CONSULTANCY REPORT ON OILSEEDS OF BHUTAN

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1. PRESENT STATUS OF OILSEEDS

The economy of Bhutan is primarily based on agriculture with arable lands having less than 8 percent of the total area and over 80% of the population engaged in farming. The share of agriculture in GDP is 32.7% (RNR statistics 2003). The dry land agriculture (32.6%) is the most dominant land use followed by tseri (28.6%) while wetland farming is relatively small (12.6%). Oilseed crops play a vital role to meet out the nutritional requirement of large population and hold an important place in the economy of the country.

1.1 Major oil crops

The major oil crops grown in Bhutan are rapeseed - mustard and *Brassica campestris* var. toria (synonym tori or peka) is predominantly grown and mostly referred as mustard in Bhutan. Besides, the farmers also grow locally available traditional variety of *Brassica campestris* var. yellow sarson and yellow sarson is preferred due to more oil content and from religious point of view. The duration of yellow sarson is comparatively more and has almost same yield level as of toria. In general, mustard refers to *Brassica* oilcrops and the same terminology shall be followed in this report. In Eastern districts of Bhutan (Yangtse, Trashigang, S/jongkhar, Mongar, Pemagatshel and Lhuntse) soybean is also grown mainly as a mixed crop with maize but is not used for oil extraction purpose and is either consumed as such or sold in market. The annual production of soybean is 576 MT in Bhutan (RNR Statistics 2000). However, the farmers/ extension officers have reported decline in the acreage due to use of urea in maize which leads to excessive vegetative growth and low yield level of soybean. Besides the processing units to extract oil from soybean do not exist in Bhutan.

The other oil crops grown in patches are groundnut, sunflower and Niger seed. Groundnut cultivation is restricted to few farmers and kernels are consumed as such by households and oil is usually not extracted. The confectionary type sunflowers are restricted to kitchen garden at isolated places. Niger seed cultivation is limited to mid hills, particularly on marginal and poor lands having low fertility and the acreage is negligible. There are also some native oil bearing species (Yika, Pangtse, Shingtse- etc), which are contributing to some extent and are used for oil extraction. The oilseed crops in Bhutan are grown to sustain the needs of households and do not attach any commercial value, at present. The strategy for marketing and processing of oil is lacking.

1.2 Production Scenario

The oilseeds production was only 1900 MT in 1981 which increased to 3476 MT in 1984 and 3900 MT in 1986. The production declined to 1695 MT the year 2000 and 1548 MT in 2004. However, the national productivity during 2004 was highest (372 kg/acre), but the area has declined (Table 1).

Table 1 : Area, production and productivity of mustard in Bhutan

Year	Area (acres)	Production (MT)	Productivity (Kg/acre)
1984	12318	3476	284
1999 (sample survey)	7993	1401	186
2000 (RNR Statistics)	8525	1695	199
2004 (MoA, unpublished data)	4383	1548	372

It is apparent that the acreage is gradually diminishing. It was observed that in prominent mustard growing districts like Tsirang, S/jongkhar, Dagana, Sarpang and Trashigang, the acreage under mustard has gone down in last two decades compared with 1984. The import of cheaper oil from India has also become a disincentive for domestic production.

The harvested area, production and yield of mustard in few important Dzongkhags is given in Table 2.

Table 2 : Area, Production and Yield of mustard in some important Dzongkhags

Dzongkhag	Area (acre)	Production ('000 kg)	Yield (Kg/acre)
Samdrupjongkhar	1050	211.5	201
Sarpang	1229	188.5	153
Chhukha	771	163.9	213
Dagana	690	154.8	224
Trasigang	588	146.4	249
Punakha	937	146.0	156
Thimphu	214	133.3	623
Wangdue	590	106.7	181
Tsirang	630	99.0	157
Samtse	563	85.3	152
Paro	165	48.6	294

Source: RNR stastistics-2000

The average yield varies from 153 to 623 kg/acre. Thus, there is wide variation in yield and some Dzongkhag (Sarpang, Punakha, Tsirang, Samtse and Wangdue) have less than national average yield (199 kg/acre). Adopting improved technology can enhance the yield. Farmers do not adopt any plant protection measures in mustard crop but are aware of the problems of White Rust, Saw-fly and Aphids. Many farmers do not wish to control aphids due to religious reasons. The use of fertilizers in mustard is also very low. The productivity of Thimphu is highest (623 kg/acre) in comparison with any other Dzongkhag (RNR Statistics 2000). This may be primarily due to cultivation of mustard in potato based system with very high chemical fertilizers used in potato. The major mustard producing Dzongkhags are: S/jongkhar, Sarpang, Chhukha, Dagana, Trashigang, Punakha, Thimphu, Wangdue and Tsirang and 26.7% acreage is restricted to S/jongkhar and sarpang.

1.3 Cropping Systems Involving Oilseeds

The mustard is grown in three cropping systems i.e. maize based, potato based and rice based. 18% of farm households grow mustard.

On unterraced land mustard is dominantly grown after maize and on terraced wetlands mustard is grown after rice. There is possibility of enhancing mustard acreage in rice based cropping system on wetlands after rice which is usually kept fallow during the winter season. Possibility of inter cropping mustard with potato, wheat and buckwheat can also be explored particularly on high altitude area for further increasing the production of mustard in Bhutan.

1.4 Oil Consumption and Import

The production of oilseeds has not kept pace with increasing demand of growing population and rise in per capita consumption. The demand of edible oils is increasing in Bhutan and to meet out the growing need, the country is importing huge quantity of edible oils. Based upon the interaction with the number of households, it has been observed that the per capita consumption of oil is fairly good and even in villages the annual per capita is estimated to range between 6 - 12 kg per annum. Assuming 10 kg per capita per annum consumption and 0.877 million population by the year 2010, the country would require 8770 MT of edible oil. The domestic production of rapeseed-mustard is 1548 MT (DOA 2005 unpublished data) and could meet only less than 10% of the total edible oil requirements. The remaining oil requirement is fulfilled though imports from India, Bangladesh, Malaysia and Thailand.

2. INSTITUTIONS INVOLVED IN RESEARCH AND DEVELOPMENT

There exist immense possibilities of increasing oilseeds production provided research and development activities are geared up through a mission mode approach so that special emphasis is accorded to oilseed sector. The oilseed research programme be strengthened under RNRRC, Bajo and given the responsibility to co-ordinate research and development activities on oilseeds in Bhutan.

The staff at RNRRC, Bajo is limited and therefore not only the staff strength need to be raised but the close collaboration with many organizations is essential if the potential for oilseed development is to be realized.

2.1 Renewable Natural Resources Research Centre (RNRRC)

Established, in 1982 as the Centre for Agricultural Research and Development (CARD) basically to undertake research on rice and rice-based crops, it was renamed as the Renewable Natural Resources Research Centre (RNRRC) in 1995 to incorporate research on livestock and forest that are inseparable components of the Bhutanese farming systems. The Centre is located at Bajo (1300m) in Wangduephodrang, which is about 70 km west of the capital Thimphu with sub-centre at Tsirang (1560m).

RNRRC Bajo has been designated as the co-ordinating Centre for Field Crops Research (cereals, oil crops, and legumes) and water Management Research at the national level. The Centre has a 64 ha research farm.

The Centre undertakes an intensive programmeof research and extension through its on-farm research program; training of extension personnel and farmers; and other interdisciplinary activities both at the national and local levels. It introduces, adapts and develops technologies suitable for the local agro ecological environments and helps farmers raise their standard of living through increased incomes and sustainable farm production. This cenre receives technical support and improved germplasm from IRRI AVRDC, CIMMYT. ICRISAT, ICARDA, CIP and number of other regional agricultural institutes.

Since, RNRRC Bajo is designated as the focal/Co-coordinating centre for field crops at the national level, the basic research work on oilseeds be strengthened in terms of multidisciplinary team of scientists to intensify research efforts to improve the productivity and profitability of different cropping systems involving oil crops. The adaptive multi location trials be carried out at 4 RNR research centres located at Bajo, Wengkher, Bumthang and Yuspang and further testing could be done at 6 regional RNRRCs sub-centres located under diverse agro-ecological situations. The oilcrops programme implementation framework is suggested as under:

Focal centre	**Main Test Location**	**Agro-ecological Zone**	**Lead RNRRC**
Bajo	Bajo	Dry sub-tropical (irrigated)	Bajo
	Wengkher	Dry sub-tropical (rainfed)	Khangma
	Bumthang	Cool Temperate	Jakar
	Bhur	Wet subtropical	Jakar

The RNR infrastructure includes the national and regional centres involved in research and extension. Some other important centres like National Plant Protection Centre and National Soil Service Centre at Thimphu and also Agriculture Machinery Centre, Post Harvest Unit, Druk Seed Corporation at Paro are also under the RNR infrastructure which support field crops research programme in Bhutan.

2.2 Extension

Presently, extension services under the Department of Agriculture are carried out by various RNR extension centres having personnel each from three major disciplines including ariculture, forestry and animal husbandry. At the Dzongkhag level, DAO coordinates the activities. The Asstt. Agriculture Extension Officer posted at geog RNR extension centre are responsible for the developmental programmes.

The involvement of extension personnel in the oilseed programme will be essential in collecting local germplasm, providing feed back information on constraints related to production, carrying out on farm trials and finally ensuring that the improved seed and technology reaches to the farmers. These activities should be a part of the work plan for extension officer. The activities be coordinated at the centre level and must be reviewed annually. Before, the crop season farmers are also trained on improved production technology through pre-seasonal training programmes. This planning would enable the different organization to participate, plan and execute a focused oilseed programme. For effective dissemination of mustard production technology the following aspects are given priority.

- The crop promotional programme is linked with front line demonstration and the remote areas be given emphasis for dissemination of improved seed and technology.
- The continuous up gradation of the knowledge and skills of the agriculture extension officer on improved oilseed production technology are done by pre-sowing training programme in Bhutan and India. In training programmes organized in Bhutan, the research and development staff of line department is also available.
- There is a need to encourage 'on farm' training programme and prepare trainers on oil crops production technology.
- Provision is made in next plan to establish the ATIC (Agriculture Technology Information Centre) at each RNR research centre to provide single window system for the farmers. A help line (toll free telephone number) for immediate reply to the farmers' queries is also established.

3. CONSTRAINTS AND OPPORTUNITIES IN OILSEEDS PRODUCTION

3.1 Constraints

The oilseed crops have not received the desired attention in the past due to which the acreage has declined. The major constraints in oilseeds production are as under:

- Traditional method of oil extraction and inadequate numbers of efficient oil expellers.
- Cultivation on small and marginal lands with deteriorating soil fertility and poor seedbed.
- Cultivation on dryland causing soil moisture deficiency during the cropping season particularly in the mid and lower altitudes.
- Adoption of low yielding traditional varieties due to lack of suitable improved varieties for different agro-ecological situations.
- Inadequate availability of quality seeds of improved varieties
- Sub-optimal agronomic practices and non-adoption of improved agro-technology.
- Use of higher seed rate for sowing leading to poor plant growth, reduced branching, low seed yield and high production cost.
- Weed pressure in the absence of any weeding / hoeing operation. Negligible use of fertilizers.
- Incidence of diseases (white rust, downy mildew and Alternaria blight) and pests (Sawfly and aphids) and adoption of no plant protection measures.
- Lack of assured market and marketing facilities.
- Inadequate infrastructure for oilseed research in Bhutan

- Limited availability of germplasm material and narrow genetic base of cultivated mustard varieties in Bhutan
- Lack of crop promotional programmes on mustard in remote areas.
- Inadequate knowledge and skills of agriculture extension agents on the improved oilseeds production technology.
- Absence of collaboration with leading international organizations involved in oilseeds research.
- Lack of desired policy framework for oilseeds sector.

Opportunities

- Considering the agro-climatic conditions, increase in oilseeds production can be attained by increasing productivity and area expansion under mustard, improvement of oil processing sector and better linkages with support services.
- In eastern parts of Bhutan, soybean cultivation can be expanded if price incentive and market support is provided.
- The research work on rapeseed-mustard should be strengthened immediately. Adaptive research be carried out for immediate solution of identified field problems in case of Soybean and Sunflower. The seeds of improved varieties can be imported from India.
- The increased production of oilseeds shall improve the living standard of rural households by creating avenues for income generation and supplement food security. The installation of oil extraction units would provide employment opportunities to rural mass which will reduce migration to urban areas.
- The availability of oil cake with the increase production shall help in improving the cattle health and enhancing milk production.

4. POLICY FRAME WORK FOR OILSEEDS SECTOR

The national policy is framed to provide adequate attention to oilseeds sector which is inadequate at present and lacks appropriate direction. The desired policy framework for oilseeds sector should include:

- Promotion of oilseeds research to generate appropriate technology to achieve self efficiency.
- Maintain balance between promotion of domestic production while safe guarding the interests of consumers through reasonable imports.
- Developing adequate level of infrastructure and support services like quality control laboratory at the central level to detect the adulteration in edible oil. Development of farm roads at the village level would also encourage oilseeds growers and help in marketing of their produce.
- Providing oilseed sector a status of cottage industry.
- Providing subsidies on inputs to encourage the farmers to adopt the recommended production technology and increased edible oil production to attain utmost self-sufficiency.
- Adoption of information technology in order to access information and rapid dissemination of technology.
- Support programmes for marketing and processing of produce.
- Ensuring minimum support price for the produce, to encourage cultivation of oil seeds.
- The research work on post harvest aspects be also given emphasis to reduce the post harvest losses, increase the efficiency of oil extraction, value addition and improve the quality of seed meal for the cattle.

5. STRATEGIES FOR OILSEEDS RESEARCH AND DEVELOPMENT

5.1 Strengthening research for generation of appropriate technology

The RNR research Centre at Bajo should undertake the basic research work and be strengthened in terms of multidisciplinary team of scientists including Plant Breeder, Agronomist, Plant Pathologist and Entomologist to intensify research efforts on oil crops. The integrated multidisciplinary approach in research should further be strengthened through increased capacity building. The adaptive multi location trials be carried out at 4 other RNR main and sub research centres. The research efforts be intensified on the following areas with emphasis on rapeseed-mustard.

Plant Breeding

- Collection, maintenance, evaluation and documentation of genetic resources available in the country for their utilization in breeding programmes.
- Genetic enhancement for seed and oil yields using the available germplasm resources by conventional breeding approaches.
- Identifying the suitable rapeseed-mustard germplasm having tolerance/resistance to biotic and aboitic stresses.
- Identification and development of improved varieties for different agro- climatic situations (cool and warm temperate and also dry, wet and humid sub- tropical regions).

Agronomy

- Development of remunerative cropping systems/intercropping systems involving mustard for expansion of acreage.
- Identification and development of suitable crop production technology including planting technique, plant population and weed management practices.
- Improvement of input (soil, water and nutrients) use efficiency to reduce the production cost to make rapeseed-mustard cultivation remunerative and competitive.

Plant Protection

- Assessment of the losses caused by various diseases and insect- pests.
- Development of eco-friendly plant protection measures for controlling diseases and pests.

Post harvest

- Develop efficient harvest and post harvest technologies.

5.2 Testing and validation of promising technologies

- The available production technology from Northern parts of India can be initially tested and further validated. Need based refinement in the technology be made under specific crop growing situation.
- There is enough scope for horizontal expansion of area under mustard by incorporating its cultivation in existing cropping system after maize and rice which are usually kept fallow during the winter season. Possibility of buckwheat + mustard intercropping be also explored on high altitude area particularly in Bumthang Dzongkhag.
- Few other intercropping combinations like potato + mustard (3:1), wheat + mustard (9: 1) could also be tested at the research stations.

- Since, the farmers are not using chemical fertilizers, it shall be appropriate to work out low cost production technologies for mustard.

5.3 Crop Promotional programme

- The crop promotional programme presently being implemented for mustard is very useful for quick dissemination of improved seeds. However, such programme should be linked with front line demonstrations. In remote areas mustard cultivation could have a greater possibility and therefore such areas be given emphasis for crop promotional programme.
- The leaflet consisting of improved package of practices be also distributed along with the seeds to the farmers.
- Continuous feed back from the farmers be obtained and reported to research station so that the suggestions could be incorporated during future planning of research programmes.
- Pre-sowing training programmes and field days be organized at appropriate sites under crop promotional programmes.
- The target should be fixed for area expansion under oilseeds.

6. POTENTIAL AREAS FOR OILSEEDS PRODUCTION

Multi-location varietal evaluation trials need to be conducted for various oilseeds (Rapeseed-Mustard, Soybean, Sunflower and Groundnut) in order to identify potential areas. The following steps be taken.

- Delineating potential zones for each oilseed crop
- Link all support services to these crop zones
- Overcome infrastructural shortcomings in identified zone

At present, there is enough scope for the improvement of traditionally grown oilseed crop i.e rapeseed *(Brassica campestris* var.toria) and focussed attention be given to the potential Dzongkhags, as given below, in different regions.

Regions	**Potential Dzongkhags**
West	Samtse, Chhukha, Thimphu
West Central	Punakha, Wangdue, Tsirang and Dagana
East	Mongar, Trashigang, Samdrup Jongkhar
East Central	Trongsa, Zhemgang, Sarpang ,Bumthang

At later stage efficient areas for cultivation be delineated for sunflower in East Central region and soybean in Eastern region. The maize + soybean system is profitable in Eastern region and early maturing high yielding soybean varieties be imported from India to enhance oilseeds production.

The potential areas for oilseeds production and researchable issues, based on the visit undertaken to different agro-ecological zones in Bhutan, are given as under:

Temperate Zone

In this zone cool temperate (2600-3600 m) and warm temperate (1800-2600 m) are the two distinct climatic conditions. The cool tempurature zone and warm tempurature zone, have the mean annual tempurature of 9.9^0 C and 12.5^0 C, respectively. The high altitude areas of Bumthang, Paro, Thimphu, Trashigang, Trongsa and Lhuentse have such climatic conditions. The altitude wise variations in different Dzongkhags have been given in map.

- In the Bumthang area, two different rapeseed-mustard types are grown:1) a biennial (or winter dormant) type rapeseed i.e. *Brassica napus*, planted in May-June, and harvested next April-May and 2) an annual type of mustard (*Brassica campestris* var *toria*) grown from April-May to September. This annual type can also be seen at 3000 m altitude. Local types have unique high altitude adaptation to cool conditions and need further improvement. The farmers yield level range from 150-300 kg/acre as mustard is cultivated usually on drylands having low and erratic rainfall in this zone. The biennial type *Brassica napus* is not common and improved varieties of *B. napus* need further testing in high altitude zone.

- There is potential for sunflower as a summer crop (between April-September) in high altitude zone. Initial tests conducted near Bumthang produced a successful crop and recorded good yields (1 tonne/acre). However, due to lack of appropriate seed production programme and introduction of new varieties, the seed quality has deteriorated. New oilseed sunflower introductions are needed from India and Europe which may be evaluated and desirable ones could be promoted for cultivation.

- Mustard seed produced in the Bumthang area has higher oil content and possess cold tolerance. Collection and selection of improved local varieties of mustard (annual and biennal forms) be made for increased seed yields through simple mass selections. Testing of this material be done in other high altitude areas of Paro, Thimphu and other Dzongkhags.

- The warm temperate zone having annual rainfall between 650-850 mm is suitable for mustard cultivation. Particularly after potato crop, the mustard yields are higher and improved Indian mustard varieties be tested in this zone and crop management practices for potato – mustard cropping system be developed.

- Mustard has the potential as an intercrop in this zone and suitable crop rotations and intercropping systems with potato, buckwheat and cereals need to be developed.

Dry sub-tropical zone (Mid altitude)

In this zone, mostly dry sub-tropical type of climate is existing having an altitude of 1200-1800 m with mean annual temperature of 17.2^0C. Large areas of Punakha, Wangdi, Trongsa, Trashigang, Mongar Dzongkhags fall in this zone. The mean monthly temperature and precipitation for various Dzongkhags form 1985-2003 have been given in Annexure –1.

The Agricultural land in this zone is broadly divided into terracted, bunded land growing rice, and rainfed unterraced land growing maize.

Terraced Land

In wangdiphodrang and Punakha areas, mustard is cultivated namely on irrigated lands following rice and planted is done, in November-December. This amounts to about 10 % of the rice terraces in the area. Experiments at wangdiphodrang indicate that the yield of Indian mustard (*Brassica juncea*) was slightly higher but was late in maturity. It is likely that an earlier

planting of mustard would produce higher yields in irrigated conditions after rice. The early duration varieties of Indian mustard released recently, in India may perform better and need testing in these areas.

- There appears to be a good potential to increase area under the rice-mustard cropping system on rice fallows in the mid hills. A green manure crop has given considerable yield increase in rice at Wangdiphodrang. Attempts should be made to fit in a green manure crop into the rice-mustard system.
- Develop an improved rice variety that can be harvested earlier, allowing mustard to be planted in October.
- Test local collections and introductions of mustard which perform well when planted in October, as well as testing lines which can tolerate a delay in planting up to December.
- Work out the agronomic requirements of mustard and early Indian mustard in rice based cropping system.

Unterracted Land

More than 70% of the mustard is planted on unterracted rainfed lands, in September and October and Maize – Mustard system is a stable system. Variety M-27 is performing well in these areas. Harvesting of this crop takes place from December to February. It was observed that the early-planted crop (early types) gave higher yields and should be encouraged.

