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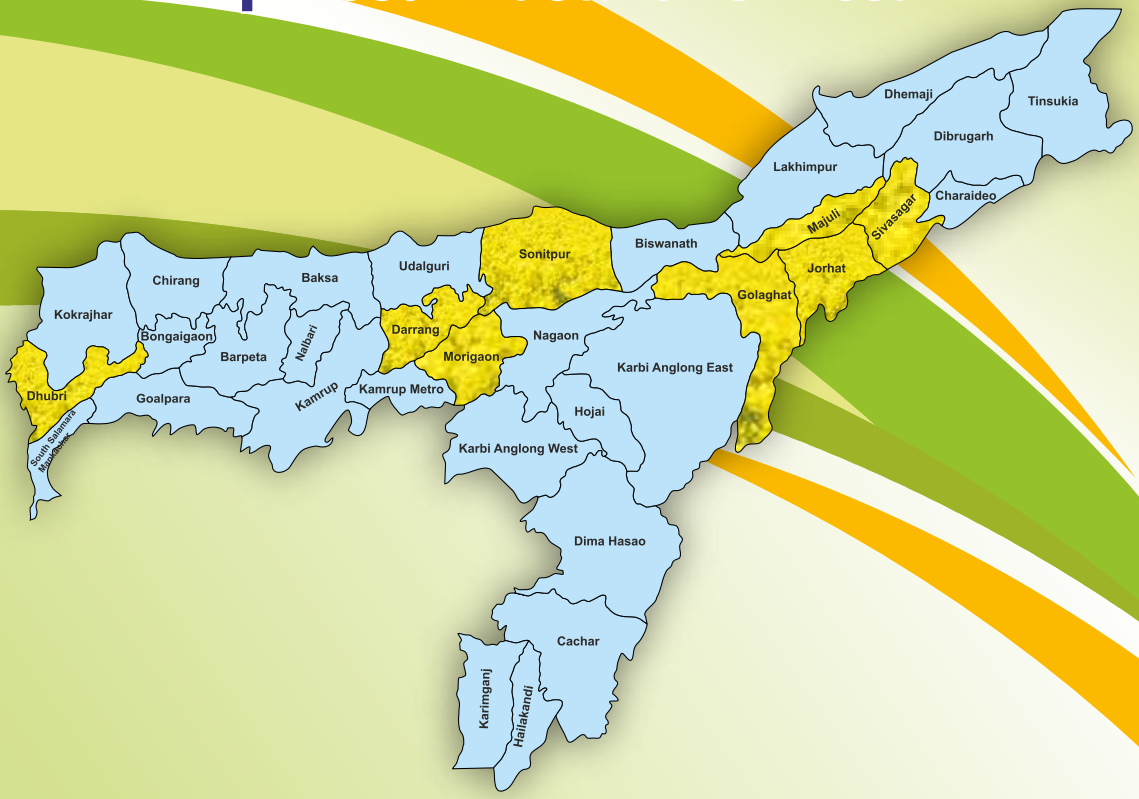
GOVERNMENT OF ASSAM

Technical Bulletin

Best Management Practices of Rapeseed-Mustard for Assam



ICAR-DIRECTORATE OF RAPESEED-MUSTARD RESEARCH

(Indian Council of Agricultural Research)

Sewar, Bharatpur 321 303 (Rajasthan) India

(An ISO 9001:2008 Certified Organization)


Demonstration on Mustard
সৰিয়হৰ প্ৰদৰ্শনীমূলক খেতি
Under
ICAR-IBSNAT-APART PROJECT

Best Management Practices of Rapeseed-Mustard for Assam

Ashok Kumar Sharma
Pankaj Sharma
Vinod Kumar
Arun Kumar
Harvir Singh
P.K. Rai

भा.कृ.अनुप.–सरसों अनुसंधान निदेशालय
ICAR-Directorate of Rapeseed-Mustard Research
सेवर, भरतपुर – 321 303 (राजस्थान)
Sewar, Bharatpur-321303 (Rajasthan)
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Sewar, Bharatpur - 321303
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অসম চৰকাৰ

सत्यमेव जयते

GOVERNMENT OF ASSAM

Sh. Akash Deep, IAS,
Commissioner & Secretary
to the Govt. of Assam,
Agriculture Department and
Director, Agriculture, Assam

MESSAGE

In Assam, the net and gross cropped areas are 28.11 (35.1 per cent of geographical area) and 40.99 lakh hectares, respectively with a cropping intensity of 144 per cent. The important oilseed crops grown in the state are rapeseed-mustard, sesamum, niger, linseed and groundnut. Among all these, rapeseed-mustard is the principal oilseed crop in Assam, contribute more than 92 per cent of the total oilseed area (2.85 lakh ha) and production (1.83 lakh tonnes) of the state. Assam contributes about 4.82 per cent of area and 2.46 percent of production to total rapeseed-mustard in area and production in the country. Though rapeseed-mustard is grown in substantial area in Assam, but productivity is very low (660 kg/ha) in comparison to national average (1511 kg/ha). Rapeseed-mustard has good production potential, if cultivation is supported with suitable technological interventions and knowledge inputs.

Director of Agriculture, Government of Assam has signed a MoU with ICAR-Directorate of Rapeseed-Mustard Research for a project on "Consultancy services for technical advisory support for augmenting rapeseed-mustard production in Assam for sustainable livelihood security" through APART. ICAR-DRMR is working as knowledge partner and providing expertise to support the Directorate of Agriculture, Govt. of Assam. ICAR-DRMR is providing technical backstopping, arranging human resources, creating awareness and capacity building of all stakeholders about improved varieties and scientific cultivation of rapeseed-mustard under the project.

I am hopeful that this state specific document on "Best Management Practices of Rapeseed-Mustard for Assam" prepared by DRMR-APART team to achieve higher productivity of rapeseed-mustard in state will help the agricultural officials and farmers to focus on the specific requirements and activities required to address the production constraints.

I extend my greetings to the ICAR-DRMR-APART team for their concerted efforts to bring out such valuable document and wish for grand success of future endeavour.

(Akash Deep)

Preface

Agriculture continue to remains as one of the most important sector in the Indian economy. It is one of the earliest economic activities and a considerably large number of population has continued to depend on agriculture for their livelihood. The economy of Assam is also mainly agrarian with agriculture and allied activities contributing about 20 per cent to the state's net domestic product and providing livelihood support to about 75 per cent of the population of the region.

At present, the net and gross cropped areas in the state are 28.11 (35.1 per cent of geographical area) and 40.99 lakh hectares, respectively with a cropping intensity of 144 per cent. Rice is the dominating crop of the state occupying around 91% of the net cropped area. Assam can be broadly divided into three distinct physiographic units - the plains, the plateau and the hills with the plains of Brahmaputra and Barak valleys being the main area for agricultural development.

