grown in rows at 30 cm spacing between the rows, 10-15 cm between plants which requires about 7-8 kg seed/ha. It requires about 20 kg of both N and P_2O_5/ha. Niger matures in November / December and produces about 100-200 kg seed/ha under mixed cropping and 500-700 kg/ha when grown as a pure crop.

Varieties

Karanataka	-	No.16, No.24
Madhya Pradesh	-	Ootacamund, No.5, N.87
Maharashtra	-	Niger B
Orissa	-	GA.2, GA. 10

Rape and Mustard

In India rape and mustard is grown during winter season and it is observed that the crop needs about 18°C to 25°C temperature, low humidity, practically no rain specially at the time of flowering. Rainfall, high humidity practically no rain specially at the time of flowering. Rainfall, high humidity and cloudy weather are not good for the crop during winter as it invites and cloudy weather are not good for the crop during winter as it invites aphids and the crop gets spoiled completely. However, under rainfed conditions one to two pre-flowering rains help in boosting the grain yield. Excessive cold and frost are harmful to the crop.

Generally the rape and mustards thrive best in medium or heavy loam soils except taramira which is grown on lighter soils but heavy soils subjected to water logging should be avoided as the crop cannot tolerate such conditions. Though the crop is grown during winter seasons and there is very little chance of water logging but still due to heavy winter rains the water may get accumulated and cause a temporary water logging. Very light soils usually cause a serious moisture stress and a poor crop growth is observed. Saline and alkaline soils are often not fit for the crop though it has good tolerance to such conditions.

Preparation of land

The rape seed and mustards require a fine, firm, moist seedbed so that a reliable moisture supply is assured for germinating seeds and young seedlings. For achieving this type of tilth the field should be given one pre-sowing irrigation if there is less moisture in the field. The field should be given a deep ploughing soon after the kharif crop is harvested in middle of September. Thereafter, it may be ploughed for 3-4 times with desi

plough and planking after each ploughing. The crop and weed stubbles along with established weeds should be picked up and thrown out of the field. In case of dry land areas where pre-sowing irrigation may not be give, the seed may be spread in damp place at night and next morning it should be sown. It increases the germination percentage of the seeds. In case when mustard is to be sown mixed it gets the same tilth as that of the main crop with which it is to be associated.

Sowing

Time of sowing. Sowing time is very important as the attack of aphids and the extent of damage can be reduced considerably by sowing the crop earlier or before middle of November. Toria must be sown between mid to last week of September as the crop suffers badly from cold if sown late and the crop duration is increased without any additional yield due to slow growth that occurs due to lower temperature. The atmosphere should range between 26-30°C at the time of sowing.

Seed rate. It depends upon the nature of the crop, such as pure crop or mixed crop. A pure crop of mustard and rape seed needs about 6-7.5 kg/ha and toria needs 4-5 kg/ha while mixed or intercrop of mustard requires about 2.5-3 kg seed per hectare however, seed rate in case of mixed crop depends on its proportionate area to the main crop. the depth of seeding should not exceed 3 cm and the seeds must be treated with Thiram or Captan @ 2.5 g/kg of seed before showing.

Method of sowing. Line sowing has always given better results than broadcasting although broadcasting in case of high moisture conditions is common specially for 'toria' crop. Thus it may be sown in shallow furrows behind desi plough or

through seed drill or 'mala basa' as it is good and economical to adopt any of these devices for sowing the crop.

Spacing. From the spacing trials it was observed that in case of pure crop a closer spacing has given better results. On an average a spacing of 40-45 cm between rows and 15 cm between plants is recommended for rai and lotani sarson but 30 cm between rows and 10-15 cm between plants is recommended for yellow sarsona and tora brown sarson. In case of mixed cropping with wheat sowing mustard in parallel rows 150-200 cm apart alternating with the main crop is recommended, however, broadcasting of mixed seed is still in practice but it gives a poor seed yield.