- The research work to improve the maize-mustard system should include the testing of improved early duration Indian mustard varieties in October planting and work out the agronomic requirements.

Humid and wet sub-tropical zone

This area include humid subtropical (600-1200 m) and wet subtropical (<600 m altitude) zone. The wet subtropical zone have high rainfall (>2500 mm) and mean annual temperature of 23.6^0C. The humid subtropical zone has 1200-2500 mm rainfall with mean temperature of 19.5^0C. Both the zones, generally receive high rainfall from June to October. Soils are generally coarse textured with medium to low fertility. In the low land areas also most of the bunded and terraced lands are planted with rice. The maize crop predominates on the unterraced lands in low land areas. The mustard planting cannot be delayed after October, as it may be adversely affected due to aphids. In the rice-mustard cropping system in lowland areas, an improved early rice variety that will allow early October planting of mustard is needed. In addition to mustard, sunflower could also be tested for suitability following rice in this area.

- The research work be carried out to select improved rapeseed-mustard varieties which have low aphid incidence.
- Evaluate different varieties of sunflower for their suitability in rice-mustard cropping system.

Eastern Region

In eastern region mustard has very good potential after maize crop. It has been observed that local mustard varieties mature earlier than improved variety M-27. The maize + soybean mixed cropping system is prevalent in eastern region and soybean is harvested in October. The early duration soybean varieties be introduced in this system so that soybean is harvested by end of September. The research work be undertaken to:

- Test the early duration soybean varieties and their feasibility to fit in the existing maize + soybean mixed cropping system.
- In eastern region, residual soil moisture after the monsoon rain determines the yield of mustard. Research efforts to improve the soil moisture availability and enhance water use efficiency are required.
- Identification of proper row ratio in maize + soybean intercropping combination instead of mixed cropping of soybean.

- It has been observed in trials laid out at Khangma that application of nitrogen and phosphorus to mustard after a maize crop is very important for obtaining good yield of mustard. The nutrient requirement for maize + soybean – mustard sequence be worked out.

7. ORGANIZATION OF OILSEEDS RESEARCH AND DEVELOPMENT

The research work can be carried out at 4 RNRRCs and multi location trials at its 6 regional sub-centres located under diverse agro-ecological situations. Since, RNRRC Bajo is designated as the focal /Co-coordinating centre for field crops at the national level, a team of multi disciplinary scientists should focus on oil crops research at this centre. The research strategy could aim at disciplinary and interdisciplinary focus to improve the productivity and profitability of different cropping systems involving oil crops.

7.1 Varietal evaluation procedure

The newly introduced or developed varieties be evaluated under specific zones. The imported varieties be tested during first year at Bajo and based on the yield performance, promising ones be evaluated under multi location initial yield evaluation trials at four RNR research centres and also six other regional RNRRCs sub-centres. The distinctly superior varieties be further tested in advance varietal trials alongwith local/national checks in large size plots for two years to make out valid recommendation for specific agro-ecological situation. The following steps are suggested:

I year -Station trial at focal research centre
II year -Multi location initial evaluation trial (IET)
III year -Advance varietal trials (AVT -I) separately for different zones.
IV year -Advance varietal trials (AVT -II) taking entries having yield superiority over local/national checks.

The criteria for promotion at the next stage could be:

- The yield superiority be at least 10% over the local check.
- The maximum C.V. % be 15% under wet lands, and 20% under drylands. (considering more variation in soil type and plant stand)

Layout of experiments for initial varietal trial (ivt) and advance varietal trial (AVT)

Trials	**IVT**	**AVT**
Design	RBD	RBD
Replication	Three	Four / Five
Plot Size	Gross: 1.5 x 5 m Net: 0.9 x 4.8 m	Gross: 2.7 x 5 m Net: 2.1 x 4.8 m
No. of Rows	Five, Data to be taken from three rows	Nine, Data to be taken from seven rows
Spacing	30 cm x 10 cm	30cm x 10 cm
Plant stand	125-150 / net plot	325-350 / net plot

Fertilizer doses :

Toria (*Brassica campestris var. toria*) : 50 : 25 : 25 , N: P_2O_5 : K_2O (kg/ha)
Yellow sarson : 50 : 30: 30, N : P_2O_5 : K_2O (Kg/ha)
(*Brassica campestris var. yellow sarson*)

Mustard (*Brassica juncea*) : Irrigated-80 : 40 : 40, N : P_2O_5 : K_2O (kg/ha)
: Rainfed- 40 : 20 : 20, N : P_2O_5 : K_2O (kg/ha)

Seed Requirement :-

IVT- 50g per location
AVT-100g per location

Note :-In each case, preceding crop may be reported. Soil test for NPK may be got done and reported along with the results. No irrigation is to be given for rainfed experiments. If there is no rain before the sowing pre-sowing irrigation is to be given.

7.2 Suggested improved varieties of oilseeds for testing

The improved varieties which needs evaluation in Bhutan are given below:

7.2.1 Rapeseed – Mustard

Crop :Toria (*Brassica rapa syn campestris* var toria**)**

Variety	Maturity (Days)	Year of Release/ Notification	Oil content (%)	Average Yield (kg/ha)	Special characteristics
Parbati	75	2001	42	1380	For rainfed areas
Anuradha	75	2002	44	1460	For rainfed areas
T 9*	90-95	1975	40	1200-1500	Highly stable variety
PT 30*	95-100	1987	40-45	775-1392	Tolerant to alternaria blight , downey mildew and white rust
PT 303*	91-97	1985	41-44	1000-1200	Tolerant to alternaria blight , downey mildew and white rust
PT 507*	82-91	1990	41-46	500-1000(rainfed)	Tolerant to drought
M 27	90-95	1978	45	1000-1200	Stable variety
TS 36	85-90	2000	42-44	1200-1500	Suitable for late sown
TS 46	80-85	2000	44-45	812-1150	Suitable for late sown
TL 15	85-88	1982	41	1000-1200	Suitable for toria-wheat crop rotation

** Already tested and PT-30 and M-27 are recommended for Bhutan.*

Crop : Yellow Sarson (*Brassica rapa syn campestris* var yellow sarson**)**

Variety	Maturity (Days)	Year of Release/ Notification	Oil content (%)	Average Yield (kg/ha)	Special characteristics
Rajendra Sarson – 1	100	1996	46	1500-1600	Moderately resistant to Alternaria blight and white rust.
Ragini (MYSL-203)	100-136	2001	44	1567	Suitable for irrigated conditions
Benoy	90-95	1982	46	852-1377	Suitable for late sown conditions and responsive to high dose of nitrogen (90 kg/ha)
Subinoy	97-103	1991	45-46	1300-1650	Spreading growth habit Non lodging, suitable for late sown.
Jhumka	90-95	1998	46	643-1421	Gives higher yield in close spacing
PYS-1	100-125	2004	42-44	1050-1163	Suitable for irrigated areas.

Crop: Indian Mustard (*Brassica juncea*)

Variety	Maturity (Days)	Year of Release/ Notification	Oil content (%)	Average Yield (kg/ha)	Special characteristics
Narendra Ageti Rai - 4	90-110	2001	40	1500-2000	Suitable for early sowing, white rust and downy mildew tolerant
Urvashi	125	2001	39	2200-2500	Suitable for irrigated conditions
Pusa Agrani (Sej 2)	95	1998	40	1718	Early maturing
Kanti (RK 9807)	100-105	2003	40-42	2000-2200	Suitable for multiple cropping, early sowing (mid September)
Mahon-8	124-135	2002	38-39	1442	Suitable for late sown conditions
JD-6 (Pusa mahak)	81-114	2005	39-44	597-1049	An early maturing, for rainfed areas
RH 30	130-135	1985	39	1600-2000	Suitable for mixed cropping
GM 2	110-115	1997	38	2400-2470	Bold seeded
Pusa Bold	110-145	1985	42	1800	Suitable for rainfed areas , bold seeded
Pusa Jaikisan (BIO 902)	115-135	1994	40	1600-2200	Resistant to lodging
Kranti	125-130	1983	40	1107-2135	Pureline selection of Varuna
Varuna (T59)	125-130	1976	42	2000-2500	Highly stable variety

Crop : Gobhi Sarson(*Brassica napus*)

Variety	Maturity (Days)	Year of Release/ Notification	Oil content (%)	Average Yield (kg/ha)	Special characteristics
Hyola-401 (Hybrid)	148-182	1997/2001	42	1200-1640	Double low (low erucic acid, 0.8 % and low glucosinolate content, 15 micromoles/g defatted seed meal)
GSL 1	160	1987	45	1900-2200	Suited for irrigated areas

The other crop varieties which may be tested, after introduction from India, in Bhutan are :

Crop	Varieties	Year of Release	Characteristics
Soybean (G*lycine max*)	Bragg	1978	JS-335, JS 93-05, Ahilya-3 , Samrudhi, Pratap soya, varieties are early (less than 100 days). The other varieties are recommended either for Uttaranchal or North Eastern parts of the Country.
	Pusa-20	1988	
	JS-335	1994	
	VL soya-21	1996	
	Pant soybean 1042	1997	
	Ahilya-1 (NRC-2)	1997	
	Ahilya-3 (NRC-7)	1997	
	VL soya-47	2000	
	Pant soybean 1092	2000	
	Hara soya	2001	
	Indira soya-9	2001	
	Pratap soya (RAUS 5)	2002	
	JS 93-05	2002	
	Samrudhi (MAUS-71)	2002	
	PS-1241	2003	
Sunflower (*Healianthus annuus*)	Morden	1979	Early in maturity (less than 95 days and have 42% oil).
	Surya	1983	
	DRSF-108	2003	
	Hybrid:		These hybrids, except KBSH have been developed by private seed companies and have wider adaptability high yielding capability, maturing in less than 100 days and oil content ranging between 40-43%.
	MSFH-8	1987	
	MSFH-17	1987	
	KBSH-1	1992	
	Jwalamukhi	1995	
	PAC-1091	1997	
	Sungene-85	1998	
	KBSH-44	2002	
	Pro sun-09	2004	
Groundnut (*Arachis hypopaea*)	ICGS-11	1986	ICGS varieties have been developed by ICRISAT and are performing well in different regions. The other varieties are also promising ones giving high yield and occupying large acreage in India due to their wider adaptability. These varieties are either bunch or spreading types. The oil content ranges between 44-48%.
	ICGS-44	1988	
	ICGS-76	1989	
	ICGV-86590	1991	
	TAG-24	1991	
	CSMG-84-1 (Amber)	1992	
	K-134	1993	
	TG-26	1995	
	HNG-10	1998	
	Dh-86	2003	
	GG-14	2003	

7.3 Integrated Pest and Disease Management Strategy

Rapeseed-Mustard crops are damaged by an array of insect-pests and diseases of which mustard aphid; *Alternaria* leaf spot and white rust are the major ones. Average yield loss of 35 to 50% has been observed due to insect pest and diseases in these crops. The following strategies are to be followed to reduce the pest incidence to sub-economic levels.

Major insect-pest and diseases of Rapeseed-Mustard

Pest	Crop stage attacked	Period of activity
Insect-pests		
Mustard aphid (*Liaphis erysimi*)	Vegetative/flowering and pod formation	December – March
Painted bug (*Bagrada hilaris*)	i. Seedling ii. Maturity stage	i.) October-November ii) March-April
Mustard sawfly (*Athalia proxima*)	Vegetative	October-December
Leaf miner (*Chromatomyia horticola*)	Reproductive	February-March
Diseases		
White rust (*Albugo candida*)	i. Vegetable ii. Reproductive	i) November ii) February-March
Alternaria leaf spot (*Alternaria brassicae*)	Throughout crop growth	February –March
Powdery mildew (*Erysiphe cruciferarum*)	Reproductive	February –March
Sclerotinia rot (*Sclerotinia sclerotiorum*)	i. Vegetative ii. Reproductive	i) October– November ii) February- March

Management

- Deep ploughing during summer months reduces the incidence of soil borne diseasesand help in eliminaton of pathogen.
- Follow clean cultivation by burning of stubble / debris in and around the field and regular weeding / Roeing.
- Treat the seeds with Carbendazim 0.1% or Thiophanate methyl 0.1% against seedling diseases.
- Provide need based irrigation and nitrogenous fertilizers. Arrange for drainage of excess water from the fields. Apply first irrigation 3-4 weeks after sowing wherever possible.
- In case of painted bug infestation dust the crop with Endosulfan 4% or Quinalphas 1.5% dust @ 20-25 Kg/ha.
- Spray the crop with Malathion 50 EC @ 500 ml or Endosulfan 35 EC @ 625 ml in 500 litres of water per hectare to control painted bug and sawfly under severe infestation.
- Thresh the crop early and dispose off plant material immediately at a distance from the cropped field in case of more painted bug problem.
- If the white rust mean disease severity is more than 3%, apply Ridomil MZ 72 WP @ 2g / litre.
- If the *Alternaria* blight mean disease severity is more than 3%, spraying of Mancozeb or Iprodione @ 2g/litre needs to be taken up at 50 and 70 days after sowing. Disease affected plants should be uprooted and destroyed by burning. If the powdery mildew

disease appears before or at flowering, spraying Sulfex @ 2g/litre may be done. If powdery mildew disease is observed at a later stage of the crop, there is no need to worry.

- Sow the crop in time as per recommendations. It helps in escape / low infestation of mustard aphid. It is advised to sow the crop early.
- Apply balanced / recommended dosages of fertilizers. Application of only nitrogenous fertilizers makes the crop vulnerable to aphids.
- Visit the field regularly as aphid infests the border rows / plants of the field first and that migrates inside the field. Plucking and destroying the infested twigs from the border rows 2-3 times at 10 days interval is very useful in preventing the further multiplication in the crop season.
- Spray the crop when the infestation on at least 10% plant population with 26-28 aphids / plant is observed.
- Spray the crop with Oxy-demeton methyl 1 (Metasystox) 25 EC or Dimethoate (Rogor) 30 EC or Monocrotophos (Nuvacron) 36 SL @ one litre of insecticide mixed in 600-800 litre of water, depending upon crop stage, in one hectare. If the population builds up again, repeat the spray at 15 days interval.
- The spraying should be done in the afternoon to avoid toxicity to pollinators.
- Prefer to grow (Indian mustard-*Brassica juncea*) varieties, which are comparatively tolerant to aphids.
- In order to protect the natural enemies like ladybird beetle (*Coccinella* spp.), syrphids (*Syrphus* sp.) mummified aphids etc., the spraying may be avoided, if these are sufficient in field.

Weeds

These are fast growing rabi crops and are rarely infested with more than one flush of weeds. Due to weed competition 10 to 30% reduction in seed yield is caused. Weeds can be hoed down easily in these row planted crops by manual weeding and hoeing. Under severe weed infestation the chemical weed control be adopted.

Application of Fluchloralin @ 1kg a.i./ha (Pre –plant incorporation), Pendimethalin @ 1 kg a.i./ha (Pre-emergence) or Isoproturon @ 0.75 kg a.i./ha (Post emergence) at 30 days after sowing (after first irrigation) can be made to control the weed population in mustard. The weedicide be dissolved in 800 litres of water per hectare. Isoproturon causes scorching effect on leaves and therefore the controlled spray should be done cautiously.

8. SYSTEMATIC SEED PRODUCTION PROGRAMME

During the year 2004 the quantity of mustard seed supplied from Paro by Druk Seed Corporation was 4046 Kg. The seed production programme need to be further systematized and its availability be ensured in remote areas. The following points need specific attention:

- The four varieties (T -9, M-27, BSA and PT -30) of mustard (*Brassica campestris* var. *toria*) have been released for cultivation in Bhutan for different cropping systems. Genetic purity of these varieties be maintained.
- The Druk Seed Corporation should take-up the seed production programme using recommended technology. In order to maintain purity of seeds. The foundation/certified seed production be taken up using the breeder seed of above varieties. The toria crop is cross pollinated and without proper isolation distance (400 m for foundation seed and 200 m for certified seed production) the seed purity is difficult to maintain. The seed chain be developed and seed production plan be prepared.
- The seed in Bhutan is distributed through the commission agents. Timely supply of seeds at the delivery centre is ensured.

- Procurement of the seeds of improved varieties of rapeseed-mustard from India which suits to the Ago-climatic conditions of Bhutan. Such varieties could be selected by the research staff during their visit to India.
- For the procurement of germplasm, Director, National Bureau of Plant Genetic Resources, Pusa campus, New-Delhi 110012 be contacted.

8.1 Pollination behaviour in rapeseed-mustard

Rapeseed-Mustard is a group of crops having different kinds of breeding behaviour. On one hand it includes self-compatible (self pollinated) crops like yellow sarson (*Brassica rapa* var yellow sarson), gobhi sarson (*Brassica napus*) and Ethiopian mustard (*Brassica carinata*) while on the other hand self - incompatible (cross pollinated) crops including toria (*Brassica rapa* var toria), brown sarson-Lotnitype (*Brassica rapa* var brown sarson) and taramira (*Eruca sativa*) are existing. In India, mustard (*B. juncea*) is the major crop of the group and has cross-pollination ranging from 5 to 15 per cent.

The important diagnostic characteristics of different species are -

Oilseed brassicas have a tap root system. Leaves are dark green, syrate, pinnatified and either sessile (rapeseed) or petiolated (mustard). in *B. rapa*, syn. *campestris*, the upper leaves are auriculate and clasp the stem closely. In *B. napus* only the lower leaves are partially clasping whereas in *B. juncea* the leaves are petiolated. The inflorescence is elongate raceme, borne terminally on the main stem as well as on the branches carrying bright yellow flowers (colour may vary from dark to cream yellow). The fruit is a long narrow pod or siliqua, usually consisting of two carpels separated by a false septum which shatters after maturity and is a varietal character detrimental to an oilseed strain. They produce dark brown (black), light brown or yellow coloured seeds.

The details of nucleus and breeder seed production are given in Annexure 6.

8. 2 Suppliers of hybrid/certified seeds of oilseeds in India

In India, the hybrid/certified seeds are also supplied by private agencies in addition to other seed producing agencies like National Seed Corporation and respective State Seed Corporations. However, the breeder seed is produced by concerned agency/breeder responsible for the release of a particular variety. The indent for breeder seed is compiled by the Ministry of Agriculture and allocated to seed producing agencies for its multiplication to different stages i.e. foundation and certified seed. The names of the private agencies involved in seed production programme in oil crops have been given below:

1. Ankur Seeds Private Limited, 27 New Cotton Market Layout , Nagpur – 440 148 (Maharashtra)
   Tel: 2725117/2726148
   Fax : (0712) 723455,
   E-mail: Makrand@nagpur.dot.net.in
2. Ganga Agro-tech Private Limited- 1406-1407 Babukhan Estate
   Bashir Bagh, Hyderabad – 500 001 (AP)
   Tel : (040) 23242450/3518
   Fax : (040) 23233418
3. Indo-American hybrid Seeds Limited
   Post Box No. 7099
   17th Cross, 2nd "A" Main, K.R. Road, Banashankari, II Stage
   Bangalore 560 070 (Karnataka)
   Tel : (080) 26760111/26762120
   Fax : (080) 26761479
   E-mail : attavar.ho@indiamseeds.com
   dr.attavar@vsnl.com
4. Advanta India Limited
   405, 4th floor, "A" Wing
   Carlton Towers, 1, Airport Road
   Bangalore 560 008 (Karnataka)
   Tel : (080) 5209941
   Fax : (080) 5209942
   E-mail : dmullick@advantindia.com
   dmullick@hotmail.com

5. Unicorn Agrotech Limited
Tirumala Complex, II Floor
Sarojini Devi Road
Secunderabad 500 033 (AP)
E-mail : uniagro@hd1vsnl.net.in

6. Proagro Seed Co. Pvt. Limited
8-1-39, Qutub Shahi Tombs Road, tolichowki
Hyderabad 500 008 (AP)
Tel : (040) 23564046/3404
Fax : (040) 23563029
E-mail : clive.pegg@bayercropscience.com

7. Maharashtra Hybrid Seeds Co. Limited
Resham Bhavan, 4th Floor
78 Veer Nariman Road, Churchgate
Mumbai 400 020 (Maharashtra)
Tel : (022) 2204 9497/2204 3020
E-mail :rbarwale@mahyco.com

8. Mahendra Hybrid Seeds Co. Limited
8-2-120/86/5 Avenue 7
Road No. 3, Banjara Hills
Hyderabad 500 034 (AP)
Tel : (040) 23555378/33
(040) 23555412/19
Fax :(040) 2355378
E-mail : vrkaundinya@emergentindia.net

9. Nath Seeds Limited
(Nath Bio-Genes (India)
Nath Road, Itkheda
Aurangabad 431 005 (Maharashtra)
Tel : (0240) 2376314/17
Fax: (0240) 2376188
E-mail: kagliwal@nathseeds.com

10. Parry Monsanto Seeds Limited
No. 277 INBRI Phase1, 2nd floor
Chowdaiah Road, Malleshwar
Bangalore – 560 003 (Karnataka)
E-mail : satish.s.ganiger@monsanto.com

11. Rashi Seeds Private Limited
273, Kamraja Nadar Road
Attur 636 102
Salem Dist., (TN).
Tel : (04282) 240158/240458
Fax : (04282) 241558
E-mail : raised@md2vsnl.net.in

12. Monsanto India Limited
Ahura Centre, 5th floor
96, Mahakali Caves Road, Andheri (E)
Mumbai 400 093 (Maharashtra)
Tel : (022) 28246450/26902100
Fax : (022) 26902111/26902121
E-mail: sekhar.natarajan@ap.monsanto.com

13. J.K. Agri-Genetics (JK Seeds)
1-10-177, 4th Floor, Varun Towers
Begumpet, Hyderabad 500 016 (AP)
E-mail : jkseeds@eth.net

14. Syngenta India Limited
1170/27, Revenue Colony
Chivaji Nagar
Pune 410 005 (Maharashtra)
Tel : (020) 25539314
E-mail: surendra.nagda@syngeta.com

15. Mahyco Monsanto Biotech India P.L.
221-224, Sahar Plaza, "MIDAS"
M.Vasanji Road, Andheri Kurla Road
Andheri (E), Mumbai 400059 (Maharashtra)
Tel: (020) 28321072/28377020
Fax : (022) 28356586

16. PHI Seeds Limited, 3rd & 4th Floor, Babukhan's Millennium Centre, No. 6-3-1099/100 Somajiguda
Hyderabad – 500 082. (AP)
Tel : (040) 23372891 to 95
E-mail: subbaraok.v@pioneer.com

17. J.K. Agrigenetics
20, Palgah Colony, S.P. Road
Secunderabad 500 003 (AP)
Tel : (040) 27903329/27900995
E-mail : svrao@hd2.dot.net.in

18 Pioneer Hybrid, K-E-91, Kavinagar, Ghaziabad –201 001(UP)
Tel: 0120-2780613

19. Krishna Agril. R&D Centre, 8/151, Jeoni Mandi, Agra – 282 004 (UP)
Tel: 0562- 2369974

20. Plant Gene Seeds Limited, Shiva Reddy Complex, Kompally, Secunderabad – 500 014 (AP)

For more details, the contact can be made at following address:

Association of Seed Industry
C/o : Nath Group, 1, Chateau Windsor
86, Veer Nariman Road, Churchgate
Mumbai 400 020 (Maharashtra)
Tel: 022-22875653
Fax: 022-22875652
E-mail : deo@nathgroup.com

9. SUGGESTED TECHNICAL PROGRAMME FOR UNDERTAKING FUTURE RESEARCH

9.1 Varietal Development

9.1.1 Creation of source population

The success of any breeding approach depends upon the magnitude of available genetic variability in the source population. Therefore, it is advised that large number of germplasm should be collected or procured from the other countries, which may be used as a source population for further improvement. These collected germplasm lines should be evaluated in yield trials in the appropriate designs, which may vary on the basis of number of lines to be evaluated. In the beginning, large number of lines (few hundreds) may be evaluated in small plots in which the existing varieties should be planted as check. Observations on the important characteristics e.g. days to flower initiation, maturity duration, plant height, seed yield, reaction to diseases and insect –pests should be recorded. The promising lines from these collections may be evaluated in replicated trials for multilocation testing at important places. On the basis of multilocation testing, the promising material, which surpasses the local checks, may be released as variety. Simultaneously, the source population for further improvement through different selection methods may be developed. An outline for developing source population for toria improvement on the year to year basis is given below:

Year 1.