The state of Assam is among the six major rapeseed-mustard producing states in the country.The important oilseed crops grown in the state of Assam are rapeseed-mustard, sesamum, niger, linseed and groundnut. Among all these, rapeseed-mustard is the principal oilseeds crop in Assam, contributes more than 92 per cent of the total oilseed area (2.85 lakh ha) and production (1.83 lakh tonnes) of the state. Assam contributes about 4.82 per cent of area and 2.46 percent of production of total rapeseed-mustard in India. Though rapeseed-mustard is grown in substantial area in Assam, but productivity is very low (660 kg/ha) in comparison to national (1511 kg/ha). Rapeseed-mustard has good production potential, if cultivation is supported with suitable technological interventions and knowledge inputs.

ICAR-Directorate of Rapeseed-Mustard Research has signed a MoU with the Director of Agriculture, Government of Assam on April 28, 2020 for a project on "Consultancy services for technical advisory support for augmenting rapeseed-mustard production in Assam for sustainable livelihood security" through APART. ICARDRMR is working as knowledge partner and providing expertise to support the Directorate of Agriculture, Govt. of Assam. ICAR-DRMR is providing technical backstopping, arranging human resources, creating awareness and capacity building of all stakeholders about improved varieties and scientific cultivation of rapeseed-mustard under the project.

The need for state specific strategic road map for enhancing rapeseed-mustard crop productivity is increasingly being felt since the production constraints are usually state specific. In view of that, ICAR-DRMR has developed this state specific document on "Best management practices of rapeseed-mustard for Assam to achieve higher productivity of rapeseed mustard that will help the agricultural officials and farmers of the state to focus on the specific requirements and activities needed to address the production constraints.

We place on record our appreciation to all the ICAR-DRMR-APART staff for providing desired information for this compilation and look forward for valuable comments and input for further improvement. We express our sincere gratitude to Sh. Akash Deep, IAS, Commissioner & Secretary to the Govt. of Assam, Agriculture Department and Director, Agriculture, Assam; Sh. Madhurum Patiri, Nodal Officer, OPIU-Agri/APART for their valuable guidance. We also express our sincere thank to Mr. Raosahab Bendre, Agricultural Specialist, APART, OPIU-Agriculture, DoA, Assam and Dr. Baljeet Singh, Market Analyst cum Operations Specialist, ARIAS Society, Guwahati, Assam; District Agriculture officers for their kind cooperation in completing project activities.

We sincerely hope that this publication shall be of benefit to extension workers and farmers alike and help the state in enhancing production and productivity of rapeseed-mustard.

Authors

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Rapeseed-Mustard Production Scenario

The estimated area, production and yield of rapeseed-mustard in the world was 36.59 million hectares (mha), 72.37 million tonnes (mt) and 1978 kg / ha, respectively, during 2018-19 but there has been fluctuations in the productivity from 1808 kg/ha in 2010-11 to highest 2107 kg/ha in 2016-17 during last 10 years, and production has increased from 60.94 mt in 2010-11 to 74.99 mt in 2017-18. Globally, India account for 16.8% and 12.8% of the total acreage and production (USDA 2018-19).

India certainly possesses the wherewithal for self-sustenance in this area. With 21% of world's area under oilseed production and 5% of world's production, India is the fourth largest oilseed producing country in the world, next only to the US, China and Brazil. Oilseeds is the nation's second largest agricultural commodity after cereals and shares 13% of the country's gross cropped area, nearly 5% of Gross National Product and 10% of the value of all agricultural products.

Soybean, groundnut and rapeseed-mustard are the major oilseed crops in India contributing nearly 85% and 90% to its total acreage and production, respectively (Average of 2014-15 to 2018-19). The average contribution of rapeseed-mustard to the total oilseed production in India was 29.5%, with its average productivity 1511 kg/ha during 2018-19. Though, rapeseed-mustard is placed 2nd in terms of production, after soybean, it ranks 1st in terms of oil yield among all oilseed crops. Oilseed Brassicas grown in India are *B. juncea, B. rapa. B. napus* and *B. carinata. B. juncea* predominates and accounts for about 90% area under rapeseed-mustard crops. These crops are grown in diverse agro-climatic conditions varying from north-eastern/north-western hills to down south under irrigated/rainfed, timely/late sown and sole/mixed cropping. Indian mustard accounts for about 75-80 % of the 6.12 million hectares under these crops in the country during 2018-19 crop season (Table 1)

Table 1: Rapeseed-mustard production trends in world & India during 2009-10 to 2018-19

Year	World			India		
	Area (m ha)	Production (mt)	Yield (Kg / ha)	Area (m ha)	Production (mt)	Yield (Kg/ha)
2009-10	30.85	61.06	1979	5.59	6.61	1183
2010-11	33.71	60.94	1808	6.90	8.18	1185
2011-12	33.51	61.64	1840	5.89	6.60	1121
2012-13	36.05	64.06	1777	6.36	8.03	1262
2013-14	36.01	71.68	1990	6.65	7.88	1185
2014-15	35.52	71.45	2012	5.80	6.28	1083
2015-16	33.86	69.96	2066	5.75	6.80	1183
2016-17	33.83	71.28	2107	6.07	7.92	1304
2017-18	36.55	74.99	2051	5.98	8.43	1410
2018-19	36.59	72.37	1978	6.12	9.26	1511

Edible oil production scenario in India

Rapeseed-mustard is the largest contributor to the domestic edible oil production in India. Though the crop comes second in terms of oilseed production after soybean, the higher oil content in the seeds makes this crop the largest source of domestic edible oil availability. The average contribution of rapeseed-mustard to the total oilseed production from the annual oilseeds was 26.2 per cent during 2014-15 to 2018-19. The crop accounted for more than 25 per cent of the domestic edible oil availability from primary sources during last ten years (2014-15 to 2018-19) as shown in Fig 1.

The need for enhancing self-sufficiency in meeting the edible oil requirements is a major challenge to researchers and policy planners because, the total consumption of edible oils in India has shown a growth (CAGR) of 4.6% from 159.54 MMT in 2008-09 to 249.8 MMT in 2018-19. As against the aforesaid status, during the same period, domestic oil seed production increased only marginally at a CAGR of 1.6% from 27 MMT to 32 MMT. Therefore, to meet the increasing demand of edible oil consumption, India bound to import (almost more than half of total consumption). The quantum of edible oil available for consumption during 2018-19 was 24.98 MMT, of which only 10.06 MMT was met through domestic supplies. The huge gap of 15.10 MMT was met through imports.

The rapeseed-mustard crop is seen as a potential source for enhancing domestic edible oil availability through crop productivity enhancement mediated by appropriate technologies intervention and extension strategies.