Manuring

Rapeseed mustards are grown rainfed with nominal use or no use of fertilizers. But the nutritional investigations and general experience show that use of fertilizers gives substantial increase in yield. However, the response patterns differ very largely according to crop, soil type, climate, crop and fertilizer practice. Most of the studies have been conducted on primary nutrients and hence the response of micro-nutrients is yet to be studied.

Nitrogen fertilization. Nitrogen is an important constituent of protein for which the plants take inorganic nitrogen in the form of ammonium or nitrate. Higher the nitrogen greater souls be the protein and protoplasm which would increase, in turn, greater cell size, leaf area index resulting into greater photosynthetic activity. Thus, the nitrogen help in formation of a larger frame on which more flowers and eventually more pods can develop. This shows a positive link between larger nitrogen supply and higher seed yield. But sometimes higher protein content in rapeseed shows a depression in oil

content proving an inverse relationship between protein and oil content of seed. It indicates clearly that from the point of view of a higher net oil recovery and quality, application of nitrogen in more than required quantity is not advisable. It is, therefore, advisable that the soil of the selected field should be analysed and application be made accordingly. If the facilities for analysis are not available, nitrogen hunger signs at the seedlings stage or at growth stage should be very carefully observed and the same be corrected immediately. In case of nitrogen deficiency the leaves may become chlorotic associated with purple coloration and older leaves may wither. The plants have poor growth with thin and short stems having few or practically no branches.

Indian mustard varieties of *B. napus* and *B. juncea* have a very short growing season and, therefore, their nitrogen requirement is very low, however, the mustard, sarson have shown better response upto an application of 100-150 kg N/ha but the method and time of application are the most important of all the factors that govern the response pattern of applied nitrogen. From the experiments it is clear that top-dressing at a seedling stage i.e. about 30-35 days after sowing is the best time. Thus it is advisable to apply about half at sowing time and rest at about 30 days after sowing, when thinning, weeding and first irrigation are over, while in case of rainfed condition only basal dose of 50-60 kg N/ha is sufficient.

Phosphate fertilization. *Brassica* sp. are believed to have a high requirement for phosphorus, yet the soil test data and information's available about phosphate fertilization show that many soils provide much, if not all, of the required quantity of phosphate to the crop. Seeing the response pattern it is observed that phosphorus has much less effect on yield compared to nitrogen but noticeably greater than potassium.

Phosphorus fertilization improves growth of rapeseed crops where it is of little or no effect on growth, is observed in case of cereals. Besides growth, phosphorus reduces the adverse effects of excess nitrogen fertilization. Phosphorus deficiency restricts growth of roots and the aerial parts and sometimes it prevents even flowering. The deficiency symptoms are characterized by a dark bluish-green coloration of leaves, often accompanied by purplish tinges. The stems become bluish-green having purple or reddish coloration. Under severe deficiency marginal necrosis of leaves or premature withering of older leaves may take place.

Quality and method of fertilizer application in mustards

Variety	Nutrients in kg/ha			Method of application
	N	P	K	
Early Torai/Lahi	30-50	25	-	All basal
Mustard/Sarson(irrigated)	80-150	60	-	Half basal + half top-dressing at 30-35 days after sowing
Mustard / Sarson (Rainfed)	40-60	25	20	All basal placed
Taramire (Rainfed)	30-40	20	-	All basal

As discussed above the rapeseeds are very rarely fertilized with phosphates but based on soil test data a dose ranging between 20-40 kg P_2O_5/ha should be basal placed. Application of phosphorus is more essential, especially in case of rainfed conditions, though it increases yield in case of irrigated as well.

Potash fertilization. The role of potash in oilseed rape crops is to activate a wide range of enzyme through regulation of stomatal opening and closing, photosynthesis by influencing chloroplast formation, transport of photosynthates, carbohydrate and nitrogen metabolism.

Under acute deficiency of potash the leaves show marginal or interveinal chlorosis followed by patches of necrosis, often initially apparent as spots of pinhead size on older as well as younger leaves and in extreme cases of deficiency the leaves die completely.