- Collection/ procurement of local cultivars/ germplasm
- Planting of the collected germplasm
- Observations on important characteristics
- Harvest the bulk seeds of identified promising germplasm lines to raise the next generation

Year 2.

- Plant bulked seeds from year 1
- Allow random/intercrossing
- Harvest bulk seeds for next generation

Year 3 and beyond

- Apply appropriate selection methods on the variable population
- Yield evaluation trials of promising lines

9.1.2 Evaluation of promising rapeseed-mustard varieties at different locations

A yield evaluation trial be laid to select the promising varieties/ germplasm out of the collected/procured material from other countries. The evaluation can be done as suggested under varietal evaluation procedure.

9.1.3 Evaluation of promising Indian mustard varieties at different locations

With the release of early maturing high yielding varieties of Indian mustard (*Brassica juncea*) such varieties be introduced from India and evaluated at Bajo. Some of the important varieties are – Sej-2, Kanti, JD-6 and NDRE-4. These varieties be tested alongwith locally caltivated mustard varieties in Bhutan.

9.2 Agronomical Trials/ Frontline Demonstration Suggested

Trial No. 1: Study the performance of mustard varieties under different temperature regimes (date of sowing)

The rapeseed-mustard varieties be tested at different locations to workout the optimum planting time in following cropping systems. The trial should also include early maturing Indian mustard varieties.

A. Maize based cropping system
B. Potato based cropping system
C. Rice based cropping system

Trial No. 2: Optimization of plant population in mustard

In rapeseed-mustard, optimum seed rate and plant population requirement be worked out for newly introduced varieties in different cropping systems.

Trial No. 3: Integrated nutrient management in mustard

In order to assess the effect of NPKS and also some of the microbial inoculants like Azotobacter and Phosphrus Solublizing bacteria, the trial be planned to workout the integrated nutrient management schedule.

Frontline demonstrations (FLD)

The following front line demonstrations at the farmers field are also suggested to validate the technology.

1. Performance of varieties

a. Local variety: M-27
b. Improved toria variety: PT-30
c. Improved mustard variety: Sej-2

2. Sowing methods

a. Broadcast method of sowing
b. Line sowing (Row to row-30cm, Plant to plant-10 cm (Maintained by thinning at 15-20 Days after sowing).

3. Fertility management

a. FYM 5.0 t/ha
b. Recommended fertility level (60-80 kg Nitrogen, 40 kg P_2O_5 and 20 kg K_2O per hectare)

10. DELIVERY OF EXTENSION SERVICES

The efficiency and effectiveness of technology dissemination for oil crops production be strengthened through the below given measures:

- Continuous up-gradation of the knowledge and skills of Agriculture Extension Agents on the improved oilseeds production technology.
- Improving the use of print and audio-visual materials depicting the technology on mustard production.
- Technology transfer through demonstrations organized pre-sowing training programmes, field days and group discussions.
- Focusing on location specific relevant problems and activities.
- Co-coordinated and packaged delivery of inputs, technology, oil expellers and credits.
- Improving linkages between farmers, Extension Agents and the RNR research centres for technical support.
- Support and facilitate oil crops growers association. Focus on the community approach for better utilization of resources.
- Incentives and rewards to innovative farmers and Extension Agents for enhancing oilseeds production.
- Encourage 'on farm' training programmes and prepare trainers on oil crops production technology.
- Provision be made in next plan to establish the ATIC (Agriculture Technology Information Centre) centre at each RNR research centre to provide single window system for the farmers. A help line (toll free telephone number) for immediate reply to the farmers queries be also established. A team of scientist should be available during the notified timing every day at the A TIC centre to help the farmers. All information and seeds could be made available at a single point.

11. HUMAN RESOURCE DEVELOPMENT

- The man-power engaged in oilseeds Research is meager. The present staff strength be increased to provide adequate technology support to oilseeds research programme in Bhutan.
- The existing research staff also requires exposure to International organization to upgrade their skills and study the technological advances made in different countries. Study visits of 3-6 months duration at any leading research institute either in Europe or India for the scientific personnel involved in research on oil crops shall be of great use to learn the recent technological advances. However, immediate action is required to accomplish at least one 3 weeks exposure visit to India during early 2006 (February) to study the rapeseed-mustard improvement programme. The visit to following centre is proposed:

    1. National Research Centre on rapeseed-mustard, Bharatpur (Rajasthan)
    2. G.B Pant University of Agriculture and Technology, Pantnagar (Uttaranchal)
    3. CCS Haryana Agricultural University, Hisar (Haryana)
    4. PAU, Ludhiana (Pb)
    5. Indian Agricultural Research Institude, New Delhi
    6. Oilseeds Research Station, Shillongani, Assam
    7. Oilseed and pulses research station, Berhampore, West Bengal

The exposure visit could be made in September/October to study the Groundnut, soybean, and sunflower Improvement programme in India. The contact addresses are given below:

1. Director, National Research Centre on Ground nut, Junagarh (Gujarat)
2. Director, National Research Centre on Soybean, Indore (M.P)
3. Project Director, Directorate of Oilseeds Research, Rajendranagar, Hyderabad (AP).

The exposure visits of research staff shall be very useful. Necessary plan of visit be developed and Department of Agriculture Research and Education, Krishi Bhawan, New- Delhi be contacted for necessary arrangements.

- The research staff at Bhutan should continue their efforts to develop international linkages particularly with India.
- The Indian council of Agricultural Research, New-Delhi be contacted for strengthening the linkages and meaningful participation in annual group meeting of oil crops and suitable MOU to this effect could be developed.
- Training (2 weeks) of research/extension staff at Indian National Research Centre responsible for co-ordinating research activities in respective oilseed crop like Mustard at Bharatpur, Groundnut at Junagarh, Soybean at Indore and Sunflower at Hyderabad.
- Conduct of training programmes in Bhutan for extension agents and involvement of scientists from India and Nepal.

12. MARKETING, PROCESSING AND UTILIZATION OF OILSEEDS

12.1 Marketing

The mustard oil produced in Bhutan is mostly consumed by households and thus there is little or no marketing of mustard seeds or oil at present. The oil cake is usually taken back by the producers for their cattle but in few cases the cake is also left with the owner of oil expellers to meet the cost of processing. Very small quantity of mustard oil is marketed by the oil-expelling units. The strategy of marketing could be as under.

- Formation of oilseeds processing and marketing groups
- Expansion of market for purchase of oilseeds by nodal agency like Druk Seed Corporation.
- The mechanism for the collection of soybean seeds be established for efficient marketing and its processing.
- Storage facilities for preserving quality of oilseeds and oils.
- Establishing information system for quick appraisal of oilseeds marketing and pricing fluctuations.
- The import duties should be structured in a manner so as to provide adequate protection against cheap imports of edible oils. The import duty could be flexible and move with the change of price of oil i.e. if prices are high, duty level should be brought down and vice versa.
- Import of seeds rather than oil to build up the capacity utilization of oil expellers and ensuring availability of quality oil. The oil millers are not getting enough seed to run their units throughout the year.
- Collaboration of various Institutions like FCB, AMU, AMC and NPHC to support processing, trading of oilseeds, oil and oil cakes for fair price business.
- Implementation of edible oil packaging order to maintain the superior product quality and reduce the sale of adulterated oil.

12.2 Processing

The oil extraction in Bhutan is usually carried out using traditional method resulting in poor oil recovery. The efficient oil expellers need to be popularized. Presently processing is fragmented, inefficient and suffers from low capacity utilization.

The policy frame work for processing of oilseeds and oil should be aimed to balance the interest of four constituents;

- An incentive price for farmers, which only an efficient processing industry with low cost of operation can secure.
- An affordable price for consumers because eventually the consumer of edible oil and its products would have to afford consumption of these production of oilseed sector.
- Reasonable profit margins for Industry, which should have the incentive to modernize and reduce cost of processing.
- Reasonable conformity to public interest ensuring satisfactory level of employment, income, export and public revenue.

The processing sector needs to be organized in a systematic manner. Particularly, in case of soybean the households consume the seeds as such and no processing is done. The soybean seeds can be used for various preparations like Soya milk, Soya floor, Soya candy, Soya Tofu (Paneer), Soya roasted Dal, Soya Nutri Nuggets and a number of such edible products. The small-scale industries need to be developed for value addition and proper utilization of soybean products.

12.2.1 Solvent extractors units available in Assam and West Bengal

Name of member	Telephone/Fax/E-mail	Plant Address
Assam		
M/s Sonipur Solvex Ltd. Mercantile Building Main Road Tezpur-784001 (Assam)	03712-220275,221261 03712-255600 (Fax) nezone@sancharnet.in	P.O. Koliabhomra, Dist. Sonitpur (Assam)
West Bengal		
M/s. Aditi Edible Oils Pvt. Ltd. 40, Weston Street 3th floor, Kolkata-700 013 (WB)	033-22368901,22112857 033-22369554 (Fax) aditioil@vsnl.net	P.O. & Vill. Kuchut, Dist. Burdwan (West Bangal) Tel : 0342-2719535-39
M/s Alock Oil Industries Ltd. 4, Synagogue Street 6th Floor, Kolkata-700 001 WB	033-22424530,22422823 033-22424530 (Fax) bhatter@vsnl.net	Tantigeria, Midnapore (W.B.) Tel : 03222-263076, 265399, 2711578
M/s Arambagh Solvent Extraction Pvt. Ltd. 59-B, Chowringhee Road Kolkata – 700 020 (WB)	033-22872154/64 033-22474137 (Fax) arambagh@cal.vnl.net.in	P.O. Chandur, Dist. Hooghly (WB)
M/s Bansal Oil Extraction Pvt. Ltd. 113, Park Street, 7th Floor, B-Block Kolkata – 700 016 (WB)	033-22177155,22177902 033-22162119 (Fax) boepl@vsnl.net.in	Vill. Malkita, Katwa Road P.O. Vita, Dist. Burdwan (WB) Tel : 0342-2521264-65 Fax: 0342-2521266
M/s. Kalyani Solvex Pvt. Ltd., Bandar Raiganj, Dist. Uttar Dinajpur – 733 134 (WB)	03523-241795,242158 03523-241795 (Fax) kalyanisolvexnarai@yahoo.com	Vill. Narai, PO. Phoolbari, PS. Gangarampur Dist. Dakshin Dinaipur (WB) Tel : 03521-254365,254466 Fax : 03521-254467

M/s Reja Tarapada Solvent Extraction Co. Pvt. Ltd. Vill. Sahalalpur P.O.Naisaraj, Via Arambagh Dist : Hooghly-712601 (W.B.)	03211-55190, 55094	Vill. Sahalalpur P.O.Naisaraj, Via Arambagh Dist : Hooghly-712601
M/s Swaika Oil Mills 18B, Brabourne Road, Kolkata-700001 (W.B.)	033-2350587 033-2350413 (Fax) swavanas@hotmail.com	9, Station Road, Liluah, Howarh (W.B.) Tel :033-6454450

The presently available Japanese oil expellers, although are good, but availability of their spare parts is a problem. Therefore, oil expellers (Indian make) can be installed. The addresses of few firms supplying oil expeller are given below:

12.2.2 LIST OF FIRMS MANUFACTURING OIL EXPELLERS IN INDIA

1. M/s United Engineering(Eastern) Corporation
   517, Ansal Tower, 5th floor, 38 Nehru Place, New Delhi - 110017
   Telephone No. : 2642-9822, 5160-8928
2. M/s United Engineering works
   B-20, G.T. Karnal Road, Industrial Area
   (Behind Gola Banquet Hall), New Delhi – 110033
   Telephone No. : 27136013, 55197767
3. M/s P.Roy Expeller Works
   C-195/3, Mayapuri Industrial Area Phase-II, New Delhi – 110064
   Telephone No. : 5460361, 5400832
4. M/s Ludhiana Expeller Industries
   471, Industrial Area-B, Ludhiana – 141 003 (Punjab)
   Telephone No. : 0161-2530305, 2530066
5. M/s Simplex Expeller Works
   Nuankari Street No. 3
   G.T. Road, Miller Ganj, Ludhiana – 141 003 (Punjab)
6. M/s Govind Expeller Co.
   645, Industrial Area –B, Ludhiana –141003 (Punjab)
   Telephone No. : 2530711, 2531591
7. M/s Guru Teg Engineering Co.
   G.T. Miller Road, Millerganj, Near Fire Brigade, Ludhiana – 141 003 (Punjab)
   Telephone No.: 2533976,2533173
8. M/s S.P. Foundries
   77/156, Latouche Road, P.B. No. 450, Kanpur – 208001 (UP)
9. Jagdish Agro
   Near Malvia Vadi, Gondal Road, Rajkot- 30 002 (Gujarat)
   Telephone No. : 0281-2462079; Fax : 0281 - 2461770
10. Chetan Agro-Industries
    108 Atul Complex, Gondal Road, Rajkot – 30 002 (Gujarat)
    Telephone No. : 0281-2461781
11. Tiny Tech Plants P. Ltd.
    Shaktinagar, Near Station Road
    Taigore Road, Rajkot – 360002 (Gujarat)
    Telephone No. : 0281-2451086

12.2.3 Apex Organizations Involved In Oilseeds trade In India

1. Central Organization for Oil Industry and Trade

The Central Organization for Oil Industry & Trade (COOIT) formed in 1950 is an Apex Organization. Several leading associations in different parts of the country representing different segments of industry and trade such as Oil milling industry, Refining industry, Vanaspati, Solvent Extraction, Soap Industry, Export-Import trade etc. including Export Pomotion Associations and Future Trading Exchanges in oilseeds / oils are members of the COOIT. Besides nearly 150 prominent manufactures/business houses/traders connected with oilseeds and their products, machinery manufacturers etc. are also its members.

The Executive Committee whose meetings are held at regular intervals at different centres manages the affairs of the Central Organization. Problems facing the vegetable oil sectors are discussed and Estimates of Oilseeds crops are periodically updated. The address of COOIT is as under:

THE CENTRAL ORGANIZATION FOR OIL INDUSTRY & TRADE
4-M, DCM Building, 16, Barakhamba Road,
New Delhi – 110001
Tel: 23712058
Fax: 23719140
E-mail: cooit@vsnl.net

2. The Solvent Extractors Association of India

Premier Association of Vegetable Oil Industry & Trade (ISO 9001:2000 Organization formed in 1963 to help and foster the development and growth of Solvent Extraction Industry in India. At present the Association is having 777 members including about 320 working solvent extraction plants having combined oilcake/oilseed processing annual capacity of about 21.0 million tonnes. The Association is an all India body to solvent extractions industry and premier vegetable oil Association in the country having wide representative membership consisting of processors of Rice bran, Oilcakes, Minor Oilseeds and Soybean. Associate Membership of the Association includes apart from processors, also merchant exporters, oil millers, refiners, vanaspati manufacturers, importers of edible oils, brokers, traders, plant & machinery manufactures, clearing & forwarding agents, surveyors, regional associations etc.

With such wide cross section of membership, SEA is a broad based, all India apex body of solvent extraction industry and at present practically all working solvent extraction units are its members. The affairs of the Association is being managed by the Managing Committee, headed by the President. The address is given as under:

THE SOLVENT EXTRACTORS ASSOCIATION OF INDIA
142, Jolly Maker Chambers No. 2
14th Floor, 225, Nariman Point
Mumbai – 400 021 (India)
Phone : 22021475, 22822979
Fax : (91-22)22021692
E-mail : solvent@vsnl.com
Web-site: http://www.seaofindia.com

3. The Soybean Processors Association of India (SOPA)

This is the only national level body representing the soybean processors, farmers, exporters and brokers in India working towards the aim to strengthen soybeans as a viable crop. The main objective of SOPA is to encourage the development and promotion of soy-based products in the interest of the farmers as well as the processors.

SOPA was established in 1979 with its headquarters at Indore in the state of Madhya Pradesh, the main soybean-growing region of India. SOPA is represented on all the important committees. There are 160 Processing units in India processing Soybean with modern processing technology. The technological excellence of the Soya processing units has earned a very good name for the Indian Soybean Meal in the international market. The address is given as under:

THE SOYBEAN PROCESSORS ASSOCIATION OF INDIA (SOPA)
Scheme No. 53, Near Malviya Nagar
Agra –Bombay Road, Indore – 452 008 (M.P.)
Tel.: 0731-2556530/32/33
Fax: 0731-2556531/5004300
E-mail : sopa@sancharnet.in
Website: www.sopa.org

12.2.4 Nutritional properties of Mustard oil

The mustard oil is considered superior oil from health point of view. The extracts from the 5th National Convention on health, nutrition and value addition of Indian mustard were published by MRPC, New Delhi (Ref.: Basant: 2(5-6) and are given below

A one day National Convention was held on Feb 5, 2003 by the Mustard Research and Promotion Consortium, New Delhi, to discuss the effect of mustard oil on human health, nutrition and value addition. This consortium was attended by 200 delegates from India and abroad. The key note address was delivered by Dr. Narender Kumar Saini, Director, Heart Disease Prevention Clinic Ohio, USA. He indicated that the trans fatty acid present in refined oil were harmful for the human health and middle and rich class group is usually consuming more refined oil, which is not desirable. He further, mentioned that mustard oil contains less saturated fatty acid and proper ratio of poly unsaturated fatty acid (N-3 and N-6). The ratio is ideal in mustard oil and thus superior for human health. The Ex-Head Division of Cardiology, AIIMS, New Delhi, Dr. S.C. Manchanda, also indicated that not only mustard oil was suitable for human heart but also advantageous for over all growth of an individual. He further mentioned that availability of anti-oxidants in mustard oil in sufficient quantity, make it further superior over other oils. Prof. Rakesh Tandon highlighted that n-3 polyunsaturated fatty acid (PUFA) was essential fatty acid and with the use of 5.5 g of n3 PUFA per month, the risk of heart diseases are reduced to half. This n3 fatty acid is present in mustard oil and also in cod liver oil. Dr. Gafur Neesa, Dy. Director of National Institute of Nutrition, Hyderabad also highlighted about the presence of ideal ratio of omega-3/omega-6 PUFA in mustard oil. It was mentioned that high PUFA also reduces the HDL. But mustard oil is capable of maintaining HDL level which protects the health due to ideal ratio. The other scientists like Dr. C. Sharma (USA), Dr. D.K. Bhattacharya (Calcutta) and delegates also endorsed the views and advocated the use of mustard oil which has scope for value addition also.