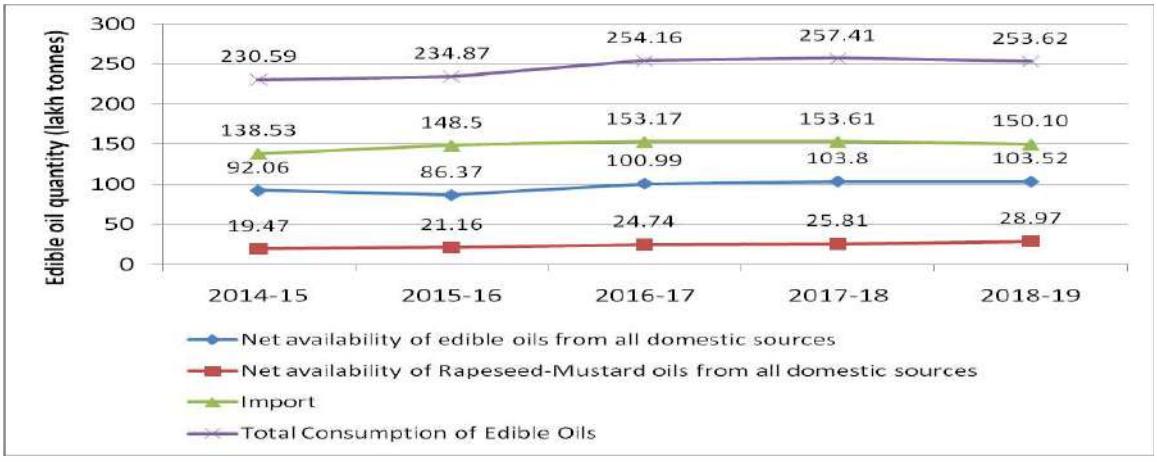

Fig 1. Trends in domesttic oil production, rapeseed-mustard oil availability, import nad total consumption of oil

The production and productivity of rapeseed-mustard in India showed a steady positive trends in the last three decades. The trends of area , production and productivity presented in Fig 2. The productivty level of rapeseed-mustard increased from 700 kg per hectare during 1986-87 to 1511 kg per hectare in 2018-19. The production also increased during the period from 2.60 millions tonnes in to 9.2 millions tonnes. The difference in yield level of the crop accross states is also considerable as evidenced by FLDs results and yield at research stations. The lack of awareness about technological options is one of the major constraints in realising the potential productivity of the crop.

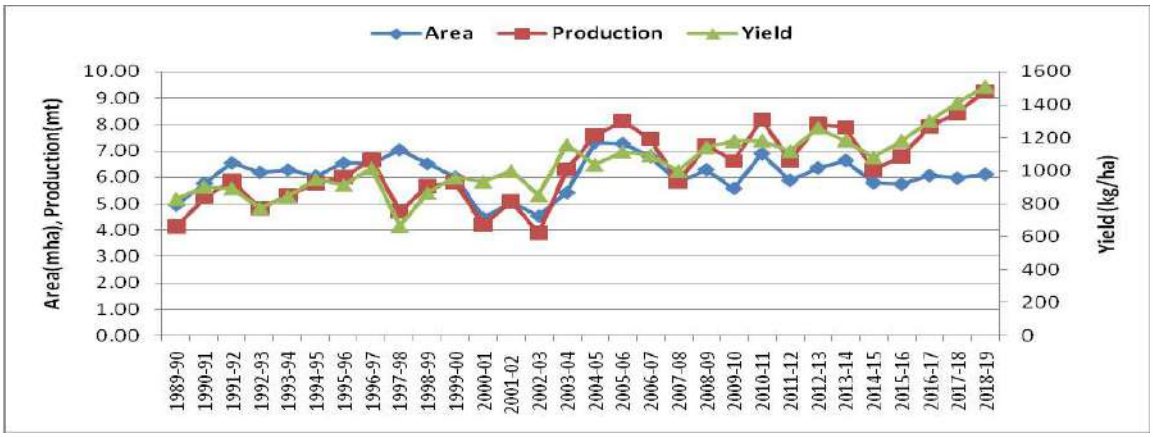

Fig 2. Trends in rapeseed-mustard area, production and productivity during last three decades (1989-90 to 2018-19)

The rapeseed-mustard crop is cultivated mainly in small holder production systems and in marginal and disadvantaged regions characterized by rainfed farming and low input intensity in cultivation. The enhancement of crop productivity and profitability is therefore critical for achieving inclusive farm growth and to enhance the livelihood security of the farmer producers. In India, eight cultivable crops under rapeseed-mustard group are grown namely toria, brown sarson, yellow sarson, gobhi sarson, raya or Indian mustard, karan rai, black mustard and taramira. In India, rapeseed-mustard is predominantly cultivated in Rajasthan, Madhya Pradesh, Haryana, Gujarat, West Bengal, Assam, Bihar Jharkhand, J&K and Punjab (Table 2). Together, these states accounted for more than 96 per cent of the area and production of rapeseed-mustard in the country during 2014-15 to 2018-19.

Table 2: Statewise Area & Production of rapeseed-mustard in India

State	Average (2014-15 to 2018-19)		Area and Production % of All India		
	Area ('000ha)	Production ('000t)	Yield (Kg/ha)	Area (%)	Production (%)
Rajasthan	2430.53	3478.64	1431	40.89	44.96
Madhya Pradesh	698.60	863.84	1237	11.75	11.17
Uttar Pradesh	668.00	821.01	1229	11.24	10.61
Haryana	533.24	963.52	1807	8.97	12.45
West Bengal	517.29	586.06	1133	8.70	7.58
Assam	287.35	189.09	658	4.83	2.44
Jharkhand	242.17	168.66	696	4.07	2.18
Gujarat	198.47	332.22	1674	3.34	4.29
Bihar	83.32	97.49	1170	1.40	1.26
Jammu & Kashmir	49.61	37.31	752	0.83	0.48
Punjab	30.94	43.49	1406	0.52	0.56
Others	204.39	155.05	759	3.44	2.00
All India	**5943.90**	**7736.38**	**1302**	**100.00**	**100.00**

Rapeseed-Mustard Production in Assam

The state of Assam is among the six major rapeseed-mustard crop producing states in the country. Rapeseed-mustard is the principal oilseeds crop in Assam, contribute more than 92 per cent of the total oilseed area (2.85 lakh ha) and production (1.83 lakh tonnes) of the state (2018-19). Assam contributes about 4.82 per cent of area and 2.46 percent of production of total rapeseed-mustard in India average during 2014-15 to 2018-19.