Thus, seeing the response pattern a dose 60-100 kg N, 40-60 kg P_2O_5 and 40 kg K_2O per hectare may be recommended for long duration varieties. Regarding the mode of application it has been found that half of nitrogen with entire dose of phosphate and potash should be basal placed about 5-7 cm below the seed or by the side of the seed and remaining half of the nitrogen should be top-dressed about 30-40 days after sowing, while for 'toria' or short duration varieties 40-60 kg N, 20-30 kg P_2O_5 and 20 kg K_2O/ha has been found to be good dose which should be basal placed.

In general, the following doses are found to be optimum:

Rainfed. 40 kg/ha N along with 15 kg of P and K both for all rapeseed and mustard crops.

Irrigated. 40, 60 and 80 kg/ha N are considered optimum for 'toria', 'sarson' and 'raya' respectively, however, for taramira 20 kg N/ha is found to be the best dose. Phosphate and potash have not given any positive response, hence they are not needed until the soil is deficient in them. The micronutrients are not found to effect either yield or quality of the produce, therefore, their use may be done under very specific conditions.

Application of 10 kg S has given higher seed yield along with higher oil percentage.

Water management

Mustard requires about 31-40 cm of water which should be provided by giving two irrigations—first at flowering/branching stage and second at pod (siliqua) formation stage (first at 30 days after sowing and second 60-65 days after sowing) in a crop of 110-120 days duration.

Plant protection measures

Weeds. In case of 'toria' or early mustard it is observed that late kharif season weeds viz. *Trianthema spp.*, *Phyllanthus spp.,* etc. are found while the main crop is infested with *Chenopodium spp*., *Anagallis spp., Spergula arvensis, ASphodelus spp.,* etc. Orobanche, a phanerogamic parasite, has been found to be very serious weed in the crop. The chemical control of these weeds is not very much in practice, hence manual weeding once about 25-30 days after sowing has been found to check the weed competition and yield is not reduced. An effective control of Orobanche may be achieved by their hand pulling and growing mustard after 2-3 years.

Diseases. Amongst several diseases the most destructive ones are Alternaria blight (caused by *Alternaria Brassicae Berk*,) rust (caused by powdery mildew (caused by *Erysiphe poligoni*) and viral diseases. All of these, except viral disease, may be controlled by the application of Dithane M-45 at the rate of 1.5 kg/ha or 2-3 applications of Bordeaux mixture.

Pests. There are many pests which have been seen attacking the crop viz. pea leaf-minor, mustard sawfly, painted bug, cabbage butterfly, Bihar hairy caterpillar and mustard aphids. Of these mustard aphids are the most serious which alone cause 66-69 per cent reduction in yield in case of *B. campestris* and 27-69 per cent in *B. juncea.* The

average loss due to aphids comes to 62 per cent. The pest attacks under high atmospheric humidity and cloudy weather conditions. It may be controlled by spraying of Methyl Demeton. Aldrin/Heptachlor/Chlordane @ 25 kg/ha controls cutworms and BHC 25 kg/ha controls sawfly.

Harvesting

The crop should be harvested as the pods turn to yellow colour. Amongst the types 'toria' is the earliest maturing variety that takes about 75-90 days time. 'Rai' needs 110-180 days, Yellow sarson 130-160 days and Brown sarson needs 105-145 days for maturity. The crop is harvested with hand-sickles and the threshing is done by beating the pods with wooden sticks or by trampling the plants by bullocks. The winnowing is done with the help of natural air current but the wind velocity should not be very high as the seeds, being very small, are blown with the air.

Yield

Rapeseed/mustard are usually grown in neglected conditions and due to this reason a very poor average yield of 4-6 Q/ha has been reported. Following yields have been obtained from different groups of the crop.

Toria : Average of 5 Q/ha and highest of 8-10 Q/ha.

Yellow mustard : Average of 10-12 Q/ha and highest of 30 Q/ha or more.

Rai : Average of 12-15 Q/ha and highest of 25-35 Q/ha.