The presence of higher level of saturated fatty acids (SFA) in edible oils is not considered suitable for health because it increases LDL level. In mustard, Mono unsaturated fatty acid (MUFA) available reduces the LDL level which protect the heart. The World Health

Organization has also suggested 1:2:1 as proper ratio of SFA, MUFA and PUFA. The mustard oil has almost the proper ratio of these fatty acids and thus is nutritionally superior. Presence of Iso-thiocynates and several other bioactive anti-oxidants and antibacterial properties of mustard oil further makes if beneficial for health. Mustard oil also improves the circulatory system and cure body ache. It gives an ample indication about the superiority of mustard oil.

Mustard oil, a healthy oil for healthy people (Extract from Hindustan Times, Jaipur, 22 April, 2005)

In view of the medicinal properties of rapeseed-mustard (RM) oil, dietary experts of the present day are giving emphasis and are now leading towards recommending increasing use of this oil in view of its fatty acid contents that have great medicinal values. Modern day science has found that RM oil contains several bioactive anti-oxidant nutrients like polyphenols, flavonoids, isoflavones, terpenes and glycosides. These nutrients appear to lower the risk of cancer and other cardio-vascular diseases. Crude RM oil contrains a good amount of alpha – tocopherol and also fulfils the requirement of vitamin E. It acts as anti-helminthes and acts as an appetizer. It also accelerates removal of harmful particles from the body by eliciting the rapid synthesis of urine and acts as a wonder drug for rheumatism and joint pain when mixed with garlic and turmeric. Be it a healing wounds, strengthening gums or even as a mosquito repellent, it gives good results. During the last three decade, these has been a major shift away from animal fat intake to vegetable fat, at global level. Rapeseed-mustard oil is nutritionally far superior to any other vegetable cultivated worldwide.

12.2.5 Utilization of mustard meal

Mustard meal contains up to 40% of high quality protein. However, the presence of breakdown products of glucosinolates can interfere with iodine metabolism and cause palatability problems, especially in monogastric animals and poultry. Farmers in Bhutan are apparently effectively mixing mustard meal with other ingredients before feeding to livestock so that the glucosinolate products are reduced to non-toxic levels. As in other countries, the commercial price of high glucosinolate mustard meal is somewhat lower than other oilseed meals. Cattle feed may contain up to 40% mustard meal. Since cattle are more tolerant, it appears unlikely that the higher proportion of mustard meal would be toxic to the cattle.

13 INSTITUTIONAL LINKAGES

Due to inconsistent support and lack of any international collaboration, the oilseed programme in Bhutan could not make any headway. Therefore, establishment of linkages with leading institutions involve in oilseeds research is necessary for enriching the information and genetic base in the country.

13.1 National

- Close collaboration with RNR research and extension Centres.
- Linkages with FCB, AMU and NPHC.
- Collaboration with Agriculture Machinery Centre (AMC) and Druk Seed Corporation

13.2 Regional

Developing Network of SAARC countries

- Under Indo-U.K project, efforts are underway to establish a net work of rapeseed- mustard research involving SAARC countries.

- A visit is planned in February / March 2006 by Dr. Nash Nashaat, Project Leader, Indo-UK project; A.D.G(oil seeds) ICAR; Director, NRCRM, Bharatpur to Bhutan for 1 week to discuss with Programme Director, National oilseed Co-coordinator and policy planners and visit the lead research centres to accomplish the mission. Involvement of Bhutan in such net work would help the country in exchange of useful information and strengthen its research activities.

India

- Director, National Research Centre on Rapeseed-Mustard, Bharatpur (Rajasthan).
- Director, National Research Centre on Groundnut, Junagarh (Gujarat).
- Director, National Research Centre on Soybean, Indore, (M.P)
- Director, Directorate of oilseeds Research, Rajendranagar, Hyderabad (A.P.).
- Solvent Extractors Association of India, Mumbai (Maharashtra) .
- The Soybean Processors Association of India (SOPA), Indore (M.P.)
- The Central Organization for Oil Industry and Trade, New Delhi.

13.3 International

- Participation of Rapeseed-Mustard research scientists in International Rapeseed congress. The next congress is scheduled in 2007 in China.
- Participation in GCIRC (Groupe Consultatif International de Recherche sur le Colza, – Secretariat : 12 avenue George V, 75008 PARIS (France), E-mail- lot@cetiom.fr, Website- www.cetiom.fr/gcirc) meetings and become a member of GCIRC. The next meeting is scheduled in India in 2009.

Australia

- Australian Centre for International Agricultural Research, GPO Box 1571, Canberra ACT 2601, Australia
- Dr. Phil Salisbury, University of Melboume, Joint Centre for Crop Improvement, Institute of Land and Food Resources, Melbourne, Victoria, Australia

Canada

- Agriculture Canada Research Station, Saskatoon, Saskatchwan, Canada U.K

U.K.

- Dr. Nash Nashaat, Project Leader, Indo-UK collaboration on oilseeds, Rothamsted Research, Harpenden, UK

China

- Prof. Fu Tingdong, Huazhong Agricultural University, Wuhan, China
- Prof. Li Yunchang, Oil Crops Research Institute, Wuhan, China

Nepal

- National Oilseed Research Programme,, Nawalpur, Sarlahi, Janakpur, Nepal

14. CONCLUSION AND RECOMMENDATIONS

14.1 Specific areas of intervention

- Replacement of local varieties in a phased manner
- Encouraging use of Single Super Phosphate in mustard as it contains 12% sulphur, also, which will improve the oil content in seeds.
- Development of location specific improved implements for sowing, harvesting and threshing of produce.
- Implementation of pest and disease management strategy.
- Organizing at least 5 Front Line Demonstrations in each geog for quick dissemination of improved variety and promising component technology. These demonstrations could be supported with critical inputs like seed, fertilizer and plant protection chemicals. A provision of Nu 800 per acre be made for such / demonstrations, which can also meet out the expenses for 'on farm' trainings and field days. This amount shall vary depending upon the technology put under testing. Therefore this can be worked out by the research station. This will also provide incentive for oilseeds growers.
- Ensuring remunerative prices in order to encourage farmers to grow more oilseeds.
- Linking soybean growers with marketing network.
- Improved soil and moisture conservation practices for yield stability of mustard grown on dry lands.
- Organized strategy on community basis for keeping away the stray animals from the cultivated lands during winter season.
- Integration of marketing and processing of oilseeds in a systematic manner.

RECOMMENDATIONS

14.2 Immediate follow up

- Immense possibilities of increasing oilseeds production exist in Bhutan provided research and developmental activities are geared up through a mission mode approach and special emphasis is accorded to oilseeds sector. Bhutan has the potential to achieve self-sufficiency in oilseeds, without displacing other crop production. The increased production of oilseeds and its processing would generate employment opportunities for rural masses. A national policy be framed to facilitate oilseeds production.
- Study visit of research scientists working on oilseeds and policy planners in Bhutan, for 3 weeks duration in February 2006, to see the rapeseed-mustard improvement programme in India. This will help in better understanding and selection of improved varieties during the peak-cropping season.
- Submit a proposal to Indian Government for procurement of seeds of improved varieties of oilseeds and develop MOU for collaboration.
- Training of Agriculture Extension staff on improved oilseeds production technology. Training could be organized in two batches every year. Oilseeds Scientists from India and Nepal can also be called.
- Preparation of literature, A.V. aids and film for effective dissemination of improved technology.
- Assessment of the requirements of improved seeds and make it available at the delivery points on time.
- Adequate provision of crop promotional programmes on mustard in remote areas.
- Educate the farmers about the benefit of using SSP in mustard for improved production of seed and oil.
- Organizing farming community to protect the crop from stray and wild animals.
- Installation of the oil extraction units in many villages and towns in Bhutan has encouraged the farmers to produce more oilseeds. Evaluation of the expellers available in India by AMC be done and efficient ones be installed in remote areas having potential for

increased oilseeds production. These units should be capable of extracting oil from sunflower as well as mustard.

- Formation of mustard growers association for facilitating marketing and processing of oil.
- Exposure visits of some progressive farmers and extension officers to prominent oilseeds growing states in India like Rajasthan, UP, Haryana and West Bengal.

14.3 Long terms recommendations

- Establishment of a multi-disciplinary team of scientists at RNRRC, Bajo to carry out necessary research and development on oil crops.
- Improving genetic base by importing germplasm/ varieties of oil crops having tolerance-resistance to biotic and abiotic stresses and their testing under different agro-climatic situations.
- Enhancing the acreage under Maize + Soybean for increasing soybean production. The improved early duration soybean varieties available in India be tested and high yielding ones be popularized.
- Evaluation of sunflower hybrids developed in India and promotion of high yielding ones at the farmers' field particularly in high altitude areas of Bhutan.
- Establishment of a good oil quality laboratory to test the adulteration in oil at the central level.
- The mustard cake is consumed as livestock feed and increased mustard production would improve the production of cakes. However, the effect of mustard cake on animal health be evaluated and it must be blended with other feeds to improve the value.
- Implementation of edible oil packaging order to maintain the superior product quality and reduce the sale of adulterated oil.
- Providing appropriate household based post harvest processing unit on subsidy. Technical collaboration should support the post harvest processing and value addition.
- Established linkages with leading international organizations and continuous exchange of experts for upgradation of latest information.
- Promotion of self helps groups and cooperative for marketing or oilseeds and oil.
- Farm mechanization and development of improved seeding and harvesting devices.
- Exploitation of oil extraction from nontraditional sources like oil-bearing plants.
- The import duties should be structured in a manner so as to provide adequate protection against cheap imports of edible oils. The import duty could be flexible and move with the change of price of oil i.e. if prices are high, duty level should be brought down and vice versa.

APPENDICES

1. ToR for Consultancy to Review and Revitalization of Oilcrops Research

General

Ever since the agricultural research in Bhutan was standardized in 1984, the Royal Government of Bhutan has maintained the high research priority on field crops (rice, maize, oilseeds and grain legumes) and horticulture crops. RNR Research is conducted through 4 RNR Research centres situated in Yusipang, Bajo, Jakar, and Wyengkhar. Each Research centre has dual mandates of commodity research and regional focus. The field crops research has been assigned to RNRRC, Bajo as its principal mandate. There are tangible outputs of the research system which has been critical input in stimulating agricultural development in Bhutan.

Among several commodities handled by research, oilcrops research is yet to make any significant impact in the overall development of the commodity. Recognizing various limitations, the decisive factor that slowed the development process is the inconsistent support and lack of project type intervention they have received in past. Further, the absence of institutional linkage with regional and international research institutions has sidelined the program.

Considering the wealth of oilcrops research in India, professional working for Indian Council of Agriculture Research (ICAR) with oilcrops background would be the best choice to facilitate streamlining the oilcrops research. The TA can also facilitate in initiating institutional linkages.
To review the status of oilcrops and propose appropriate research approach to revitalize the program, it is proposed that a TA will be fielded at RC Bajo. Considering the relevance of the issue at national level, the TA's input will help in shaping up Oilcrops Research at national level. Further, the input can also help the Department of Agriculture in reinforcement of oilseed development program.

Terms or Reference

- Review past and current status of oilseed research approach and suggest for improvement
- Visit potential oilcrops production areas and discuss with District Extension officials and farmers to identify crop types, constrains and potentials.
- Visit all RNR Research centres to discuss with relevant researchers to identify regional priority constraints and opportunities in oilcrops development.
- Identify gaps (technical, physical and manpower) in oilseed research and suggest strategies for improvement.
- Identify potential regional and international institutions and suggest strategy to establish and strengthen contacts.
- Make specific recommendations on research strategies for oilcrops development in relation to the national research strategy.

Time and Duration of Consultancy

Considering the volume of the work, one man month in September-October, 2005 would be sufficient.

Local Counterpart and Reports

One research staff from RNRRC Bajo will be attached to the T A. As in most cases, T A will make presentation of the draft findings to a peer group (senior management, policy makers, extension, and researchers) before the departure. The final version of the report will be submitted within a month from the date of draft presentation.

Work Station

RNRRC Bajo will provide work space for the TA. TA will report to ProgrammeDirector, RNRRC, Bajo.

2. ITINERARY

People met and places visited

Place	Date	Activity
Delhi	September 29, 2005	
Phuntsholing	September 30, 2005	Travel from Bagdogra to Phuntsholing
Wangdiphodrang	October 01, 2005	Arrival in Wangdue from Phuntsholing Discussion with Mr. Tayan Raj Gurung
	October 02, 2005	Discussion with Mr. Mahesh, Mr. Tayan and Mr. Yonten Detail planning of the assignment with Mr. Tayan Literature Review
	October 03, 2005	Discussion with Mr. Singey Phub on recently completed oilseed survey and Review Visit to Punkha – Discuss with DAO (Mr. Lakey) and visit farmers /Eas – Khabjisa , Ghuma, Talow.
	October 04, 2005	Visit to Wangdue Phodrang Dzongkhag – Discuss with Acting- DAO (Mr. Galey Phuntsho) and visit farmers fields and Eas – Gaselo, Geog
	October 05, 2005	Discussion with Mr Chogyal Norbu and Ms Ugyen Dema (AAEO) Discussion with farmers / Eas – Samteygang, and Thetsho Geog
Tsirang	October 06, 2005	Travel to Tsirang – Discuss with DAO (Mr Jigme) Visit to RNRRC sub-centre Thirang – Discussion with Mr. C.B. Tamang
	October 07, 2005	Visit to farmers field / Eas in Mendryelgang and Betni Geog Discussion with Mr. N.B. Lama and Mr. Tshering Dhentup (AAEO)
	October 08, 2005	Visit to farmers field / Eas in Tshirang and Bokray Discussion with Mr. Tshering Tobgyel and Mr. Tashigyal Tshen (AAEO)
	October 09, 2005	Travel to Dagapela Visit to Tsendagang Geog Discussion with farmers Goshi and Drugyegang Geogs Discussion with Ms. Tsheringpen and Yeshey Chedup (AAEO) Back to Tsirang
Wangdue	October 10, 2005	Travel to Wangdue
Thimphu	October 11, 2005	Travel to Thimphu Discussion with Mr. N.K. Pradhan, Chief Research Officer, CoRRB, MoA and Mr. G.B. Chhetri, Joint Director, DOA, MoA Meeting with DAO, Thimphu Mr. Karma

	October 12, 2005	Visit to farmers field / Eas in Thimpu and Mewang Geog Discussion with Ms. Thuji Wangmo and Mr. Sonam Dorji (AAEO) Travel to Wangdue
Wangdue	October 13, 2005	Discussion with PD, RNRRC, Bajo Preparation of lecture Lecture to NRTI diploma students, Lobesa
Bumthang	October 14, 2005	Travel to Bumthang Discussion with P.D., RNRRC, Jakar, (Mr. K. Wangdi) and FC Researchers (Programme Officer Mr. Wangda Tuppa)
	October 15, 2005	Discussion with DAO, Bumthang, visit to Chamkhar RNR Extension Centre and Farmer's field visit in Bumthang Discussion with Mr. Wangde Duppa and Ms. Delme (AAEO) Visit to farmers field / Eas in Ghoekhor and Chhume Geog Visit to oil meal in Jallikhar (Ms. Tshering Chadan)
Mongar	October 16, 2005	Travel to Mongar
	October 17, 2005	Discussion with PD, RNRRC, Wyengkhar Mr. Karma Tashi and FC researcher (Mr. Tirtha Bahadur Katwal) Discussion with DAO Mongar (Mr. Tandin) and AAEO of different Geogs.
	October 18, 2005	Visit to farmers field / Eas in Mongar and Saling Geog Visit to RNRRC sub-centre, Linghmethang and discussion with Mr. Sangye Wangdi
Lhuentse	October 19, 2005	Travel to Lhuentse Discussion with DAO (Mr. Sonam Zangpo) and meeting with AAEO of different Geogs of Lhuentse. Back to Mongar
Trashigang	October 20, 2005	Travel to Trashigang Discussion with DAO (Mr. Chimmi Rynzin) and Asstt. DAO (Mr. Dendup Duppa) and Ext. Officer (Mr. Ngawang) Visit to RNR extension-centre at Bikar Discussion with Mr. Ugen Sonam, AAEO, Samkhar Geog Visit to farmers field / Eas in Samkhar Geog.
Trashiyantshi	October 21, 2005	Travel to Trashi ' yangtse Discussion with DAO (Mr. Dogo) and AAEO of different Geogs. Back to Trashigang

	October 22, 2005	Visit to RNRRC sub-centre, Khangma Discussion with Mr. Namgye, FO. Discussion with Mr. Sangay AAEO Kanglung Geog Meeting with Mr. Ugen Dorji. Visit to Oil Mill Owned by Mr. Cheda (Japanese Make) in Kanglung. Travel to Mongar
Wangdue	October 23, 2005	Travel to Bumthang and Wangdue
	October 24, 2005	Report writing
	October 25, 2005	Report writing Report discussion with Mr. Tayan
	October 26, 2005	Report writing Discussion on the final draft report with Mr. Tayan
	October 27, 2005	In house Seminar on, "**Oilseed Development in India"**. Discussion on the final draft report with Mr. Sangay Duba, Programme Director, RNRRC, Bajo ; Mr. Mahesh, Programme Officer and Mr. Tayan Raj Gurung, Sr. Research Officer, Bajo Travel to Thimphu
Thimphu	October 28, 2005	Presentation of the Report –"Seminar **– Oilseed Development in Bhutan**" findings and recommendations to the participants from different organizations. Meeting with Dr. Pema Choephyel, Director CoRRB and Dajo Sherub Gyaltshen, Director Agriculture. Travel to Phuntsholing
Bagdogra	October 29, 2005	Travel to Bagdogra Travel to Delhi and Bharatpur

3. OIL CROPS OF BHUTAN AND PRODUCTION TECHNOLOGY

The main oilseed crop of Bhutan is mustard. The other oilseeds grown on smaller area are soybean, sunflower, niger seed and groundnut. The production strategy in lecture notes delivered to NRTI Students at Lobeysa (Annexure –9). The important point of intervention in rapeseed-mustard are given below:

- Replacement of local types of mustard with improved varieties like M-27, PT -30, T -9 and BSA.
- Increase acreage under mustard on wet lands after rice and introduction of early duration high yielding rice varieties to promote timely planting of mustard.
- Conservation of soil moisture in dry lands by proper levelling, bunding and ploughing across the slope.
- Use of 2 kg seed rate/acre and encouraging line sowing at 30 cm distance. Seed treatment with Azotobacter and PSB(Phosphorus Solubilizing Bacteria) cultures.
- Balance fertilizer use and addition of 20 kg N and 15-20 kg P_20_5 per acre at the time of sowing. Ensure application of single super phosphate for supplying phosphorus as it contains 12% sulphur, also.
- Introduction of improved implements by AMC, Bhutan for timely land preparation after rice harvest and planting devices for mustard.
- Thinning of extra plants at 15-20 days after sowing to maintain optimum plant population.
- Irrigation at critical stage at 30 days after sowing.
- Top dressing of 10 kg N/acre on wet lands after irrigation. In drylands, depending upon winter rains 5 kg N/acre be top dressed.
- Plant protection measures for controlling aphids. Use of ash could be made to minimize aphid infestation. Spray the crop with Metasystox (0. I %) or Rogor (0. 1%)
- Harvest the crop when 75% pods turn yellowish.
- Store the seeds at 8% moisture content.

4. SUGGESTED APPROACHES FOR BREEDING

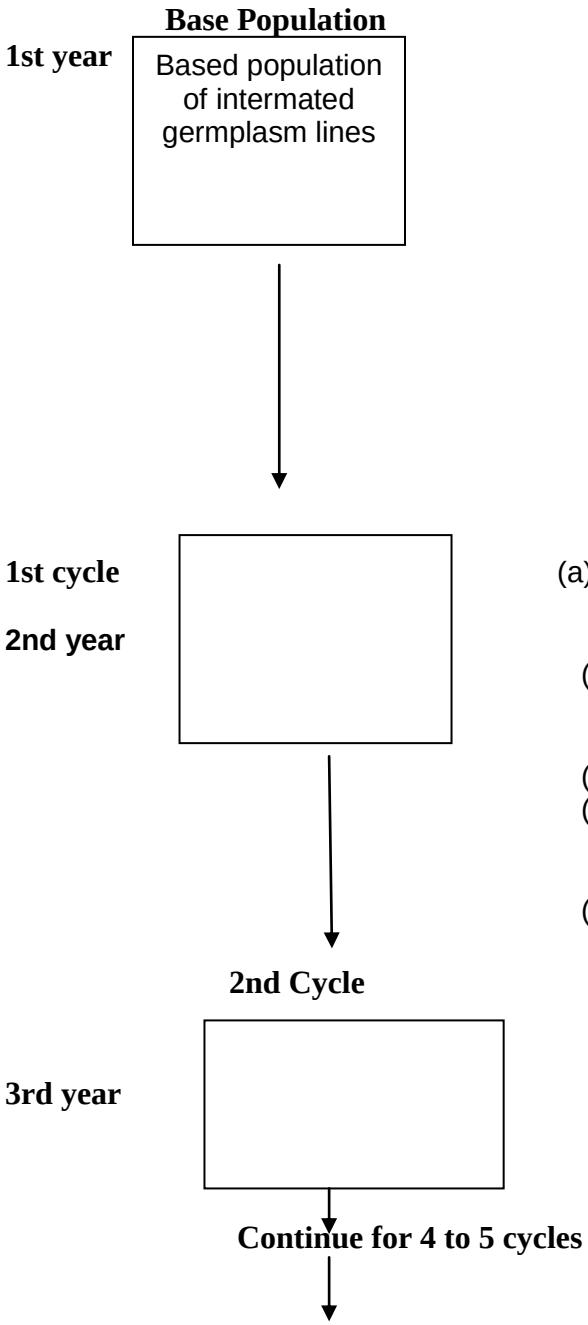
Different methods of selection, viz., mass selection; pure line selection, bulk selection and pedigree selection are followed for crop improvement in rapeseed-mustard.