In Assam, the compound annual growth rate (CAGR) of rapeseed-mustard area and production Showed positive trends during 1980-81 to 1989-90 and was recorded 4.04 and 3.14 percent, respectively. However, during the same period productivity growth rate recorded negative by 0.85 percent. After that, area, production and productivity growth recorded negative till 2009-10. The rapeseed-mustard production again got momentum during 2010-11 to 2018-19 as the CAGR of area, production and productivity recorded 2.26, 3.57 and 1.28 percent respectively. Thus, the production of the crop in the state has remained increasing during the period 2009-10 to 2018-19. The area, production and productivity trends of rapeseed-mustard in Assam during the period 2009-10 to 2018-19 are presented in Fig 3.

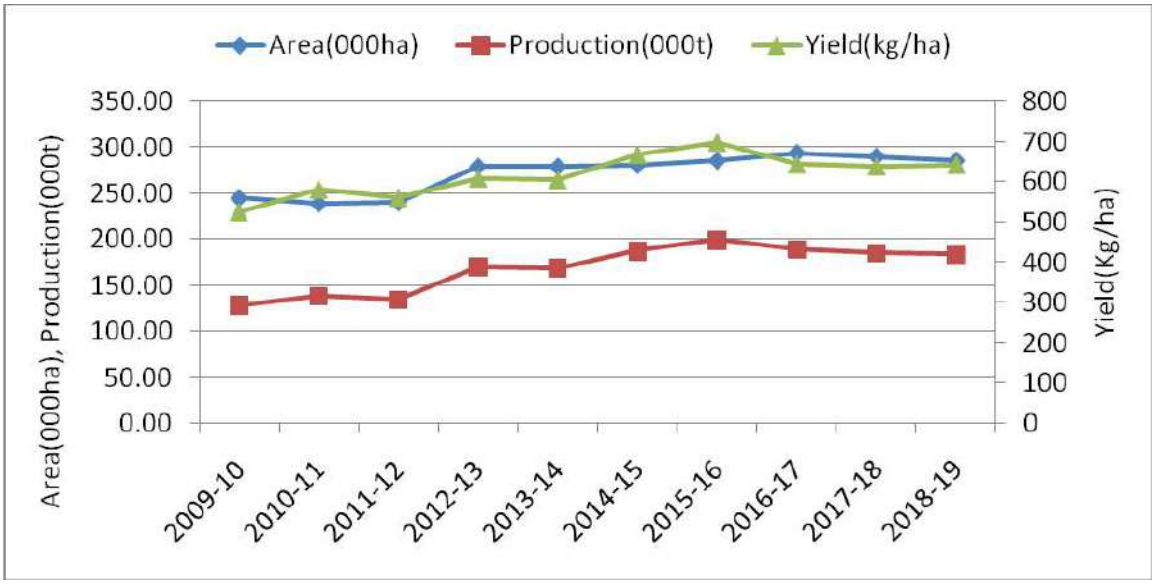

Fig.3: The area, production and productivity trends of rapeseed-mustard in Assam during the period 2009-10 to 2018-19

Table 3: CAGR of Area, Production and Yield of rapeseed-mustard in Assam and India

Period	CAGR (%)					
	Assam			India		
	Area	Production	Yield	Area	Production	Yield
1980-81 to 1989-90	4.02	3.14	-0.85	2.13	6.71	4.48
1990-91 to 1999-00	-0.34	-2.22	-1.89	0.46	1.14	0.67
2000-01 to 2009-10	-1.26	-1.03	0.23	2.49	5.19	2.63
2010-11 to 2018-19	2.26	3.57	1.28	-1.48	1.56	3.09

District wise analysis

In Assam, rapeseed-mustard are grown almost in entire state, however it is more popular in the areas where the early maturity rice varieties are being grown. The average productivity 660 kg/ha of the crop in the state is less as compared to average productivity of country 1511 kg/ha during 2018-19. In the state, rapeseed-mustard is grown entirely as a rainfed crop, because of non–availability of irrigation facilities. Moreover, about 90 per cent of the crop is cultivated by the farmers in marginal and sub-marginal land. Production of rapeseed-mustard is also limited owing to non adoption of recommended agronomic practices like timely sowing, optimum fertilizer application, seed rate etc. which also reduce the yield to a greater extent.

In Assam, major rapeseed-mustard growing districts which contributes more than 70 percent of area and production of state are Lakhimpur, Kokrajhar, Sonitpur, Dhemaji, Dhubri, Barpeta, Nagaon, Karbi Anglong, Darrang, Jorhat, and Kamrup (Fig 4). The rapeseed-mustard growing districts categorized in high medium and low categories are presented in Table 4.

Table 4: Classification of rapeseed-mustard production districts of Assam in high, medium and low categories

	High	Medium	Low
Area	Barpeta, Darrang, Dhemaji, Dhubri, Kokrajhar, Lakhimpur , Nagaon, Sonitpur and Karbi Anglong (9)	Baksa, Bongaigaon, Chirang, Goalpara,Golaghat, Jorhat, Kamrup, Morigaon, Nalbari, Tinsukia and Udalguri (11)	Cachar, Dima Hasao, Hailakandi, Ibrugarh, Kamrup Metro, Karimganj and Sivasagar (7)
Production	Barpeta, Darrang, Dhemaji, Dhubri, Kokrajhar, Lakhimpur, Nagaon, Karbi Anglong and Sonitpur (9)	Baksa, Bongaigaon, Chirang, Golaghat, Jorhat, Kamrup, Morigaon, Nalbari, Tinsukia and Udalguri (10)	Cachar, Dibrugarh, Dima Hasao, Kamrup Metro, Hailakandi, Goalpara, Karimganj and Sivasagar (8)
Yield	Barpeta, Bongaigaon, Dhemaji, Dibrugarh, Dhubri, Kamrup, Kokrajhar, Jorhat, Lakhimpur, Nagaon, Nalbari, Sonitpur and Tinsukia (13)	Cachar, Chirang, Darrang, Kamrup Metro, Morigaon and Sivasagar (6)	Baksa, Dima Hasao, Goalpara, Karbi Anglong, Hailakandi, Karimganj, Golaghat and Udalguri (8)

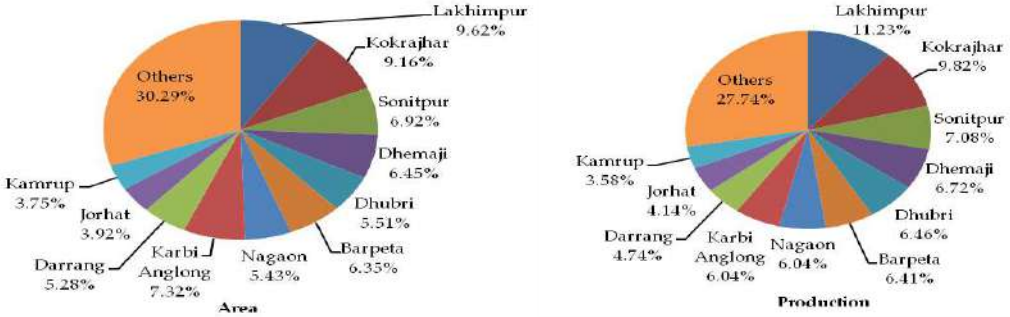

Fig 4: Major districts of Assam contributing more than 70% of total production of state during last ten years

The rapeseed-mustard productivity level in different districts of Assam has shown large variations. It ranged from 340 kg/ha (Hailakandi) to 1060 kg/ha (Dima hasao) during 2017-18. Lakhimpur district ranks 1st in area and production based on 10 year average data. The 10 years average productivity of major rapeseed-mustard producing districts in Assam is presented in Fig 5.

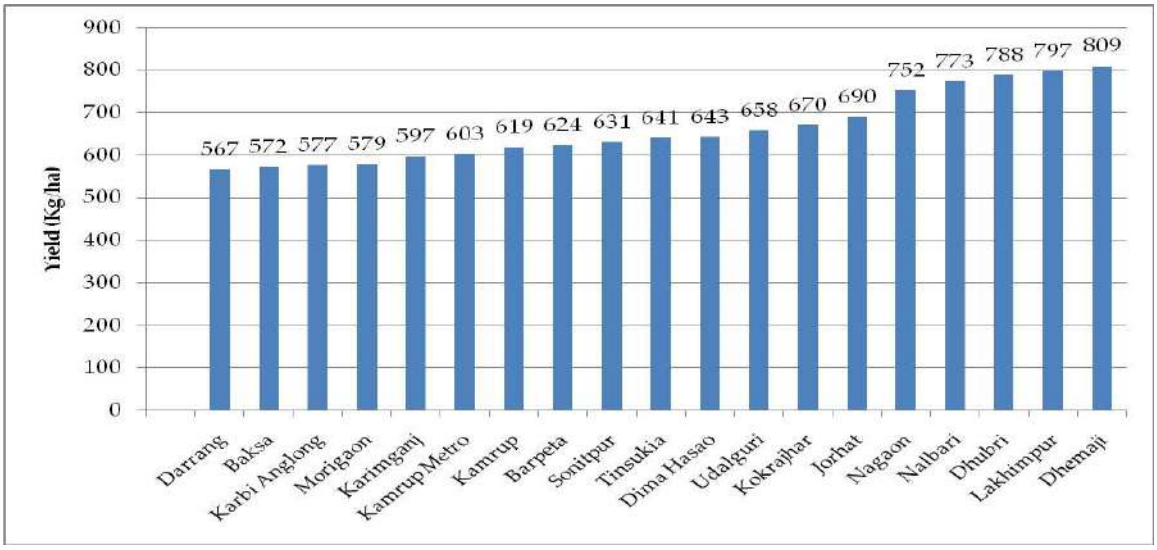

Fig 5: Average yield of rapeseed-mustard producing districts of Assam during last 10 years

Constraints in Rapeseed-Mustard Production in Assam

The average yield of rapeseed-mustard recorded in the farmers field in the state is far below the potential productivity of the crop. The difference between the yield of improved variety obtained at the research station and at the farmers field has been reported to be as high as 18 per cent. The initial step in achieving the potential productivity of the crop lies in the identification of the constraints to high productivity. The major constraints identified in the state are given below:

- Low and erratic rainfall, high temperature at the sowing time.
- Salt affected soils.
- Non-availability of seeds of improved varieties.
- Non-adoption of improved varieties.
- Imbalanced fertilizer use.
- Poor plant protection measures.
- Inadequate moisture conservation techniques.
- Infestation of insects-pests and diseases like mustard aphid, sawfly and painted bug, White rust, downy mildew and Alternaria blight.
- Late sowing of the crop and .
- Low adoption of suitable high temperature tolerant early maturing varieties of mustard for rainfed situation.

Major Recommendations for Rapeseed-Mustard in Assam

Suitable varieties

The selection of the appropriate variety suited to the growing condition and specific characteristics of the region is the most important factor in determining the yield and production of the crop. Toria crop is popular in Assam as it matures in 85-95 days. The majority of farmers in Assam generally grow traditional varieties i.e. locally available germplasm especially short duration toria (mostly nondescript naturally crossed bred) varieties, which are low yielder. Yellow sarson is also an important crop. It matures in about 100-125 days and is also in cultivation in some regions of Assam. Now improved short duration varieties of Indian mustard, suitable for Assam, have also been developed, which are gaining popularity in Assam. A large number of varieties suited for cultivation in various parts of Assam have been identified and notified under the All India Coordinated Research Project on Rapeseed-Mustard (AICRP-RM). The adoption of improved and suitable variety alone can make significant difference in the crop productivity. As Assam comes under zone V, early maturing/short duration varieties are well suited. On the basis of recommendation of AICRP-RM/ state/ AAU and results of FLDs, the following varieties of rapeseed-mustard are most suitable for Assam (Table 5).

Table 5: Recommended varieties of rapeseed-mustard for Assam

Variety	Maturity (days)	Oil (%)	Av. Yield (kg/ha)
Indian Mustard			
DRMR-150-35	110-120	38-42	1200-1800
NRCHB - 101	105-130	35-42	1382-1500
PM-28	95	41-42	1910-2090
Toria			
TS-38	90-95	40-41	1200
TS-46	94	40-41	900
TS-67	90	40-42	700
Yellow sarson			
NRCYS 05-02	94-181	40-46	1239-1715
YSH 401	110-113	43-45	1273-1651
Pitambari	110-115	40-48	1417-1765

Recommended Cropping Systems

Rapeseed-mustard crops fit well in various cropping systems, because of its low water requirement (80-240 mm). Cropping sequence with kharif legumes like green gram, dhaincha, etc are beneficial for their N-fixing nature. Apart from legumes, maize, jute and rice can also be included in the cropping system along with rapeseed-mustard. The economically remunerative crop sequences with rapeseed-mustard for Assam is given in Table 6.

Table 6: Rapeseed-mustard based cropping systems for Assam

Sl No.	Growing condition	Cropping sequence
1.	Irrigated	· Rice-Toria
2.	Irrigated	· Jute-Summer Rice-Toria
3.	Irrigated	· Rice-Toria-Green gram
4.	Rainfed	· Rice-Toria
5.	Rainfed	· Jute-Summer Rice-Toria
6.	Rainfed	· Rice-Toria-Green gram

Seed treatment

Prophylactic seed treatment is one of the low cost technologies which can contribute to higher productivity of rapeseed-mustard crop. The seed treatment provides protection against a range of diseases and insects. The recommended dosages of chemicals for seed treatment is given in Table 7.