4.1 Improvement of cross-pollinated crops

4.1.1 Mass Selection

Mass selection and recurrent selection are followed for the improvement of cross-pollinated crops *viz*., toria (*B. rapa* var toria). In mass selection, phenotypically desirable plants are harvested and seeds are bulked without progeny test to produce next generation till desired result is achieved. In cross-pollinating types *B. rapa*, mass selection aims at developing an open-pollinating population.

Mass Selection In Toria



(i) Grow base population in isolation
(ii) Undesirable plants should be rouged out before flowering
(iii) At maturity, select agronomically superior plants having profused branching with high density of siliquae bearing longer silique with bolder seeds and less affected with Alternaria blight disease
(iv) Collect the seeds of individual plant separately
(v) Collect the bulk seed of base population (BS_0)

(a) Mix the equal quantity seed of each selected plant and grow in isolation

(b) Rogue out undesirable plants before flowering and allow the random mating only among the desirable plants
(c) Repeat as (iii) and (iv) above
(d) Mix the equal quantity seed from each selected plant, which will serve as base population for next cycle.
(e) Collect the bulk seed of 1st cycle seed (BS1)

Repeat as above

Conduct yields trial of bulk seed from populations (BS0, BS1, BS2 etc.) and bulk seed of selected plants from each cycle and find out response to selection. If necessary go further otherwise put in coordinated trial

4.1.2 Recurrent Selection

In *B. rapa* var. toria and brown sarson (lotni type), where self-incompatibility ensures a high degree of heterogeneity, recurrent selection is the most effective method for increasing seed yield as well as oil content. In population improvement, plant breeders aim at increasing the frequency of desirable alleles through selection of superior recombinants. Recurrent selection typically starts with harvesting of individual open pollinated plants from the source population. A portion of the seed from each plant is sown in a single progeny row and the remaining seed of these plants is saved as reserve. The agronomic characters of progeny rows are evaluated visually and superior rows are identified on the basis of desirable characters. Equal quantities of reserve seed from selected single plants, based on the progeny performance, are bulked. The first recurrent selection cycle is started when the new composite is grown in an isolated plot where random mating occurs among the plants within the composite. Single plants are harvested from this composite. A bulk seed sample is harvested from the remaining plants of each composite for use in replicated yield trial to determine response to selection in each recurrent selection cycle for the characteristics under improvement. Recurrent selection is continued till reasonable response to selection is achieved. Each cycle of recurrent selection produces a new population. The improved population with increased frequency of desirable alleles can be used as a cultivar per se or as a source for developing inbred lines.

Conduct yield trial of bulk seed from populations and bulk seed of selected plants from each cycle and find out response to selection. If necessary go further otherwise put in coordinated trial

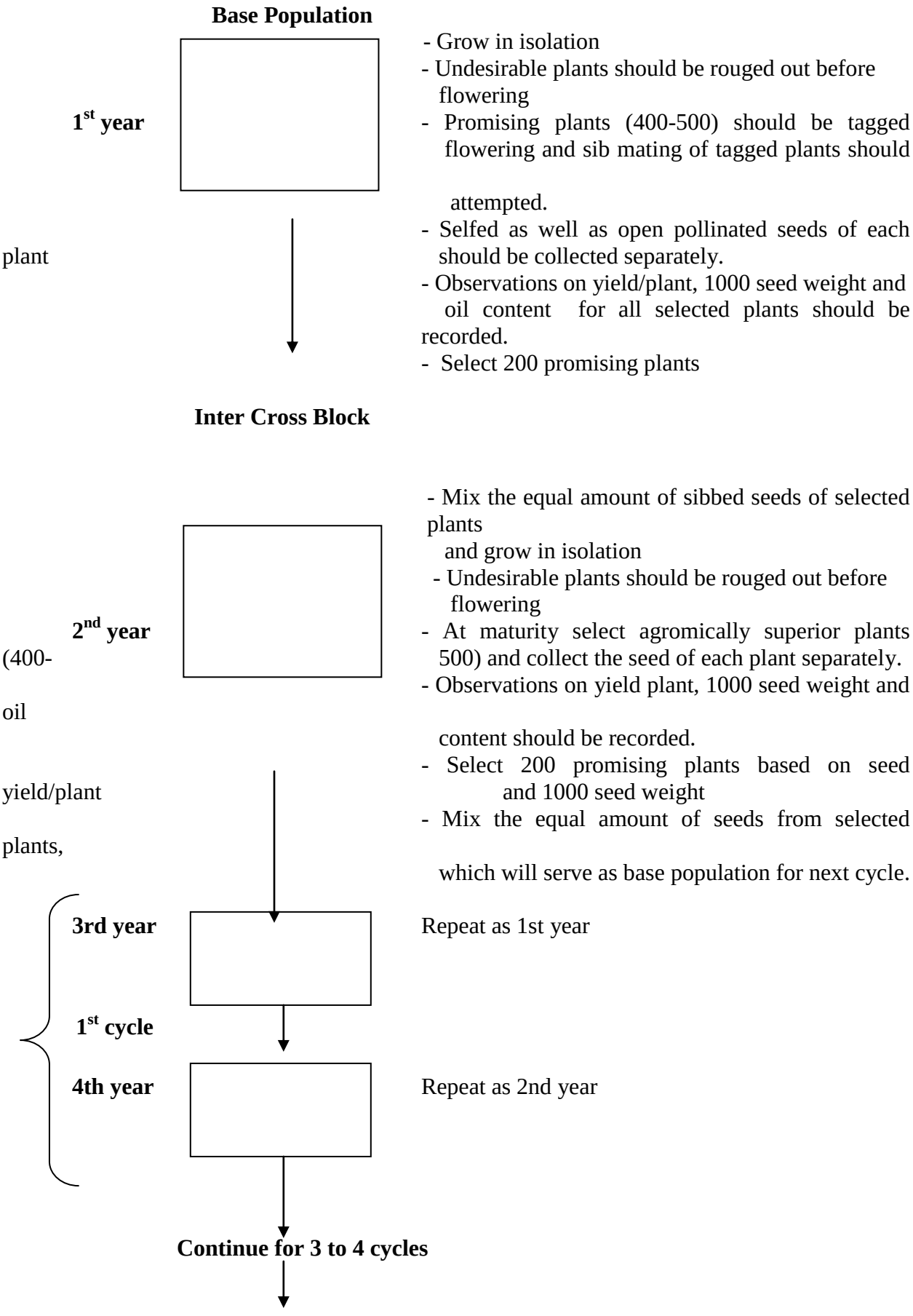
4.2 Improvement of self-pollinated crops

Pureline and pedigree methods are followed for the improvement of self-pollinated crops viz., Indian mustard (*Brassica juncea*), The most commonly used breeding procedure for cultivar development is pedigree selection. The pedigree method in the most extreme sense assumes selection of the best plants in the best families starting the first plant selection in the F_2. The selection is based not only on the phenotype but also on the genotype. The breeding objectives must be clearly defined and suitable parents identified. Potential parents should be intensively evaluated over a wide range of environments before hybridization and selection.

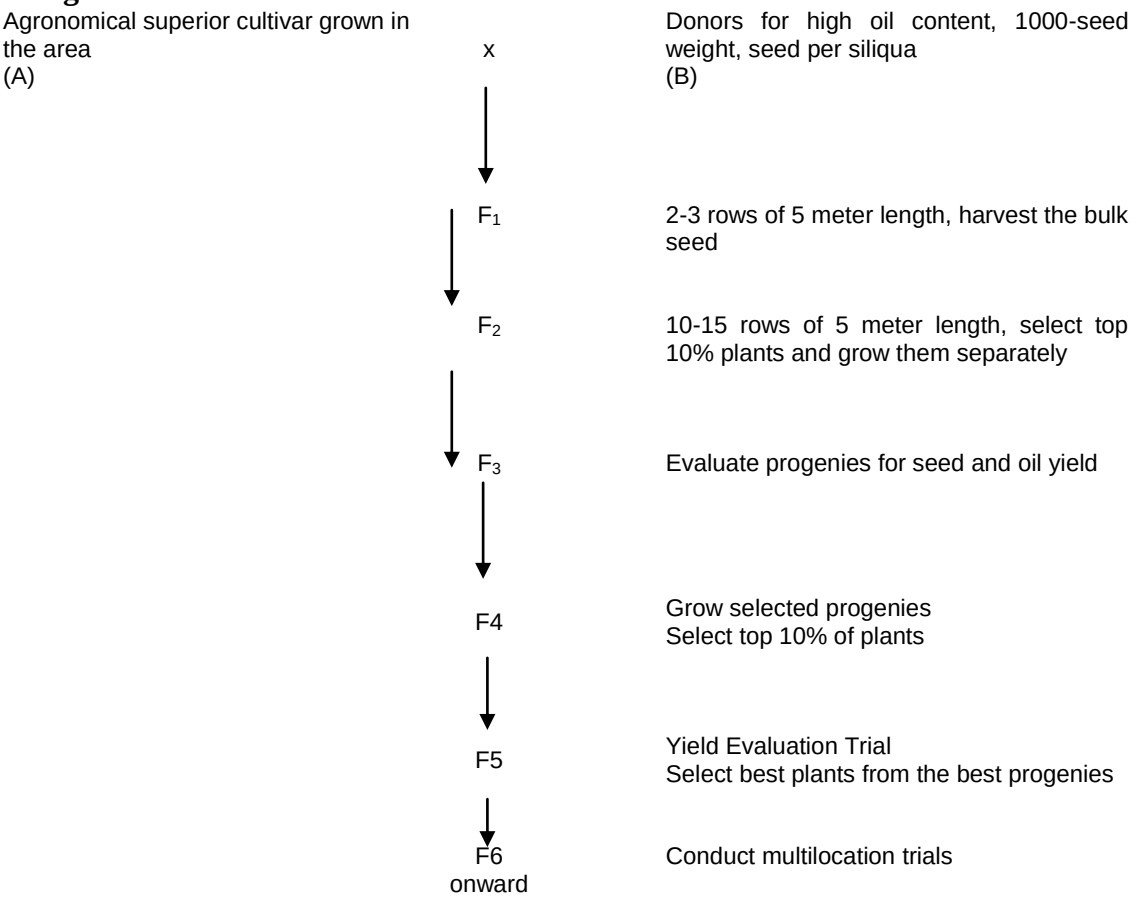
Once the parents have been selected, artificial hybridization is performed. Fifteen to twenty F_1 plants from each cross are grown and the plants within each cross are either open-pollinated or selfed. F_2 seeds from F_1 plants of each cross are harvested in bulk and sown. Depending upon the objective of the cross, sufficient number of open pollinated F_2 plants is individually harvested. The F_3 progenies from seeds of each plant are grown in a single row for agronomic evaluation. The selection is practiced among and within superior families. The single progeny row or single F_3 plants are harvested for evaluation in F_4 generation. The selection continues in F_4 and F_5 generations in the same manner as in F_3 until desired level of homozygosity in achieved.

Pedigree method of selection used in Brassica improvement differs from that being used in cereals. Since these crops have a high multiplication ratio (1000: 1) and the plant to plant out crossing rate is much higher, the replicated progeny testing can begin as early as in the F_3 generation and a certain level of heterosis from the initial cross can be captured and retained in subsequent generations.

Recurrent Selection For Seed Yield & Bold Seed Size



Pedigree method :



4.3 Pure line selection

In pure-line breeding, a new variety is the progeny of a single, selfed homozygous plant (pure-line), i.e., maximum selection intensity is combined with maximum inbreeding. The value of the selected plant is ascertained by progeny tests. Thus, a selection of genotype takes place.

5. PROMISING VARIETIES OF OILSEEDS FOR SPECIFIC SITUATION

The promising varieties of rapeseed-mustard, soybean, sunflower and groundnut released/notified recently in India have been given below:

5.1 Rapeseed-Mustard Varieties Released /Notified During 1995-2004

Crop :Toria (*Brassica campestris* var toria)

Variety	Maturity (Days)	Oil content (%)	Average Yield (kg/ha)	Recommended for the states	Special characteristics
Parbati	75	42	1380	Orissa	For rainfed areas
Anuradha	75	44	1460	Orissa	For rainfed areas

Crop : Yellow Sarson (*Brassica campestris* var yellow sarson)

Variety	Maturity (Days)	Oil content (%)	Average Yield (kg/ha)	Recommended for the states	Special characteristics
Rajendra Sarson – 1	100	46	1500-1600	Bihar, Eastern Uttar Pradesh and WB	Moderately resistant to A. blight and white rust.
Ragini (MYSL-203)	100-136	44	1567	Bihar, Eastern Uttar Pradesh and WB	Suitable for irrigated conditions
PYS 1	99-125	42-44	1050-1163	Uttaranchal	For irrigated areas

Crop : Gobhi Sarson(*Brassica napus*)

Variety	Maturity (Days)	Oil content (%)	Average Yield (kg/ha)	Recommended for the states	Special characteristics
Hyola-401 (Hybrid)	148-182	42	1200-1640	Haryana, Himachal Pradesh and Punjab	Double low (low erucic acid, 0.8 % and low glucosinolate content, 15 micromoles/g defatted seed meal)
TERI (OE) R-03 (TERI UNNAT)	128-138	40-44	800-1450	Madhya Pradesh, Rajasthan and Uttar Pradesh	Low erucic acid (< 2%) and high oleic acid (59.5%)
GSC-5	141-168	37-43	1719-2390	Punjab	Low erucic (< 2%) and low glucosinolate (26-41 micromoles/g defatted seed meal)
TERI –Uttam-Jawahar [TERI (00) R 9903]	130-135	43-45	1619-2685	Madhya Pradesh	Low erucic acid (< 2%) and glucosinolate (12.2 micromoles/g defatted seed meal)

Crop : Karan rai (*Brassica carinata*)

Variety	Maturity (Days)	Oil content (%)	Average Yield (kg/ha)	Recommended for the states	Special characteristics
Pusa Gaurav (DLSC-5)	170	40	1717-1950	Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab and Rajasthan	For both rainfed and irrigated areas

Kiran	170-175	40	2200-2500	Rainfed and low fertility areas of Delhi, Haryana and Punjab	For both rainfed and irrigated areas
JTC-1	161-171	36-41	1420	Delhi, Haryana, Himachal Pradesh and Punjab	Suitable for rainfed conditions
PC 5-17	154-192	33-39	1515 – 1725	Delhi, Himachal Pradesh and Punjab	Suitable for both rainfed and irrigated conditions
Pusa Swarnim (IGC-01)	157-185	42-43	1567	Delhi, Haryana, Himachal Pradesh and Punjab,	Suitable for irrigated and rainfed conditions.

Crop :Taramira (*Eruca sativa*)

Variety	Maturity (Days)	Oil content (%)	Average Yield (kg/ha)	Recommended for the states	Special characteristics
Karan Tara (RTM-314)	142	34-35	1050	Harayana, Punjab, Rajasthan and Uttar Pradesh	For rainfed areas.

Crop : Indian Mustard (*Brassica juncea*)

Variety	Maturity (Days)	Oil content (%)	Average Yield (kg/ha)	Recommended for the states	Special characteristics
Mustard Karishma	124-149	39	1800-2000	Haryana,Panjab, Rajasthan, Uttar Pradesh	Moderately resistant to Alternaria blight, downy mildew and white rust. Suitable for irrigated areas.
PBR-97	136	41	1900-2200	Harayana, H.P. Jammu, Punjab and Rajasthan	For rainfed areas.
CS-52	135-145	41	1141	Haryana, Rajasthan and UP	For sodic and saline soils
Aravali Mustard	136	42	1265	Haryana, Punjab and Rajasthan	Suitable for rainfed conditions
Jagannath	125-130	39	1790	M. P., Rajasthan and Uttar Pradesh	Suitable for normal sown irrigated conditions
Jawahar Mustard –1	125-127	42	2000-2100	Madhya Pradesh	White rust resistant
Narendra Ageti Rai - 4	90-110	40	1500-2000	Uttar Pradesh	Suitable for early sowing, white rust and downey mildew tolerant
Urvashi	125	39	2200-2500	Uttar Pradesh	Suitable for irrigated conditions
Basanti	130	40	1488	Uttar Pradesh	Yellow seeded, white rust resistant and alternaria blight tolerant
Pusa Agrani (Sej 2)	95	40	1718	Haryana, Punjab and Rajasthan, East and N Estates	Early maturing
Geeta (RB 9901)	145-149	40-42	1773	Delhi, Haryana, Punjab and South Rajasthan	Suitable for rainfed conditions
Kanti (RK 9807)	100-105	40-42	2000-2200	Uttar Pradesh	Suitable for multiple cropping, early sowing (mid September)
Maya (RK 9902)	130-135	39-40	2500-2900	M. P. and U. P.	Suitable for irrigated conditions, resistant to white rust

Mahon-8	124-135	38-39	1442	Delhi, Haryana, Punjab and Rajasthan	Suitable for late sown conditions
RGN 13	135-163	41-43	2200	Rajasthan	Suitable for normal sown irrigated conditions
Swaran Jyoti (RH 9801)	123-130	39-43	1377	Haryana, M. P., South Rajasthan and U. P.	Suitable for irrigated late sown conditions
Vasundhra (RH 9304)	129-137	38-40	2109	Haryana, M. P., South Rajasthan, U. P. and Uttranchal	Suitable for normal sown irrigated conditions
CS 614-4-1-4 (CS54)	109-147	39-41	1932	Indo Gangetic plain and water-logged saline soils of semi-arid regions	For salt affected soils
JD-6 (Pusa Mahak)	81-114	39-44	597-1049	Orissa, WB, Bihar, Jharkhand, Chhattisgarh and Assam	An early maturing, for rainfed areas
Rajendra Rai Pichheti	108-135	37-40	547-1400	Bihar	Suitable for late conditions after paddy harvest
RGN-48	138-157	39- 41	1692-2924	Haryana, Punjab and Rajasthan	Suitable for rainfed conditions
RL-99-27	144-153	39-41	1130-2696	Haryana, Punjab and Rajasthan	Suitable for rainfed conditions
RK-01-03	125-135	31- 41	1450-2358	Madhya Pradesh, Rajasthan, Uttar Pradesh, and Uttaranchal	Moderately resistant at leaf and pod stage for Alternaria blight and resistant for White rust. Suitable for irrigated late sown conditions
JM 2	135-138	39-42	1717-2150	Madhya Pradesh	White rust resistant variety
Pusa Karishma (LES 39)	137-161	37-38	1731-2506	Delhi	Low erucic acid (< 2%)
Shivani (BAUR 9502)	93	41	600-750 (Rainfed) 1200-1500 (Irrigated)	Jharkhand	Suitable for rainfed, low fertility conditions.
Narendra Swarna Rai 8	130-135	36-46	1234-2357	Uttar Pradesh	Yellow seeded and high oil content
Rajendra Anukool	107-115	40-41	1275	Bihar	Suitable for late to very late sown conditions
YRN-6	122-134	39-40	1253-1803	Punjab, Haryana	Yellow seeded and suitable for late sown condition

Indian mustard (*B. juncea*) – low erucic acid variety					
Pusa Karishma (LES 39)	137-161	37-38	1731-2506	Delhi	Low erucic acid variety (< 2%)

5.2 Some Important Soybean Varieties Released And Notified In India

S.N.	Soybean variety	Area of adaptability	Days to maturity	Yield (Kg/ha)	Salient features
1.	SL 525	Northen Plain Zone	121	2303	Determinate plants with white flower, brown hairs present on stem and pods, cream colour seeds with grey hilum.
2.	PS 1241	Uttaranchal	121	1800 to 2000	Semi determinate with yellow seed and black hilum
3.	Shakti (MAUS 81)	Central Zone	93-97	3278	Semi determinate plants with dark green glabrous leaves, purple flowers, yellow oblong seed and brown to blackish hilum.
4.	JS 93-05	Central Zone	90-95	2000 to 2500	Semi determinate, violet flowers, lanceolate leaves, four seeded pods, glabrous stem & pods, non shattering, black hilum
5.	Pratap Soya (RAUS 5)	North Eastern Zone	96-104	3000 to 3500	Determinate, purple flower, yellow seed, hilum light to dark brown
6.	Samrudhi (MAUS 71)	North Eastern Zone	95-100	2000 to 2500	Semi determinate, purple flowers, glabrous leaves, yellow seed with black hilum
7.	Hara Soya (Himso 1563)	Himachal Pradesh, Uttaranchal	108-130 days with a mean of 117 days	1500 to 2000	Semi-determinate, white flowers, dark brown pubescence on stem, Leaves remain green in colour even at senescence. Pods turn black on maturity. Seed green, round, bold with black hilum.
8.	Indira soya 9	North eastern zone and Madhya Pradesh	106	2200 to 2300	Semi determinate plants having grey pubescence, yellow seeds and black hilum
9.	Pant Soybean 1092	Tarai and Babar region of U.P. Uttaranchal	118	2500 to 3500	Determinate, purple flower, dark green leaves, yellow seeds with black hilum
10.	Pabhani Sona (MAUS 47)	Central Zone	85-90	2500 to 3000	Determinate plants with purple flowers, tan to dark brown pods, yellow round seeds and brown hilum.
11.	VL Soya –47	Northern hill zone	122-125	2300	Determinate plants with white flowers, grey pubescence, yellow shiny seeds and brown hilum
12.	Ahilya 3 (NRC 7)	Madhya Pradesh	99-99	2500 to 3500	Determinate, purple flowers, grey pubescence, yellow seed coat, brown hilum, high oil content, resistant to pod shattering
13.	Pant Soybean 1024	Northern plain zone	115	2500 to 3000	Determinate plants, white flowers, narrow leaves, yellow seed with brown hilum
14.	Pant Soybean 1042	Northern plain zone	110-119	3000 to 3500	Determinate plants with thite flowers, yellow seed and brown hilum
15.	VL Soya-21	Uttaranchal	120-122	2000 to 2500	Determinate plants with white flowers, tawny pubescence, yellow seed and brown hilum
16.	JS 335	Central zone	95-100	2500 to 3000	Determinate habit, purple flowers, yellow seeds with black hilum. Absence of hairs on leaves, pod and stem is the most distinguishing trait.
17.	Pant Soybean 564	Northern plain zone	110-120	2500 to 3000	Determinate plants with sturdy pant type, white flowers, tawny pubescence yellow seed and brown hilum
18.	VL Soya-2	Northern hill zone	117	2500 to 3000	White flowers, tawny pubescence, yellow seed and black hilum
19.	Pusa – 20	Northern hill zone	110-120	2500 to 3000	White flowers, tawny pubescence, yellow seed and black hilum
20.	Shilajeet	Northern hill zone and Northern plain zone	100-105	2000 to 2500	Determinate plants with purple flowers, tawny pubescence, yellow seed and light brown hilum
21.	Bragg	Throughout India	115-120	1500 to 2000	Determinate plants with white flowers, tawny pubescence, yellow seed and black hilum.