Table 7: Recommended seed treatment for rapeseed-mustard

Fungicide	Dose (g/kg seed)	Disease/ Insects
Metalaxyl (Apron 35 SD)	6.0	White rust and downy mildew
Carbendazim	2.0	Sclerotinia stem rot
Trichoderma	10	Sclerotinia stem rot
Imidacloprid 70WS	5	Painted bug

Seed should also to be treated with Azotobactor and PSB, each @ 50 gm /kg seed.

Climate and Soil

Rapeseed-mustard grown in rabi season from October-November to February-March. The crop generally do well in loam/sandy loam soils. However, other light soils are also equally good for production of rapeseed - mustard.

Land preparation

Preparation of the land is important for maintaining a proper health and other soil characteristics required for the crop. Adoption of proper land preparation technology also helps to reduce the pest and diseases infecting the crop apart from providing good control of weeds in the field. The traditional farmers of the state keep their lands barren after harvesting the rice crops till next cultivation. Since most of the farm operations in Assam are done using animal power, hence, there is great scope of mechanization in Assam. For land preparation, in Assam cultivators are generally being used. there is great scope of introducing improved

tractor drawn land preparation implements like; M.B. plough, Disc plough, Rotavator, etc.

A fine seed bed is essential for rapeseed – mustard. The field should be ploughed 4-6 times followed by planking every time after harrowing or ploughing to avoid clod formation and prevent moisture loss. Pulverize the soil, using cultivator before sowing.

Time of sowing

Timely sowing is an important aspect to obtain good seed and oil yield and the timely sown crop often escapes diseases and pest attack. Delayed sowing of the crop could result in reduced yield and increased incidence of pest and diseases. Since rapeseed-mustard crops are grown in diverse agro-climatic conditions, the optimum sowing time varies widely. It should also be ensured that crop is sown when the maximum day time temperature is not more than 32°C, which is essential for proper germination of the seeds. The optimum time of sowing in Assam is second week of October to middle of November. Early sowing helps in escaping the attack of aphids. In Barak Valley Zone, rapeseed-mustard can be sown as late as November 30th in upland condition and up to third week of November in medium upland condition.

Sowing method

There are various sowing methods of mustard including broadcasting, zero till sowing, ridge sowing and line sowing. Line sowing method is the best method for obtaining optimum crop geometry and also for yield enhancement.

Seed rate and Spacing

The maintenance of an optimum plant population is a pre-requisite for a good harvest of the crop. The use of recommended seed rate and spacing will ensure the proper plant population in the field. Seed rate of 10 kg/ha for toria and 8 kg/ ha for mustard has been found to be optimum for broadcasting method. Seed rate can be reduced to 5-6 kg/ ha for line sowing through seed drill.The distance between rows should be 30 cm and plant to plant distance within the row should be maintained between 10 -15 cm under irrigated condition. Plant population should be maintained at 3 to 3.5 lakh/ha. The method of line sowing using seed drills gives a higher yield per unit area when compared to broadcasting of seeds. Seed rate of rain fed or late sown toria after sali paddy (rice-toria sequence) should be 30% higher than normal recommended rate.

Integrated Nutrient management

Rapeseed-mustard is an energy rich oilseed crop which requires adequate quantity of nutrients. The crop is capable of removing large amount of nutrients depending on seed yield biomass production. If these crops are grown in energy starved conditions, the productivity of the crop is severely compromised. Therefore, the role of balanced and judicious fertilizer application attains importance in enhancing the level of productivity in rapeseed-mustard. It is estimated that 64.5 kg N, 20.6 kg P205, 53.4 K20, 16 kg S, 56.5 kg Ca, 9.5 kg Mg, 0.068 kg Zn, 0.63 kg Fe, 0.2 kg Mn and 0.02 kg Cu are removed in producing one tonne of mustard seed. The requirement of fertilizer varies with the soil type, status of irrigation and species being grown. For example, in coarse textured soils, at high yield levels and where leaching is of major concern, availability of potash (K) becomes critical. Similarly, the level of Iron (Fe) assumes importance in the alkaline-calcareous soils. Keeping in view, the diversity in the nature of soil, cropping sequence and agro-climatic conditions, the application of fertilizers should be done based on regular soil testing which can help in determining the exact fertilizer dosage required. Fertilizer recommendations must be modified based on soil test value for attaining better nutrient use efficiency and for minimizing the cost of fertilizers. The general recommendation of fertilizers for Assam is given in Table 8

Table 8 : Recommended dosage of fertilizers for rapeseed-mustard in Assam

Nutrient	Requirement (kg/ha)	Form	Fertilizer requirement	
			(kg/ha.)	(kg/bigha)
For Rapeseed				
(A) Plains:				
Rainfed condition				
N	40	Urea	87	12
P_2O_5	35	SSP	220	30
K_2O	15	MOP	25	25
Irrigated condition				
N	60	Urea	130	18
P_2O_5	40	SSP	250	33
K_2O	40	MOP	66	9
(B) Hills				
Rainfed condition				
N	65	Urea	140	20
P_2O_5	35	SSP	220	30
K_2O	0	MOP	0	0
(C) Central Brahmaputra Valley Zone				
Rainfed condition				
N	60	Urea	130	18
P_2O_5	30	SSP	190	27
K_2O	30	MOP	50	6
Mustard (For All Zones)				
N	80	Urea	175	23
P_2O_5	40	SSP	250	33
K_2O	30	MOP	50	7
B	-	Borax	7.5	1

These recommendations are general in nature and the actual fertilizer requirementmay vary depending upon the soil test values and cropping systems. Along with the right quantity of fertilizers the timing of fertilizer application is also important for the crop. The following points should be kept in mind while deciding the dose and timing of fertilizer application.

- Application of FYM or compost @ 2-3 t/ha is beneficial for the crop.
- Apply 75% N and P when seeds are inoculated with *Azotobacter* @ 50 g/kg seed and PSB @ 50 g/kg seed.
- If SSP is not used as source of P, sulphur @ 20 kg/ha in the form of gypsum (133 kg/ha) should be used.
- NPK may be supplied in the form of mixed fertilizers. Nutrient requirements are to be adjusted according to contents in fertilizers. Rapeseed-mustard have been found to respond well to the application of borax in some agro-climatic zones of Assam. For higher yield of rapeseed-mustard in the North Bank Plains Zone, a fertilizer dose of 60:40:40 kg NPK/ha is recommended.
- Use Borax @ 10 kg/ha for North Bank Plains Zone, 5-10 kg/ha for Upper Brahmaputra Valley Zone and 7.5kg/ha for Central Brahmaputra Valley Zone in addition to recommended dose of fertilizers.
- *Application of Lime:* $CaCO_3$ in the form of dolomitic lime @ 500 kg/ha should be applied 15 days before seeding and incorporate in the soil in areas where multiple cropping is practiced.
- *Foliar spray of urea* : Two foliar applications of 1% urea at flowering and pod filling stages along with basal application of recommended fertilizer dose, i.e. 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha.
- Half of the recommended dose of N should be applied as basal dose at the time of sowing preferably through drilling at least 5.0 cm below the seeds for proper absorption. The remaining half should be applied by top dressing before the first irrigation and necessarily before flowering.
- Full dose of phosphorous (P_2O_5) is recommended as basal application at the time of sowing of irrigated crop. If the soil test values indicate deficiency of potash (K_2O), apply the full dose of potash at the time of sowing under irrigated condition.
- For rainfed crop apply the full-recommended dosages of all nutrients at the time of sowing.
- Bio-fertilizers can play an important role in improving the nutrient supply for the rapeseed-mustard crop and thereby enhancing the seed yield. The nitrogen fixing bacteria (Azotobacter), Phosphate Solubilizing Bacteria (PSB) and Mycorrhizae are the most commonly used bio-fertilizers which are recommended for rapeseed-mustard. Use of Azotobacter can reduce the nitrogen requirement up to 25-30 kg/ha provided bacterial strain is efficient and soil is rich in organic matter. The PSB and mycorrhizae are important to increase P uptake and dry matter yield at lower level of applied P.