5.3. Characteristic Features Of Recommended Varieties / Hybrids Of Sunflower

S.N.	Varieties/hybrids	Seed yield (kg/ha) under rainfed conditions*	Duration (days)	Oil content (%)	States for which recommended
A.	**Varieties**				
1.	EC 68414	800-1000	100-110	40-42	All states
2.	Morden	600-800	75-80	30-38	All sunflower growing states
3.	Surya	800-1000	90-95	32-35	Maharashtra
4.	CO-2	800-1000	85-90	38-40	Tamil Nadu
5.	TNAU SUF-7	800-1200	90-95	38-42	UP, Gujarat, Maharashtra Tamil Nadu, Andhra Pradesh
6.	GAU SUF-15	800-1200	90-95	38-42	Gujarat
7.	SS 56	600-800	85-90	40-42	Maharashtra
8.	AKSF-9 (PKVSF-9)	800-1200	85-90	38-42	Maharashtra
9.	LS-11 (Sidheswar)	800-1200	80-85	38-42	Maharashtra
10.	DRSF-108	800-1200	90-95	38-42	All states
B.	**Hybrids**				
1.	BSH-1	1000-1500	85-90	40-42	All states
2.	APSH-11	1000-1500	90-95	40-44	Andhra Pradesh
3.	MSFH-8	1500	92	43	Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu
4.	MSFH-17	1500	92	43	Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu
5.	LSH-3	1000-1500	90-95	38-40	Maharashtra
6.	KBSH-1	1200-1500	90-95	42-44	All states
7.	PSFH-67	1000-1500	90-95	38-42	Punjab
8.	PKVH-27	1200-1500	85-90	40-43	Maharashtra
9.	Jwaalamukhi	2500	95-115	42	All India
10.	PAC-1091	1600	100	38	All India
11.	DSH-1	1200-1400	88-90	41-43	Karnataka
12.	Sungene-85	1500-2000	80-92	38	All India
13.	TCSH-1	1200-1500	85-90	40-44	Tamil Nadu
14.	MLSFH-47	2200-2500**	85-100	35	Maharastra, Andhra Pradesh, Karnataka, Tamil Nadu, Orissa, Gujarath, Madhya Pradesh
15.	KBSH-41	1560	90-92	36-38	Karnataka
16.	KBSH-44	1200-1600	95-100	38-40	All India
17.	HSFH-848	1600-2400**	95-98	42-44	Haryana
18.	NDSH-1	1200-1400	88-90	40	Andhra Pradesh
19.	SH-416	1500-1700	95-100	36	Maharashtra, Andhra Pradesh and Karnataka
20.	Pro. Sun 09	1200-1600	90-95	42-44	All India
21.	PSFH-118	1600-2400**	95-98	39-42	Punjab
22.	RSFH-1	1200-1400	95-100	38-39	Karnataka

*** Irrigated conditions*

5.4. Groundnut Varieties Released During Last Five Years In India

S.N.	Name of the Variety	Pod yield (kg/ ha)	Special attributes		Recommending place	Additional information	
			Shelling (%)	Oil (%)		Disease reaction	Salient Features
1.	ALR 3 (ALG 63)	1939	69	50	Tamilnadu	Resistant to LLS and rust (Late leaf spot)	Suitable for early sown conditions during south west monsoon
2.	Co 3 (TNAU 256	1750	71	49	Coimbatore	Tolerent to PBND (Peanut budnecision disease)	Bold kernel suitable for Kharif and Rabi season
3.	GG 5	1270	73	49	Junagadh	-	Early Maturity, high shelling %
4.	JL 220	1900	68	48	Jalgaon	-	Early Maturity
5.	CO 4	1950	70	53	Coimbatore	Resistant to LLS and rust	Suitable for Rabi / Summer also
6.	VRI 5	2133(K)	74	50	Vridhachaiam	Resistant to LLS and rust	Suitable for Rabi / Summer also
7.	GG 7 (J-38)	2149	76	49	Junagadh	Tolerant to tikka	Early Maturity
8.	TPG 41	2088	69	49	BARC, Mumbai	Moderately resistant to rust	Large seeded, High O/L ratio (3.267)
9.	TG 37A	1900	64	48	BARC, Mumbai	Moderately tolerant to collar rot, rust and leaf spot	Fresh seed dormancy up to 15 days
10.	GPBD 4	1900-2200	68	49	Dharwad	Resistant to LLS and rust	Ealy (105-110 days) maturity
11	GG 6	2782	73	50	Junagadh	-	For summer cultivation
12.	AK 159	1606	66-68	51	Akola	-	Early (105-110 days) maturity
13.	Dh 86	4022	68	48	Dharwad	Tolerant to tikka, sucking pests	Suitable for rice fallows
14.	Kadiri 5	1800-2200	-	48	Kadiri	Tolerant to leaf spot	Early (105-110 days) maturity
15	Kadiri 6	1800-2400	-	49	Kadiri	Tolerant to leaf spot	Early (105-110 days) maturity
16.	GG 14	2159	65	52	Junagadh	Tolerant to trips, Spodoptera, Leaf miner	Suitable for rained conditions, medium maturity

Some Other Promising Groundnut Varieties

S.N.	Name of the Variety	Pod yield (kg/ ha)	Special attributes		Recommending place	Additional information	
			Shelling (%)	Oil (%)		Disease reaction	Salient Features
1.	ICGS-11	1600	70	49	ICRISAT	Tolerant to PBND	Tolerant to End season drought
2.	ICGS-44	2500	70	49	TCRISAT	Field tolerant to PBND	Suitable for rabi summer
3.	ICGS-76	1300	72	43	ICRISAT	Resistant to ELS (early leaf spot)	-
4.	ICGV-86590	1785	62	46	ICRISAT	Tolerant to LLS	Resistant to rust
5.	K 134	1670	71	46	Kadiri	Tolerant to LLS, PBND	Drought tolerant
6.	DRG-12	2604	70	39	DOR, Hyderabad	Toleant to rust LLS and PBND	Suitable for rabi /summer season
7.	TG-26	1596	65	49	BARC, Mumbai	-	Early maturity having fresh seed dormancy (30 days)
8.	TAG-24	1680	70	51	BARC, Mumbai	Toleant to LLS, Jassids and drought	High HI (50%), wider adaptability.
9.	HNG-10	1918	71	51	Hanumangarh	-	High shelling and oil %
10	Amber	2704	64	48	Manipuri	Toleant to rust & termite	Variegated rose kernel
11.	Chitra	2500	72	48	Manipuri	Toleant to rust & termite	Spreading type
12	Kaushal	1500	70	44	Manipuri	Toleant to rust & termite	Bunch type, seed coat red.

6. NUCLEUS AND BREEDER SEED PRODUCTION PROGRAMME

The procedure of nucleus / breeder seed production varies from crop to crop according to their breeding behaviuor. The field should be preferably selected where no Brassica species had been grown for last three years, unless the crop was raised for nucleus sed production of the same variety. Field should be properly isolated from the other field of any Brassica species.

An isolation distance of 400 m is recommended for production of nucleus and breeder seed of self-incompatible (cross pollinated) crops, including *B. rapa var. toria*; *B. rapa* var brown sarson and *E. sativa* (taramira) and 200 m for self compatible (self pollinated) crops, including *B. juncea* (Indian mustard), *B. rapa* var yellow sarson and *B. carinata* (Karan rai). Approximately 500 true-to-the type plants are selected from the basic bulked or multiplication plot for nucleus seed production of self pollinated crops while 2500 or more plants are selected in cross pollinated crops to prevent the narrowing of genetic base of these crops. Five border rows of the same variety (true to type) should be planted around the plot.

Selected plants are harvested and threshed separately. The seed lot from each selected plant should be examined critically for seed characters like shape, colour etc. off type seed lots (or plants) are discarded and only the true to type lots (plants) are maintained separately for raising nucleus seed plot.

Sowing for nucleus seed plot is done from the selected individual nucleus plants in plant to progeny rows. Each progeny row is examined critically at different growth stages for diagnostic characteristics. If any progeny row shows any variation the entire progeny row should be uprooted before flowering.

In case off-types are found after flowering, the surrounding rows should also be uprooted to avoid contamination. Single plants (about 500 in self pollinated and about 2500 in cross pollinated crops) are harvested and their seed is kept separately for raising the next cycle of nucleus progeny rows next year.

Roguing

The removal of off type plants should be carried out at 3 stages. First, the off-type plants distinguishable on the basis of morphological characteristics should be removed before flowering. Second, the off-type plants, which are identified at flowering, should be removed before pod-formation. Third, the off-type plants should be removed on the bsis of siliqua and seed characteristics and also on the basis of maturity duration. Disease infected plants should also be removed. The field should be kept free from all kinds of weeds particularly from *Argemone maxicana* (Satyanashi) which should be uprooted altogether, before it flowers.

Seed processing and packaging

After threshing, the seed should be dried either in sun or in mechanical seed drier to bring the seed moisture content to 8%. The temperature of air in seed drier should not exceed 40^0C. A random sample from the dried seed is taken and analysed for quality characters and oil content before the grading. The Indian Minimum Seed Certification Standards recommends the size of screen aperture as given below for seed grading of rapeseed-mustard which vary according to the seed size of a variety.

Top screen (round	: 2.75, 3.00, 3.25 mm
Bottom screen (slotted)	: 0.90, 1.00, 1.10, 1.40 mm

The graded seed is treated with Apron 35 SD @ 6 g/ kg seed or Bavistin @ 2 g /kg to give protection against diseases during emergence. The treated seed is packed in cloth bags properly labeled. The seed should be packed in small packings because the seed rate for sowing these crops is less. The label should contain all the quality attributes of the seed standards.

Seed testing

After processing, a sample of seed is taken to seed testing laboratory for the examination in respect of seed standards. The seed purity, germination percentage and moisture content is seed is thoroughly checked in seed testing laboratory. Breeder seed is considered of high quality because it is foundation of further seed multiplication chain.

The seed standards are given below

Factor	Class of seed	
	Foundation	Certified
Pure seed (minimum)	97.0%	97.0%
Inert matter (maximum)	3.0 %	3.0%
Other crop seeds (maximum)	10/ Kg	20/ Kg
Other distinguishable varieties (maximum)	10/ Kg	20/Kg
Total weed seeds (maximum)	10/ Kg	20/Kg
*Objectionable weed seeds (maximum)	5/ Kg	10/Kg
Germination (minimum)	85%	85%
Moisture (maximum)	8.0%	8.0%
For vapour-proof containers (maximum)		
-Mustard	5.0%	5.0%
-Rapeseed	7.0%	7.0%

Storage

Seed should be dried to bring the moisture content up to 8% before storage. Seed should be stored preferably at less than 20^0C and at less than 30% relative humidity (RH). The stores should be properly fumigated to avoid storage pests.

7. ADDRESSES FOR USEFUL CONTACTS FOR COLLABORATION

India	
Dr. Arvind Kumar Director National Research Centre on Rapeseed-Mustard Sewar, Bharatpur-321 303 (Rajasthan) Phone : 915644-260495, 260379 (O) 915644-260381 (R) Fax 915644-260565, 260419	Regarding information on rapeseed-mustard in India
Dr. M.S. Basu Director National Research Centre for Groundnut Ivnagar Road, Junagarh-362001 (gujarat) Phone : 91285-2673382 (O) 91285-2675831, 2673709 (R) Fax: 91285-2672550	Regarding information on Groundnut in India
Dr. G.S. Chauhan Director National Research Centre for Soybean Indore-452017 (M.P.) Phone 91731-2476188 (O) 91731-2470127 (R) Fax 91731-2470520	Regarding information on Soybean in India
Dr. D.M.Hegde Project Director Directorate of Oilseeds Research, Hyderabad-500030 (A.P.) Phone 9140-24015222 (O) 9140-23512798 (R) Fax 9140-24017969	Regarding information on Sunflower, Safflower and Castor
Dr. Nawab Ali Director Central Institute of Agricultural Engineering Navibagh, Berasia Road, Bhopal-462038 (M.P.) Phone 91755-2737191, 2734016 (O) 91755- 2732969 (R) Fax 91755-2734016	Safflower and sesame processing
Director Central Institute of Post Harvest Engineering and Technology, Ludhiana-141004 (Punjab) Phone : 91161-2808669 (O) 91161-2808196 (R) Fax 91161-2808670	Post harvest aspects of oilseeds
Department of Post Harvest Study College of Engineering, GBPUA&T Pantnagar-263145 (Uttaranchal)	Rapeseed and Sunflower processing
Director National Bureau of Plant Genetics Resource, Pusa Campus, New Delhi-110012 Phone : 9111-25843697 (O) 9111-25841177 (R) Fax 9111-25842495	Nodal Agency for Exchange of Germplasm in India
The Solvent Extractors Association Of India 142, Jolly Maker Chambers No. 2 14th Floor, 225, Nariman Point Mumbai – 400 021 (Maharashtra) Phone : 22021475, 22822979 Fax : (91-22)22021692 E-mail : solvent@vsnl.com Web-site: http://www.seaofindia.com	Regarding information on Solvent Extraction Process
The Central Organization For Oil Industry & Trade 4-M, DCM Building, 16, Barakhamba Road, New Delhi – 110001 Tel: 23712058 Fax: 23719140 E-mail: cooit@vsnl.net	For development of oilseeds industry and trade

The Soybean Processors Association Of India (SOPA) Scheme No. 53, Near Malviya Nagar Agra –Bombay Road, Indore – 452 008 (M.P.) Tel.: 0731-2556530/32/33 Fax: 0731-2556531/5004300 E-mail : sopa@sancharnet.in Website: www.sopa.org	For information regarding to soybean processing and its utilization

Other Countries

Agricultural Canada Research Station 107, Science Crescent Saskatoon, Saskatchwan, Canada	Early lines of spring rapeseed for high altitude spring planting. Winter rapeseed for high altitude summer planting
Coordinator National Oilseeds Development Programme Nepal	Locally adapted toria/ sesame varieties
Agricultural Officer AGPC Room C 769, FAO Via Termedi Caracall 00100 Rome, Italy	Sesame and Sunflower materials
Sunflower Breeder Agricultural Canada Research Station Morden Monitoba, Canada	Sunflower lines, composites and uniform populations
Research Institute for Cereals 8264 Fundulea Bucharest,Romania	Sunflower lines, composites uniform populations
Principal Groundnut Scientist International Crops Research Institute for the semi-arid tropics Patancheru PO Andhra Pradesh (India)	Groundnut germplasm
Dr. Phillip Salisbury ACIAR Project Leader National Brassica Improvement Programme Leader, Institute of Land and Food Resources The University of Melbourne, Parkville Victoria 3052 Australia	Winter/Spring rapeseed cultivars
Dr Martin Bartetti Principal Plant Pathologist Department of Agriculture, Western Australia Crop improvement institute, South Perth, Western Australia	Diseases of rapeseed-mustard
Prof W. Cowling Brassica Breeder The University of Western Australia, Faculty of Natural and Agricultual Sciences, Crawley, Western Australia	Brassica material, Canola Quality Rapeseed
Prof Fu Tindong Head of Institute, Crop Genetics and Breeding, Huazhong Agricultural University, Wuhan, China	Brassica germplasm
Prof Li Yunchang Brassica breeder Oil Crops Research Institute, Wuhan, China	Brassica material, Canola Quality Rapeseed-Mustard
Dr. Nash Nashaat, Project Leader, Indo-UK collaboration on oilseeds, Rothamsted Research, Harpenden, UK	Brassica material having tolerance/resistance to diseases.

8. SUGGESTED LITERATURE ON OILCROPS

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9. SELECTED OBSERVATIONS BASED ON FIELD VISIT

9.1 General observations

- In general, the farmers have poor access to inputs particularly seeds of improved varieties of mustard and are also not fully aware of improved production technology in most of the areas. The use of excessive seed rate and poor seed bed preparation further lower down the productivity. The preference of farmers is mostly for M-27 variety is comparison with T -9 or PT -30. The local variety seed is used year after year causing genetic deterioration.
- Replacements of local mustard variety with improved ones need to be targetted in a phased manner. Systematic seed production programmes, using breeder seed could be taken up by adopting recommended practices.
- A good beginning was made in oil crops research after the establishment of CARD in 1982. The efforts were intensified after 1988 with the introduction of rapeseed- mustard varieties from India. The research work carried out during' 1990-1995 provided very useful information but thereafter the research efforts were minimal.
- The results of experiments carried out at RNRRC, Bajo indicated that yield of mustard *(Brassica juncea)* was more than toria (*Brassica campestris* Var. toria). However, it was late in maturity. Systematic information about the comparative performance of promising rapeseed-mustard types in different agro-ecological regions is lacking. Multi-location trials with more number of varieties shall help in selection of promising variety for specific situation. In high altitude area of Bumthang, *Brassica napus* cultivars also need further testing.
- Most of the mustard acreage is under low and mid hills and its cultivation is done in Bhutan between 200 m - 3000 m altitude. Various rapeseed-mustard varieties need testing under different situation in particular cropping systems. Local mustard variety available at Tang (Bumthang) needs improvement through traditional breeding methods as it can perform very well on high altitude areas. Similarly, mustard seeds grown at other places could be collected and improved upon through selection at the research station.
- The oil expellers are not readily available and farmers have to carry their produce to long distances for oil extraction. Few farmers still follow the traditional method of oil extraction with very low recovery (25% to 27%). The oil expellers available in Bhutan are

Indian or Japanese make. There are 144 small capacity oil expeller spreads over the country. The Japanese expeller, although good, but it is difficult to replace its spare parts as reported by owner, Mr. Cheda in Kanglung. The oil expeller gives oil recovery ranging between 34-37%, depending upon seed type and management practices.

- There is preference for mustard oil over the imported oil and therefore, farmers consume all the domestic mustard oil produced. The mustard oil produced by the farmers provide assurance for quality and import of cheaper oil, which may sometime be also adulterated, can cause health hazard. Therefore, more emphasis need to be given for increasing the domestic production.

- In Chhume geog (Bumthang), 29 kg mustard seed was distributed and farmers have grown the crop for the first time. The crop performance was very good and the yield of local mustard is expected to be good. Similarly, RNR centre, Chamkhar simply distributed the seeds and area has increased under mustard after potato. Therefore, it is apparent that seed is one of the most critical inputs in mustard. Similar efforts in other areas could lead to expansion of acreage under mustard and thus reducing the imports of edible oils.

- Another example of collective farming was seen in Samkhar geog (Trashigang Dzongkhag) where the acreage under mustard increased to 67 Acres as against only 10 acres on 2002. In two villages of Bikar and Khapti, 47 households have grown mustard. The seeds of M-27 variety were distributed under crop promotional programme in the year 2002. The crop performance was good after maize crop. The Extension officer of RNR Centre has persuaded the farmers to keep the stray animals away from the field and this has helped in planting of winter crop like mustard on community basis. Although, there is no oil expeller available in this area, efforts have been made by the Department of Agriculture in this direction. Farmers of this area are also selling the seeds to the nearby villages and with such efforts the geog may become self sufficient in edible oil production.

- The agriculture extension officers posted in different geogs need to be upgraded about the improved technology for oil crops production through training programmes.

- Sunflower was introduced in the country about two decades back but could not. become popular amongst the farmers. This was due to the fact that introduced varieties did not produce the desired result and processing was not given due attention. The crop has potential on mid and high altitude hills and adaptive trials are needed taking new improved varieties.

- Soybean crop is grown in Eastern region as a mixed crop with maize and the, presently cultivated local type matures late. Early duration varieties of soybean released in India could be tested.