Thinning

To keep an optimum plant population per unit area and uniform plant growth, thinning operation by removing the extra plants should be done 20 to 25 days after sowing (DAS) to maintain a distance of 10-15 cm between plants in a row.

Weed management

Weeds reduce productivity, compete for nutrients and soil moisture, reduce quality of farm products, affect health of animals & quality of product, increase production and processing cost, affect human health, reduce land value and crop choice. Reduction in yield up to 40-50% and nutrient depletion (up to 48 kg N, up to 14 Kg P and up to 82 Kg K/ha) has been reported. Critical period of crop weed competition has been identified between 15-40 days after sowing. Therefore, the field should be kept free from weeds. Manual and mechanical methods (hand weeding and hoeing) are still commonly used methods for weed control in mustard cultivation. One hand weeding 15-25 DAS is recommended for manual weeding/hoeing. Pendimathaline @ 1.0 a.i./ha, as pre emergence herbicide is recommended for chemical control of the weeds in rapeseed mustard crop.

Intercultural operations

Intercultural operations helps in removal of weeds and conservation of soil moisture, which is important, especially in rainfed areas. Apart from thinning, intercultural operation should be done 15-25 days or 35-40 DAS with khurpi or double wheel hand hoe before the first irrigation to keep the field weed free. The weeding should be done either along with thinning or immediately after thinning.

Irrigation

Since the availability, mobility and uptake of plant nutrient are primarily dependent upon soil water, timely irrigation can increase yield by 15-20% through effective utilization of applied nutrients. A substantial area of rapeseed-mustard in Assam is still grown under rainfed conditions. The rapeseed-mustard crop requires about 190-400 mm of water. Proper scheduling of irrigation is important to ensure optimum water use efficiency. In general, one irrigation of 6 cm depth of water may be applied at 35-40 days after sowing or either at 50% flowering or at early siliqua formation stage. In case a rainfall of 20-25 mm is received during this period, no post sowing irrigation is essential. Pre-sowing irrigation is normally not required for timely sown crop. However, in dry areas one pre-sowing irrigation may be applied. As moisture conservation tillage practice for rapeseed after sali rice, one cross ploughing by power tiller incorporating rice stubbles is recommended. The situation for this practice should be medium land with medium textured soil, field capacity 23-25%, soil moisture at the time of land preparation around 22.5%, and time of sowing 4th week of November to 1st week of December.

Harvesting, threshing and storage management

Failure to adopt proper harvesting and post-harvest operations can lead to substantial losses. Therefore, the proper harvest, threshing and storage of the crop is important. The crop should be harvested when 75 per cent of pods turn to golden yellow in colour. At this stage, majority of seeds are firm when pressed between fingers. The oil content in the seed is the maximum at this stage. Harvesting during the green pod stage reduces the yield and oil content. For manual harvesting, use a sickle that is light in weight and easy to handle (example: Naveen sickle).This will reduce the drudgery and the time taken for harvesting. After harvesting, the harvested plants are made into bundles and stacked in the sun for 7-8 days before threshing. Threshing is done by beating the pods with wooden sticks or by trampling with bullocks. However, threshing should preferably be done by using tractor threshers. Threshing is followed by winnowing, where the seeds are separated from the straw. The seeds should be sun dried for 2-3 days before storage to reduce the moisture content. For safe storage, moisture content of seeds should be eight per cent.

Biotic Stress Management

Insect management

Among the major insect in rapeseed-mustard, mustard aphid *(Lipaphis erysimi)*, saw fly (*Athalia lugens proxima*), painted bug *(Bagrada hilaris)*, pea leaf miner *(Chromatomyia horticola)* and bihar hairy caterpillar (*Diacrisia obliqua*) are commonly seen in Assam. In the absence of true resistant variety of rapeseed-mustard for these insect, chemical and bio-control has been recommended for their management. However, an integrated approach including cultural practices is recommended for effective management of insect pest to prevent the build-up of insect resistance to various commonly used insecticides and to reduce the environmental pollution resulting from use of pesticides.

Mustard aphid (*Lipaphis erysimi*)

The mustard aphid is a key insect of rapeseed-mustard and is widely distributed in all parts of India including Assam. The insect is also known as "*Chainpa, Mahoo, Moyala, Lahi, Tela* etc.," in local languages. The infestation of mustard aphid is known to cause significant yield losses in rapeseed-mustard in Assam. The mustard aphid is a small, globular, pear shaped and delicate insect, which mostly appears at the end of December and remains active up to month of March. The insect lives in colonies and has a high rate of multiplication. Low temperature (8-18^{O}C), high RH (60-80 %), and cloudy weather favour the rapid multiplication of aphid. Mustard aphid (both nymph and adult) feeds on different parts of the plants (inflorescence, leaf, stem, twig and pods) by sucking the cell sap. In cases of heavy infestation, the entire plant can dry up and lead to seed yield losses up to 80 per cent. The infestation of mustard aphid also results in reduction in oil yield and such reduction has been recorded up to 10 per cent. The aphid also secretes honey dew, which is responsible for the growth of black fungus called "sooty mould" which hinders the photosynthesis in the plant.

Management

Grow improved and early maturing varieties of Indian mustard (*Brassica juncea*) as they are fairly tolerant to mustard aphid and have more yield potential than rapeseed (*Brassica rapa*). Early sowing of the crop (before 15th October) can help the crop to avoid the infestation by mustard aphid. Other management strategies include:

- Use the recommended fertilizer dose as excess nitrogen application induced crop growth which attracts more aphids.
- Monitor the crop field, especially during the month of December and January, when the chances of infestation and resultant yield losses remain high. Pluck and destroy infested twigs 2-3 times at 10 days interval during this period to prevent the multiplication of aphids.