9.2 Specific observations based on field visit

1. Punakha :

Contact persons : Lakey, DAO ; Gaylong, Asstt. DAO, Punkha

Farmers : Dechen Tshomo (Village- Kabjisa-Kabji geog); Jecko Panjor (Village – Siragang-Kabji geog); Kinley Wangmo (Village – Wollakha-Guma geog), Tsheten Wangchuk (Village- Laptshaka-Talow geog)

Observations :

- Cultivation of mustard is done after rice and area under improved varieties (T9 and M-27) was about 10%.

- The improved varieties yielded higher than local types. In Talow geog, a local variety Gubzi was reported to perform well.
- The sowing is done in Nov. – Dec., depending upon the altitude with very high seed rate ranging between 8-10 kg / acre.
- The wetlands, after rice, some times cannot be prepared for sowing before November due to rains.
- The crop growth is stunted due to compact soil after rice and the yield is low.
- Although, the use of fertilizer is minimal but farmers use suphala @ 25 kg /acre. The farmer apply FYM to the mustard crop at the time of sowing.
- Application of three irrigations is common in mustard.
- Problem of aphid is usually observed causing yield reductions but the farmers do not use any chemical.
- The yield level after rice is usually below 200 kg / acre.
- Oil consummation range between 8-10 litres/ capita / annum and the oil produced is not sufficient to meet the need of the farmers.

2. Wangdiphodrang

Contact persons: Galey Phuntsho, Actg. DAO; Kinley, Training Officer, Wangdi ; Tika Ranthapa, Ag. Inspector (Lower Gashilo geog); Tikoo Dukpa, AAEO (Upper Gashilo geog); Choguyal Norbu, AAEO (Nisho geog) ; Ugyen Dema, AAEO (Thedtsho geog)

Farmers : Yangka, Chatolham, Rinchen (Village – Lower and Upper Gashilo-Gashilo geog), Tawchu, Nampa, Daw (Village- Samteygang-Nisho geog) ; Dema ,Sangey Wango, Kakam (Village – Rinchengang-Thedtsho geog)

Observations :

- Mustard is grown in all geogs, except high altitude area of these three geogs. However, Gashilo, Nisho and Thetsho geogs have higher acreage under mustard.
- Variety M-27 is grown between 1500-2500 metre altitude and at lower altitude Bajo local is grown. Genetic deterioration was reported to be more in improved variety. The crop season is from early November to March and in high altitude area the crop is harvested late. Usually mustard sowing is delayed after rice in this area.
- Livestock grazing after rice harvest is common and therefore early sowing was difficult.
- The land preparation is very poor and planting is done with inadequate ploughings. The seed rate is 5 kg/acre.
- Mustard is preferred over wheat due to easy threshing.
- Thinning for vegetable purpose is usually done and 5 kg / acre seed rate is common.
- Two irrigations are done at two weeks after sowing and one week before flowering.
- In village Chebakha, the use of suphala in mustard, grown after rice, is done @ 8-20 kg /acre. Urea @ 10-12 kg /acre is also top dressed at first irrigation.
- White rust disease and aphids were reported to be the major problems. The problem of caterpillars was also reported in Thedtsho geog.
- Farmers do not use any chemical to control disease and pest. However, the farmers in Thedsho geog use ash to control aphids.
- The yield level of mustard was reported to be between 200 – 300 kg /acre.
- The mustard cake is fed to the animals and households consume oil.

3. Tsirang

Contact persons : Jigma, DAO; Tashi, Asstt. DAO, Tsirang; C.B. Tamang, (Mithun farm, Tsirang) Incharge ; N.B. Lama, AAEO (Betni geog) ; Tshering Dhentup, AAEO (Mendrelgang geog) ; Tshering Tobgyel, AAEO (Tsirang geog); Tashigyal Tshen, AAEO (Kilkorthang geog)

Farmers : Dhan Bahadur Tamang, Dil Bahadur Tamang, Sukhmuya Tamang (Betni geog); Phurba Tamang, Partap Singh Rai, P. K. Tamang (Village- Kuchi-(Betni geog); Padama Lal Tamang, Kul Bahadur Muktan (Village – Reserboo-Mendrelgang geog); Tara Bhir Kepcheki (Village-Harpeney-Tsirang geog); Dhan

Bahadur Subba (Village – Lower Tsholingkha- Tsirang geog); K. B. Pulami, Tulsi Ram Gazmir (Village – Lower Bokrey- Kilkorthang geog)

Observations :

- Mustard is mainly grown after maize on drylands. Yellow sarson is also grown and takes longer time than mustard. M-27 variety of mustard is common with the farmers. It was reported that improved variety matured earlier but seeds were small. The acreage of mustard depends upon the availability of seed and the area is more when improved variety seeds are supplied. The mustard crop was reported to be profitable over wheat crop.
- The major mustard growing geogs are Semzong and Patala (rice-mustard sequence); Phuntenchu, Betni and Tsirangtoe (maize-mustard sequence). In wetlands, after rice, the crop is usually grown from Dec. – April. In maize-based cropping system the mustard crop do not receive irrigation and is grown from Sep. – Feb as a dryland crop. The soils are loamy or sandyloam.
- The farmers are aware that with the use of less seed rate, the seed yield is more but farmers use mustard crop as leafy vegetable and therefore higher seed rate (5-7 kg/acre) is used.
- Only compost or FYM is used and no chemical fertilizers is used in mustard crop.
- Mustard crop receive two irrigations at vegetative and flowering stages.
- Problem of aphids is observed in late planting. In wetland the problem of pest and disease was more. Cattlrepillar problem was reported in village Harpeney.
- The oil extraction is done at Damphu and Sarphang and the numbers of oil expellers are not enough in Tsirang.
- In lower Bokrey, a toria crop was at flowering stage and the crop planted as an intercrop in orange orchards is affected due to shading and there are poor developments of pods.

4. Dagapela

Contact persons : Tsheringpen, AAEO (Tsendagang geog) ; Yeshey Chedup, AAEO (Trashigang geog)

Farmers : Narayan Kumar Gurung (Village – Norbuzinkha-Tsendagang geog); Pasang Sherpa (Village- Upper Goshi-Goshi geog); Mingma Sherpa (Village – Upper Goshi-Goshi geog)

Observations :

- Mustard is dominantly grown after maize on drylands.
- Mustard is also taken after potato or rice. In lower altitude area, rice-wheat is the common sequence.
- The yield of yellow sarson was slightly better than mustard but takes about 15 days more time to mature.
- In high altitude area, the crop is grown from March – September.
- The wild animals affect the mustard crop during the winter season.
- Frost and aphids cause damage to mustard crop in Dec. and Jan.

5. Thimphu

Contact persons: Kama, DAO, Shankar Chhetri, Asstt. DAO (Thimphu); Thuji Wangmo, AAEO (Thimphu geog) ; Sonam Dorji, AAEO (Mewang geog)

Farmers : Ngawang Choden, Kiva, Tshering Choden (Village – Jemina -Mewang geog) Tshewang Norbu, Dechen Dolma, Pema Dorji (Village – Jigmenang - Mewang geog)

Observations :

- Mustard variety M-27 is common and the crop is also grown in apple orchards.
- The improved varieties take more time to mature than the local varieties.
- Mustard is also grown after potato harvest and the crop is sown early in August.
- The farmers use high seed rate in mustard (6-8 kg/acre) because of slow growth.

- The mustard seeds were obtained from Punakha and same seeds are being used for more than one decade.
- The fertilizer use in potato is high and farmers use Suphala (100-150 kg/ acre), SSP (200 kg/acre) and Urea (50-100 kg/acre) in this crop. Farmers also use urea both in potato and mustard crops.
- The problem of sawfly and aphids is observed in mustard.
- There is no oil mill and mustard seeds are taken to Paro for oil extraction.

6. Bumthang

Contact persons: K. Wangdi, Programme Director, Wangda Dukpa, Programme Officer (Field crops) ; Wangda, AAEO (RNR, Chamkhar-Ghoekhor geog); Delma, AAEO – Chhume geog.

Farmers : Lhamosithup, Sangjay Dorji, Lapo, Tshering Wangdi, Keeva (Ghoekhor geog); Chhokiwngchu (Village – Domkhar – Chume geog); Tashi (Village - Jaytoe-Chume geog)

Observations :

- Mostly the mustard is cultivated on dryland and the land is also kept fallow for fertility restoration.
- The mustard crop is grown from June-October. The sowing is done between June-early August and mainly potato based farming system is common in this area. After potato harvest, only one ploughing is given before mustard sowing.
- There is no suitable mustard variety available for cultivation in spring season for high altitude area. The improved mustard varieties for high altitude areas are lacking.
- The area under Bumthang, particularly in Chume geog, has increased due to distribution of mustard seeds by AAEO, which were procured from Tang.
- The use of less seed rate at farmers field has helped in raising a good crop by the farmers in Chume geog.
- Locally available mustard varieties were growing very well up to 3000-metre altitude.
- The farmers use high fertilizer dose (100-200 kg urea and 150-200 kg suphala per acre) in potato crop.
- The weed problem was more and downy mildew (stag head) was seen in the mustard crop. The frost start from end of October.
- The sunflower crop can be grown during spring season and takes about 150 days to mature.
- One oil expeller at Jalikhar is available.
- The average yield of mustard is about 300 kg/acre.

7. Mongar

Contact persons: Karma Tashi, Programme Director; Tirtha Bahadur Katwal, Programme Officer (Field crops-Wyengkhar); Tandin (DAO, Mongar); Sangye Wangdi, (RA, RNRRC, Sub-Station, Linghmethang) AAEOs of different Geog .

Farmers : Kinzang, Wangmo, Dechen, (Village – Hurung Pam–Mongar geog); Namgay (Village – Kalapong–Saling geog)

Observations :

- Mustard varieties M-27 and T-9 are grown in this area but genetic deterioration was reported.
- The soil becomes hard if mustard is grown. Seeds are shattered and creates problem for the next crop.
- Cattle grazing create hinderence for winter cropping. Stray cattles affect the winter crop.
- No fertilizer or chemical is used in mustard but the aphid problem was observed.

- The average mustard yield is 200 kg / acre.
- In Pangthang village, in Gumdue geog, an oil expeller was installed but is not being used. The oil expellers are not sufficient and one Japanese make oil expeller available in Khangma was working very well. However, the availability of its spare parts was a problem for this expeller.
- Few farmers also grow groundnut in this Dzongkhag.
- The soybean is grown in mixed cropping with maize and soybean grains are consumed by households.

8. Lhuentse

Contact persons: Sonam Zangpo, DAO, Lhuentse; AAEOs of different Geogs .

Observations :

- Mustard varieties M-27 and T-9 are grown in this area but genetic deterioration was reported.
- The farmers usually do not apply any chemical to mustard crop.
- Stray animals affect the winter cultivation.
- The soybean is grown in mixed cropping with maize and soybean grains are consumed by households
- The oil expellers are not sufficient. It was reported that with the increase in number of oil expeller, the area under mustard would increase.

9. Trashigang

Contact persons: Chimmi Rinzin (DAO); Dendup Dukpa (Asstt. DAO) Ngawang Extension Officer (Trashigang); Ugen Sonom (AAEO- Samkhar geog)

Farmers : Rinchen (Village – Bikar –Samkhar geog)

Observations :

- Mustard variety M-27 is common with the farmers. The yellow sarson takes more time to mature.
- The mustard crop is sown in the month of September and the seed rate is 5 kg/acre.
- Maize - mustard sequence was common with the farmers. The other cropping system in high altitude areas is maize + potato where planting is done in February.
- Maize + soybean combination is commonly existing but there is gradual decline in soybean acreage due to increased used of urea in soybean.
- The area under mustard crop in Samkhar geog has increased with the initiation of AAEO. He advised the farmers to keep the stray animals out of the fields during the winter season. As a consequence this geog is heading towards achieving self-sufficiency in edible oils. However, there is no oil expeller in this area.
- Farmers are taking groundnut in some pockets.
- Only five oil expeller are available in whole Dzongkhag.
- The average yield of mustard is 200-250 kg / acre.

10. Khangma

Contact persons: Duptho Wangchuk, OIC-Khangma, Namgye (RA, RNRRC, Khangma); Sangay (AAEO – Kanglung geog); Ugen Dorji (Chairman); Cheda (Kanglung geog-oilmill owner)

Observations :

- Mustard variety M-27 is common and sown in the month of September after the maize or potato crop.
- The seed rate of mustard is very high i.e. 8 kg/acre.

- Soybean is grown as a mixed crop with maize. However, area under soybean has declined due to use of urea. In maize crop 150 kg urea / acre is used.
- Wild animals affect the winter crops.
- Migration of labourer to urban areas result in reduced manpower for the cultivation of crops.
- The mustard yield ranged between 300-400 kg/acre.
- The mustard is selling @ NU 21/kg.
- The Japanese oil expeller owned by Mr. Cheda can extract oil from 300 kg seeds in 8 hours. However, availability of its spare parts was reported to be the major problem. The oil content up to of 37% in mustard seeds could be extracted from this oil expeller.

11. Trashi Yangtse

Contact persons: Dodo (DAO, Trashi Yangtse); AAEOs of different geogs .

Observations :

- Availability of improved variety seeds is not as per the requirements. M-27 variety of mustard is commonly grown in this area.
- Foggy weather affects the mustard crop.
- Wild / stray animals affect the wintercrop and therefore the area under mustard crop has not increased.
- Migration of manpower from rural to urban areas has resulted in acute labour shortage. As a consequence the availability of labouers for agricultural operations has reduced.
- There are no plant protection measures to control aphids.
- Under good management, the yield level of 500 kg /acre in mustard can be obtained.
- In Bumdeling geog, oil expeller has been installed recently.
- Soybean is taken as a mixed crop with maize in most of the areas.

10. PRODUCTION TECHNOLOGY FOR OIL CROPS IN BHUTAN*

In Bhutan, actual operated agricultural area is 261,776 acres out of which 21 percent is wet land, 43 percent is dry land and remaining being under tsheri/ pangshing and orchard. About 16% of farm households own wet land less than acre each, while 68% have wet land between 1.0 to 4.99 acre each. Similarly about 66% of the households have dry land between 1 to 4.99 acre each. Eight percent of the house holds have less than 1 acre each (RNR- statistics 2000).

Bhutan can be divided into three distinct geographical zones. The southern zone (250-1500 m altitude) having a hot humid climate with temperature being fairly even through out the year, the central zone (1500-3000 m) having cool temperate climate and Northern zone (above 3000 m) having alpine climate. The country has vast variation in rainfall, soil type and the climatic components from one valley to another.

Agriculture plays an important role in the economy of Bhutan. Although, cereals occupy large area but oil crops play important role from nutritional point of view. Among oil seeds, usually following 9 crops are taken into consideration.

Edible oil crops

Rainy season crops

1. Ground nut (Arachis hypogaea)
2. Soyabean (Glycine max)
3. Sesamum (Sesamum indicum)
4. Sunflower (Helianthus annuus)
5. Niger seed (Guizotia abyssinica)

Winter season crop

6. Rapeseed mustard (Brassica sp)
7. Safflower (Carthamus tinctorius)

Non Edible oil crops

8. Castor seed (Ricinus communis)
9. Linseed (Linum usitatissimum)

The major oil crops grown in Bhutan comprise rapeseed-mustard. The other oil crops grown on smaller scale are groundnut, nigerseed and soybean. Groundnut and soybean seeds are consumed as such and oil is not extracted in Bhutan from these crops. The oil crops production in Bhutan is much lower than the domestic need and country has to depend on huge import of edible oils. The harvested area, production and yield of rapeseed-mustard was 8,525 acres, 1,695,911 kg and 199 kg/acre in Bhutan (RNR statistics, 2000). The domestic oilseedproduction is largely for subsistence purposes and rapeseed-mustard (Brassica species) being the predominant crop.

Lecture delivered to NRTI students at Lobeysa

The important cultivated species included under rapeseed-mustard are.

Botanical Name	Correct English	Synonyms
Brassica napus Ssp. Oleifera forma biennis forma annua	 Winter rape Summer rapeseed	 Oilrape, rapeseed Oilseed rape, Swede rape
Brassica campestris or Brassica rapa Ssp. oleifera forma biennis forma annua	 Winter turnip Summer rape turnip rape	 Rapeseed, Oil turnip
Forma annua Var. Chinensis Var. Pekinensis Var. trilocularis Var. dichotoma	 Summer turnip rape -do- -do- -do-	 Chinese mustard Celery cabbage/ Chinese kale, Yellow Sarson, Toria
Brassica juncea	Brown Mustard	Leaf mustard, Indian mustard, oriental mustard
Brassica carinata	Abyssinian mustard	Ethiopian mustard
Brassica nigra	Black mustard	Banarasi Rai

Besides, Eruca sativa (Rocket Salad syn. Taramira) is also included in this group and is grown in extremely drier parts of India.

In temperate regions, oilseed rape and turnip rape predominate while in the semi- tropics of Asia, Brassica campestris and Indian mustard are major source of vegetable oil.

In Brassica campestris there are 5 different eco-types (Brown seeded toria, yellow seeded toria, Lotni type brown sarson, tora type brown sarson and yellow sarson). Amongst these, toria and lotni type brown sarson have cross-pollination

Depending on form, species and climate, the plant may differ in morphological characteristics. It is an erect annual herb having primary and secondary branches, thin stem with spreading type and plant height may vary from 0.5 – 2.0 m. The toria crop has less height in comparison with other types. The stem begins to elongate after flower initiation and afterwards the growth is rapid.

In Brassica campestris the lower part of the blade (lamina) grasps the stalk completely while in Brassica juncea it is petiolated. In Brassica napus, the blade is half grasping the stem.
The inflorescence is an elongated raceme bearing bright yellow coloured flowers. The plants come to flowering at 35-45 days after planting depending upon the species and environment. The flower is radial with four erect prominent sepals and four petals, which alternate with the sepals in the form of a cross. The receptive surface of the stigma centreed within the four inner stamens, the two outer stamens and the four petals forming a cross from which the crucifereae family derives its name. Corolla is cruciform, yellow and consists of six stamens, which are tetradynamous (4 + 2) with 2 short at the outer whorl and 4 long at the inner whorl. Inner four surrounds the stigma. The gynoecium is bicarpellary. The ovary is originally unilocular but because of growing in of the two parietal placentae, it becomes 2 chambered. This type of partition is called as false spectrum or replum. Following pollination, the petals are shed and the pistil elongates to form a pod (stigma) with two carpels. The number of ovules in the ovary may vary from 15 to 40. The fruit is called siliqua and pod is 5-10 am in length. The weight of 1000 seeds may vary from 3-6 gm.

In Bhutan, rapeseed (Brassica campestris, var. toria) is dominantly grown and is known as peka in northern Bhutan and tori in Southern Bhutan. In some areas, the farmers using locally available traditional variety also grow *Brassica campestris var.* yellow sarson.

Toria is a short duration crop in comparison with other species. However, in *Brassica juncea* also early maturing cultivars have been released in India. In general, *Brassica campestris* is more susceptible to diseases in camparison with *Brassica juncea*.

In Bhutan, mustard word is used commonly for rapeseed-mustard group of crops. The harvested area, production and yield of mustard in few important Dzongkhag is given below.

Dzongkhag	Area (Acre)	Production ('000 kg)	Yield (Kg/Acre)
Samdrupjongkhar	1050	211.5	201
Sarpang	1229	188.5	153
Chhukha	771	163.9	213
Dagana	690	154.8	224
Trasigang	588	146.4	249
Punakha	937	146.0	156
Thimphu	214	133.3	623
Wangdue	590	106.7	181
Tsirang	630	99.0	157
Samtse	563	85.3	152
Paro	165	48.6	294

Source: RNR stastistics-2000

The average yield vary from 153 to 623 kg/ha. Thus, there is wide variation in yield and some Dzongkhag have less than national average yield (199 kg/ha). Thus, the yield level can be increased to a greater extent by adopting improved agro-technology, given below.

Climate and Soil requirements

These crops are basically temperate crops and have wide adaptability. Climate plays an important role and due to climate fluctuations 10-50% of flowers develops into pods. The temperature range of 0.5-3°C, 20-25 °C and 35 – 40°C can be considered to be minimum optimum and maximum, respectively for these crops. These crops require higher temperature for the completion of vegetative phase and clear sky with cold temperature during reproductive phase for better development of seed and oil. The frost and cloudy weather during flowering is quite harmful and also affect adversely the honeybee activity. The low temperature reduces the water and nutrient absorption by roots. Rapeseed-mustard performs well on loamy soil having pH around 7.0. The pH range of 6.5- 8.3 does not adversely affect the yield. On light textured soil, also, rapeseed could be grown successfully provided moisture and fertility are adequate. These crops cannot tolerate waterlogged condition and on heavy soil drainage should be good. Proper planking should be done after each ploughing for fine seedbed. If soil moisture is not optimum, pre-sowing irrigation is needed for better germination and early seedling vigour. One deep ploughing for low land paddy field be done followed by 2-3 ploughings. Planking should be done after each ploughing. These crops give better yield when available soil moisture in soil profile is 175-225mm per metre of soil depth.

Improved varieties

The varieties having more seed yield and oil content with better stability are desirable. The improved varieties have better tolerance to biotic and abiotic stresses. Some of the improved varieties are as under:

1. Toria: T-9, PT-30, PT 303, PT 507, M-27, TS-36, TS-38, TS-46, Anuradha, Parbati, PBT-37, TL-15
2. Yellow sarson: Rajendra sarson-1, Benoy, Subenoy, Jhumka, Ragini
3. Indian Mustard: Early types-Sej-2, NDRE-4, JD-6, Kanti
4. Gobhi sarson : GSL-1, Hyola-401

Few other important varieties of Indian mustard are :

GM-2, JM-1,Pusa bold, RH-30, Urvashi

The above varieties, however, need to be tested in different agro-climatic regions in Bhutan.

The oil content in improved varieties of toria is(42-44%), mustard (40-43%) and yellow sarson (43-45%). Toria matures early in 95 days under higher temperature but duration is prolonged to 120 days when grown under lower temperature. The yellow sarson and Indian mustard take more time than toria but yield level is high. Indian mustard have better tolerance to pest and diseases. The use of local seeds year after year is an important factor affecting the yield adversely in Bhutan.

Improved method of sowing

Healthy seeds of recommended variety be grown. Seeds are to be treated with Apron 35 SD @ 6 g/kg of seed for reducing white rust and downy mildew incidence at the initial stages. The seeds be also treated with carbendazim @ 2g/kg seed to protect the crop from seedling and sclerotinia disease.

The sowing be done in lines, 30 cm apart, and plant to plant spacing of 10-15 cm be maintained by thinning done at 15-20 days after sowing. Use of higher seed rate is not desirable and 2-3 kg seed rate per acre is sufficient to maintain optimum plant population. Thinning is a very important operation and improves the yield level. Rapeseed (toria) is a cross-pollinated crop and therefore for seed production purpose, at least 200 m of isolation distance be kept from other varieties to maintain the purity of the seeds. Early sown crop on well-prepared seedbeds will produce higher yields.

Optimum sowing time

These crops are thermo- sensitive in nature and planting at a right time is necessary to get an optimum temperature during the particular growth phase. Late planting reduces the reproductive phase and allows less time for development of pods and seeds. In addition, late-planted crop is exposed to diseases like white rust, Alternaria and pest like aphids. Usually sowing time may vary in different environment depending upon the crop rotation. The optimum sowing time in Bhutan for different cropping systems is as below:

1. Maize based cropping system (dry lands)-September
2. Potato based cropping system – August – September
3. Rice based cropping system (Wet lands) – October – November

However, on higher altitude above 1900 m, it is advisable to sow the toria crop early (August-Early September) so that the crop matures before the severe winters. In late sown crop, frost or low temperature would damage the crop. Therefore, on high altitudes, the crop be harvested by December. After rice crop, also, the sowing be done as early as possible to avoid the damage due to aphids.

Judicious use of manures and fertilizers

Farmers usually apply FYM or compost prior to sowing of crop and do not apply chemical fertilizers due to which mustard yields are very low. The balance application of nutrients be made, depending upon the soil test values. Cultivation of mustard after cereals crops like rice and maize further lead to deficiency of nutrients. NPK S are very important nutrient elements for these crops. The deficiency symptoms of the nutrients are as follows:

Nitrogen: Plants generally exhibit a light green colour followed by yellowing and drying or shedding of older leaves. Older leaves may show a colouring from yellow to red orange with red veins. The branching is also reduced.

Phosphorus: In early stages, there is reduced growth and dark green foliage, older leaves may first show a pink purple colouring on tips and margins, then a gradual reddening or purpling of foliage under severe deficiency.

Phosphorus is considered necessary for meristematic growth, seed and fruit development and stimulates flowering. Phosphorus deficiency may result in poor seed set.

Potassium: Older leaves may first exhibit deficiency symptoms. Development of yellow colour at tips and margins, gradually expanding towards the midrib. This is gradually followed by mottling or chlorosis of older leaves and drying of leaf tissue. Flower buds may whither and die and in case of severe deficiency, whole plant may affect, stalks may be weak and plants lodge easily. Seed size is reduced and plant become susceptible to disease.

Sulphur: Yellowing of younger leaves in initial stage and gradually progressing to all leaves. Sometimes, a pink colouring may show on the leaf midrib on the under side of the leaves. Later, older leaves may become pale and show purpling around the margins, with a tendency to curl or roll inwards. The purple colouring then spreads through the inter veinal areas. Younger leaves are poorly developed and fail to set seeds if sulphur deficiency is severe. The seeds may by shrunken and shrivelled.

In soils, where available nitrogen is below 280 kg/ha, phosphorus below 10 kg/ha and potassium less than 110 kg/ha, application of these nutrients become necessary. Rapeseed mustard crops are exhaustive in nature. According to an estimate, a mustard (B. juncea) crop producing 2.6 tonnes per ha takes 131 kg N, 26 kg P, 133 kg K and 45 kg S.

In Bhutan, application of fertilizers is made in rapeseed-mustard to improve the yield level. The productivity of Thimphu is higher because of more use of chemical fertilizers in potato- mustard cropping system. The use of fertilizers may also vary with the moisture availability.

In dry land, apply FYM @ 2 tonnes/acre with 20 kg N/acre and 15 kg/acre P2O5 as a basal dose. In case of winter rains, top dress 5 kg N per acre before flowering.

In wetlands apply FYM @ 2 tonnes/acre with 20 kg N per acre and 15-20 kg P2O5 per acre. Top dress 10 kg N per acre at pre flowering stage. In case of deficiency of K, 10-15 kg K2O per acre be also applied depending upon soil test values, in both dry lands and wet lands.

These crops uses heavy amount of sulphur from the soil. Therefore, use of single super phosphate is desirable as it contents 12% sulphur, also, in addition to 16% phosphorus. Application of 10-12 kg S per acre is important for higher yield of seed and oil.

Weeding and hoeing at right stage

Hoeing is very effective in controlling annual weeds. In mustard, one hoeing and weeding at 20-25 days stage is very useful in controlling weeds and conserving moisture. Weed competition reduces the yield levels. The reduction in yield in mustard due to weeds have been reported to be from 24-40%, depending upon the type of weeds, intensity of weed growth and their time of occurrence.

Irrigation at critical stage

The growth stages can be divided as

Vegetative stage	Reproductive stage
1. Seedling stage	4. Flowering stage
2. Rosette stage	5. Ripening stage
3. Bud stage	

Under favourable condition, emergence of the two cotyledons or seed leaves usually occurs within 4 or 5 days. Soon after this, there is quick development of the first true leaves. The crop, thereafter establishes a rosette or broad leaves, which tend to shade the surrounding area and reduce with competition. Subsequent growth pattern differ depending upon the environment, species or varieties. These crops have low water requirement (80-240 mm) and therefore, fit well in the dry land cropping system.

First irrigation in these crops be applied at 25-30 days after sowing, before flowering. The second irrigation be applied at pod development stage which may be 55-60 days after sowing. If only one irrigation is available, it should be applied at the flowering stage.

Integrated management of pests and diseases

Major diseases

1. Alternaria blight (*Alternaria brassicae*)
2. White rust (*Albugo candida*)
3. Downy mildew (*Peronospora parasitica*)
4. Powdery mildew (*Erysiphe spp.*)

Major Pest

1. Sawfly (*Athalia proxima*)
2. Aphids (*Lipaphis erysimi*)
3. Painted bug (*Bagrada cruciferarum*)

Diseases

Alternaria blight

This disease is caused by the fungus and fungi have been found to survive through affected plant debris in soil. The secondary spread of the disease in crop season occurs through fungal spores called conidia. Symptoms of the disease are characterized by formation of small blown to black spots on the leaves, stem and siliquae (pods). On leaves the spots are dot like initially but gradually enlarge and become circular concentric up to 1 cm in diameter. On stem, the spots are elongated and siliquae, the spots are round deep black without concentric rings. The yield losses may be up to 47% due to this disease.

White rust

Usually white rust and downy mildew appears simultaneously on these crops. Symptoms of white rust on leaves become visible at about 30-40 days after sowing in the form of isolated particles spread all over the leaves on the lower surface. The particles are raised, white or creamy yellow and the diameter ranges from 1-2mm. The affected plants show elongation of flower bearing stalks with slight thickening as compared to healthy plants. The fungus survives through resting spores named as oospores. The oospores are found in the malformed tissues of the floral parts. The losses could be up to 40%.

Downy mildew

The disease causes 17 – 34% loss in yield. Symptoms of the disease are observed on leaves as well as on inflorescence. Formation of round to irregular necrotic lesions on the first two to three leaves. The under surface of lesion is yellow. The whitish fluffy growth (Downy growth) of the fungus becomes visible only on the lower surface of the lesion. In later stages, affected plants (upper 8 – 10 cm of the stalk bearing the flowers) shows thickening. The affected stalk shows profuse sporulation of the fungus, which becomes visible in the form of downy growth. The affected flower does not set siliquae.

Powdery Mildew

Symptoms of the disease are characterized by formation of white floury patches on the leaves, stem and flowers. The affected plants show defoliation and reduced seed setting in the siliquae. The seed remains undersized.

Insect Pest

Sawfly

The adult fly is orange yellow with smoky wings and black veins. The young larva has a black head and is about two mm in length, the full grown larva is greenish-grey having five strips of black dots on the lower ride of the body and about four mm in length. Larva affect the young crop.

Aphids

Aphid infestations take place with the help of winged forms. The colonies comprising nymphs and adults feed on the reproductive parts as well as on the tender side of the leaves. The adult aphids are soft bodied, pale green in colour and about 1 to 2 mm long. Adult and nymphs suck cell sap from various plant parts. The pest lives in colonies and has a high rate of multiplication. Heavily infested plants remain stunted and do not bear siliquae.

Painted bug

The nymphs have a number of pale, brown and red markings on their bodies. The adults are pretty looking with yellow and orange markings. The nymphs and adults suck the cell sap from the foliage and pods causing drying up. The pest damages the crop more at seedling stage. The sucking of the leaf sap causes white blotchy spots.

Management strategy for Diseases

- Sowing at an appropriate time
- Deep summer ploughing
- Use of disease resistant/tolerant or cultivation of early maturing cultivates
- Use of certified seeds of improved varieties
- Seed treatment also with bio control agents viz, Tricoderma viride or botanicals like Allium sativum bulb extract (1% w/v), which are eco-friendly and cost effective.
- Application of balanced dose of nutrients
- Adopting optimum plant population with recommended spacing
- Proper drainage to avoid water stagnation
- Clean cultivation, elimination of weeds
- Rouging out diseased plants and burn them
- Judicious use of irrigation water
- Proper crop rotation

Chemical control

Alternaria blight

Spray the crop with Rovral or mancozeb @ 0.2% at 50-60 days after sowing followed by another spray depending upon severity of disease.

White rust/ downy mildew:

First spray with Ridomil MZ @ 0.25% at 50 days after sowing followed by 1-2 spray of Rovral or Mancozeb@ 0.2% at 15 days interval.

Powdery mildew:

Spray Dinocap @ 0.1%. Need based spray of carbendazin (0.05%)

Management strategy for insect-pests:

- Grow improved varieties
- Early sowing to reduce the damage due to aphids
- Use balance dose of fertilizers
- Plucking and destruction of infested twigs is very useful. It may be done twice at 10days interval
- Spray the crop if there is more infestation
- Spraying be done after 2 p.m to avoid toxicity to insect pollinators
- Follow clean cultivation by weeding, hoeing and burn the debris around the field

Chemical Control:

Sawfly

Spray 500ml of Malathion 50 E.C or Endosulfan 35 EC in 500 litre of water per hectare. Painted bug can also be controlled by above chemical but quantity be increased to 625 ml per hectare

Aphids

Use Oxydemeton methyl 25 EC or Dimethoate 30 EC (0.1%) to control aphids

Harvest and Pest harvest operations:

The time of harvest shall depend upon the sowing date, Variety, management practices and environment. Harvest the crop when 75% pods turn yellowish. After this stage, there is no increase in seed weight. Harvesting can be done when seed moisture content is 25%. During this stage the seeds will be firm when pressed between the fingers and change their natural colour. Harvest in the morning hours to avoid shattering losses.

The crop may be tied in small bundles, stacked and dried in sun till the seeds attain their normal colour and moisture content reaches below 15 percent. At threshing the seed moisture content should not be below 12%. Threshing can be done on small scale manually or by usual method of treading by bullocks.

The seeds be stored at 8% moisture content after proper cleaning. If the seed moisture content is higher, it may cause bin heating and damage the seeds.

Mustard oil extraction:

Many farmers in Bhutan follow the traditional methods of oil extraction with oil recovery of 25 – 30%. The use of oil expellers can give 35% oil recovery. The bigger size oil expellers can further increase the oil output. The oil content may vary with the environment and type of variety grown.

Yield:

With the adoption o improved technology, the average yield of 800 – 1000 kg/acre can be obtained from rapeseed –mustard, depending upon the variety and management practices.

The other oil crops grown in Bhutan are Niger seed , Sun flower, Ground Nut and soybean. In addition there is also oil extraction from some tree origin.

1. Niger Seed (*Guizotia abyssinica*):

In mid-hills, this crop is presently grown in small areas in the Bhutan and planted just after the harvest of maize in dry land areas in the month of August. In low land areas, there are also few fields cultivating niger seed but planting is done late. The seed is small and oil recovery can be to the extent of 35%. Presently niger seeds are mixed with mustard seeds for oil extraction. Seeds are also used for preparation of pickles. There are possibilities of increasing the acreage under this crop, particularly on soils having low fertility in Bhutan. This crop requires high temperature during early stages of growth and mild temperature, during reproductive growth phase. Some improved varieties from India like Ootacamund, IGP-76, N12-8, N-71 etc can be tested in Bhutan for their commercial cultivation. These varieties mature in less than 100 days duration and could be sown in August. The seed rate of 5-6 kg/ha is optimum and planting be done at 30 cm spacing. For obtaining good yield 10 kg N and 10 kg P_2O_5/acre be applied. Under rain fed conditions 600 kg yield per hectare can be obtained.

2. Sunflower (*Helianthus annuus*)

In Bhutan this crop is not grown at present on commercial basis. However it is growing as an ornamental plant. Sunflower can be grown on mid hills and high hills during spring season. However, problems of birds and difficulties in oil extraction were felt.

Cultivation of sunflower in large area would probably avoid bird damage. The possibilities of sunflower cultivation during winter season can also be explored in mid as well as low hills. Improved sunflower varieties can be obtained and tested in Bhutan. Because of higher oil content (45%) and good quality oil, sunflower is considered to be an important crop. It also contains high amount of protein good for animal and poultry feed. In sunflower both open pollinated varieties and hybrids are available. A number of high yielding hybrids have been developed in India and can be tested in Bhutan. Sunflower seeds be stored at low temperature for higher longevity. Sunflower is a cross pollinated crop and hand pollination is needed in the absence of honey bee / insect activity. The row spacing of 60 cm for hybrid and plant spacing of

20cm is recommended. For varieties like Morden, a row spacing of 45 cm is recommended. The sunflower field must have proper drainage to avoid stagnation of water.

Sunflower does well on fertile soils but can tolerate dry conditions. Loam soils with well-drained systems are best for its cultivation. The crop could be sown either during spring or winter season. The duration of crop shall vary from 100-135 days depending upon variety and season. The seed rate of 8-10 kg per hectare is sufficient. Under good management the crop may give 20 quintal per hectare seed yield.

3. Groundnut (*Arachis hypogaea*)

This crop is usually grown during rainy season but may have its potential as a summer crop in low land in those areas of Bhutan where rain does not start early. Therefore only early maturing varieties should be grown.

Groundnut requires light textured soil having sufficient amount of organic matter. For germination, the temperature of top 10 cm soil should not be below 18°C. It can not tolerate water logging. In groundnut both bunches as well as its spreading types are available. Early maturing bunch types need to be tested in Bhutan. The seed rate may vary depending upon the size of seed and type of variety. The bunch types are planted at 30 cm distance and require 80-100 kg kernels per hectare. The spreading types require 60-80 kg kernels / ha and be planted at 45 cm distance. The plant-to-plant spacing of 15 cm be maintained. Earthing at peg formation help in better pod setting. The soil must have sufficient moisture at the time of peg formation in groundnut, otherwise, the fertilization is adversely affected. Application of gypsum @ 200 kg/ha is desirable as it contain sulphur which is very much needed for obtaining higher yield of seed and oil. In the absence of gypsum phosphorus be applied through SSP, which contains 12% sulphur, also. The groundnut is given, 15 kg, 30 kg P_2O_5 and 45 kg K_2O/ha at the time of sowing. The groundnut produced is usually consumed as kernels in Bhutan.

4. Soybean (*Glycine max*)

Soybean grown in Bhutan is not used as oil crop. It has rich protein content (more than 40%) with 20% oil content in seed. It can yield 20-25 q/ha. The cultivated soybean is an annual, erect and sparsely branched one. The stem is rounding, often hairy with 3 distinct types-determinate, semi determinate and indeterminate. The flowers are purple to white and typical leguminous. The fruit is a short, hairy pod usually black or brown. The pods contain 3 seeds and seed colour is yellow or black. It is grown during rainy season and seed rate of 80 kg / ha is desirable. For maintaining adequate viability, seeds are stored at lower room temperature. Row spacing of 60 cm is recommended. The crop requires 15 kg, 60 kg P_2O_5 and 60 kg K_2O /ha for higher yield.

5. Oilseeds from tree origin

The possibility of extracting oil from oil-bearing trees may also be explored in Bhutan. For instance, SINGMA a tree that is spontaneously grows in land used for shifting cultivation. Other native oil bearing trees are PANGTSHI and Mahua. The information on the availability of oil from tree origin is scarce. An oil-bearing plant-SEELAAM could also be exploited.

Constraints in increasing production of oilseeds in Bhutan

1. Cultivation on dry land with poor soil fertility.
2. Small and marginal land holdings
3. Non availability of improved varieties
4. Lack of improved technologies for specific area. Almost negligible use of chemical fertilizers and plant protection measures
5. Lack of varieties resistant to biotic and abiotic stresses
6. Production and distribution of quality seeds
7. Lack of efficient oil expellers
8. Lack of assured market support.

Annexure -11

11. MEAN MONTHLY TEMPERATURES (DEGREE CENTIGRADE) OF VARIOUS DZONGKHAGS FROM 1985-2003

Dzongkhag	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Thimphu	6	8	11	14	17	20	21	21	19	16	11	7
Paro	7	9	12	15	18	19	21	21	19	15	10	7
Ha	3	5	7	10	14	16	17	17	15	11	7	5
Chhukha	10	11	13	16	18	20	19	19	19	17	14	11
Samtse	18	20	23	25	26	27	26	27	26	24	22	19
Punakha	11	14	16	20	22	24	24	24	24	22	16	13
Gasa	5	5	8	11	13	16	16	17	16	13	10	6
Wangdue	11	14	17	20	22	25	24	24	23	21	16	13
Tsirang	13	14	17	20	21	23	24	24	22	20	17	14
Dagana	10	10	13	17	19	20	21	20	20	18	14	12
Bumthang	5	6	9	12	15	18	18	18	17	13	9	6
Trongsa	9	10	13	16	17	20	21	21	19	16	13	10
Zhemgang	14	16	19	20	24	26	26	26	25	22	19	16
Sarpang	18	19	22	25	26	27	27	27	27	25	22	19
Lhuentse	10	12	15	17	20	22	23	23	22	18	14	11
Mongar	11	13	16	19	21	23	23	23	22	19	16	13
Trashigang	11	13	17	19	21	23	24	23	22	20	17	13
Yangtse	9	10	13	16	18	21	22	22	21	17	13	10
Pe/gatshel	11	12	15	17	19	21	22	21	21	18	16	13
S/jongkhar	19	20	23	25	26	27	28	28	27	25	23	20

Source : CoRRB, MoA, 2004

MEAN MONTHLY PRECIPITATION (MM) IN VARIOUS DZONGKHAGS FROM 1985-2003

Dzongkhag	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Thimphu	1	5	25	39	57	142	212	113	87	26	2	9	718
Paro	12	2	30	29	56	115	172	140	118	48	22	12	758
Ha	21	30	51	64	83	156	201	182	146	69	4	6	1015
Chhukha	24	49	76	124	164	280	289	286	187	71	19	12	1581
Samtse	25	32	64	189	418	738	864	1008	660	246	39	9	4292
Punakha	21	8	82	56	55	125	255	175	115	55	6	8	961
Gasa	12	39	91	121	231	312	482	415	290	160	45	30	2228
Wangdue	12	9	17	45	53	105	143	154	90	30	10	6	676
Tsirang	1	13	24	45	106	388	533	275	157	41	2	6	1590
Dagana	17	47	44	120	231	378	431	983	662	104	19	11	3048
Bumthang	7	10	29	50	83	126	141	137	94	53	8	6	745
Trongsa	18	34	50	91	145	206	230	224	163	71	13	8	1255
Zhemgang	4	15	71	43	142	381	501	495	223	78	0	2	1956
Sarpang	23	23	58	175	392	841	1119	1261	691	334	59	19	4995
Lhuentse	21	14	36	74	108	105	146	177	100	46	5	6	839
Mongar	9	11	35	57	92	143	205	192	88	52	7	4	895
Trashigang	22	27	44	72	102	223	278	240	118	70	3	4	1203
Yangtse	12	26	38	92	131	176	222	237	175	64	18	6	1198
Pe/gatshel	18	34	120	119	189	341	454	352	185	122	45	21	2000
S/jongkhar	37	52	92	161	328	625	559	478	453	197	13	11	3005

Source : Co RRB, MOA, 2004

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