- Apply chemical control when the aphid population reaches the economic thresh-hold level (ETL). Generally, ETL is reached when 25-26 aphids/ plant is observed in at least 10 per cent of the plant population.
- Foliar spray of 2% neem oil or 5% Neem Seed Kernel Extract (NSKE) dissolved in 700-800 litre of water/ha is effective and avoid toxicity to pollinators.
- Use predators such as coccinellids, syrphid and lacewing, etc to minimise the incidence.
- Chemical control is done by spraying Oxydemeton methyl 25 EC @ 1.0 litre dissolved in 700-800 litres of water/ha when ETL is reached. Repeat the spray at 15 days interval, if the aphid population builds up again. Spray the pesticides in the afternoon (after 4 PM) to avoid toxicity to insect pollinators



Painted bug (*Bagrada cruciferarum*)

Painted bug is a polyphagous insect, which also infest the rapeseed-mustard crops. The insect has been found to cause serious damage in the state of Assam. The other names of the insect are "Chitkabra, Sunder, Jhanga, Dagila etc. Adult bugs are sub ovate, grey to dark brown or black in colour having many orange/ brownish spots on the dorsal side of the body. The painted bug attacks the crop in warmer months when moderate temperature (20-40^{O}C) and low humidity persists during September-November and March-April. The insect is more serious in early stages of the crop. Both adults and nymphs suck the cell sap from the leaves, shoot and pods and can cause up to 30 per cent loss of seed yield. The infestation in the two-leaf and vegetative stage results in whitening of leaves then wilting leading to complete drying of the tender shoot/plant. In such cases re-sowing becomes necessary leading to a delayed crop which is more susceptible to insect and diseases. The cost of cultivation also increases due to the additional cost involved in re-sowing. The infestation at maturity results in curling of pods and shriveling of grains.

Management

- Deep ploughing of the field after harvesting during summer.
- Clean cultivation by weeding, hoeing and destroying of debris in and around the field.
- Seed treatment with imidacloprid 70WS @ 5g/kg seed.
- Conserve bio-control agents such as *Alophora* spp. (tachinid fly) parasitizing eggs of painted bugs.
- Harvest the crop at appropriate time (75% pod have golden yellow colour) and thresh as early as possible to avoid the further losses.

Mustard sawfly (*Athalia proxima*)

The insect is found in all rapeseed-mustard growing areas of the country, especially in Assam, Bihar and West Bengal. This insect is also commonly known as "Ara makhi" in Hindi. Adult sawfly happens to be orange yellow in colour with black head and legs and its ovipositor is serrated and saw like hence called sawfly. The larvae are yellowish green to dark green with five lateral longitudinal stripes. The insect attacks the crop at early stage. Usually the infestation occurs on three to four week old crop during the months of October and November. Moderate temperature (20-30^{o}C) and low humidity favour its development. The larvae make irregular holes in the leaves. Grown up larva feed from the margin of leaf and in severe infestation the crop looks as grazed by animals. It can cause loss up to 35 per cent. The insect survives on the alternate host (radish) and shift to toria crop in September from where they migrate to the germinating crops of rapeseed- mustard in October.

Management

- Deep ploughing of the field in summer to destroy the pupae.
- Clean cultivation by weeding, hoeing and destroying of debris in and around the field.
- Early irrigation helps in killing the larvae through drowning.
- Conserve *Perilissus cingulator* (parasitoids of the larvae), and the bacterium *Serratia marcescens* which infect the larvae of sawfly.
- Spray the crop with malathion 50 EC @ 500 ml in 500 litre of water in one hectare. Repeat the spray if population builds up again.

Pea leaf miner (*Chromatomyia horticola*)

The pea leaf miner is a highly polyphagous pest and found in all the mustard growing areas of the country. It is called as "Patti ka surangi keet" in Hindi. The adult is a black coloured fly with yellow head and resembles a housefly but smaller in size. Young maggot is

dirty white in colour with smoky brown mouthparts, while full-grown maggot is greenish yellow with thickest region in middle and tapering at both ends. The adult makes feeding puncture and feeds on the sap that oozes out from the puncture. The maggots mine the leaf and a larger number of silvery zig-zag mines appear due to the feeding on the parenchyma tissues. Maggot remains inside the mine and pupates therein. The insect population increases at the temperature ranging from 20-30 ^{O}C during February-March. The heavily infested leaves become yellow and fall down affecting the yield adversely. Its damage is more conspicuous on the older leaves. Yield losses up to 15 per cent has been observed due to pea leaf miner infestation.

Management

- Pluck the infested leaves and bury them to kill the maggots and pupae resting inside.
- Parasitoids: *Gronotoma micromorpha* (larva and pupa), *Diglyphus isaea* (larva) *Halticoptera circulus* and *Opius phaseoli* (pupal) *Chrysocharis pentheus*, *Neochrysocharis formosa* (westwood).
- Predators : Lacewings, ladybug beetle, spiders, fire ants.
- Foliar spray of systemic insecticide such as Oxydemeton methyl 25 EC @ 1.0 litre in 600-800 litre of water/ ha controls the insect effectively.

Bihar hairy caterpillar (*Spilosoma obliqua*)

The insect is a highly ploy phagous and sporadic in nature and is reported throughout rapeseed-mustard growing areas of the country. The insect is also known as "Katra, Kamla, Kambal-keera, Balon wali sundi, Bhabhu kutta" in different localities in India. Adult moth is dull yellow in colour with orange tiny wings having black spots. The body of full-grown larva is covered with tuft of thick long hairs. The insect attacks the crop in vegetative stage during September-October. A temperature range of 20-30^{O}C with medium humidity is suitable for this insect. The Bihar hairy caterpillar infestation is more severe on toria crop. They feed on chlorophyll content from the margin of leaves and make them almost transparent and gradually defoliate the entire plant. In case of severe attack, re-sowing has to be done. Grown up larvae migrate to other plants in the field and even to other plants in adjoining fields.

Management

- At the initial stages destroy the insect through hand collection, which is effective and eco-friendly.

- Collect the infested leaves and dip them in kerosene or any insecticide treated solution.
- Conserve the natural bio control population of spiders, long horned grasshoppers, praying mantid, robber fly, ants, green lace wing, damsel flies/dragon fly, flower bugs, shield bugs, lady bird beetles, ground beetle, predatory cricket, earwig, braconids, trichogrammatids.
- Dust the border of fields with malathion 5% to check the spread of larvae to new fields, and 25-30 kg/ ha against young caterpillars.
- Spray the crop with malathion 50 EC @ 1.0 litre in 500 litre of water in one hectare. Removal of alternate host plants from the surroundings of the field is beneficial.

Diamond back moth (*Plutella xylostella*)

This is a sporadic insect of late sown rapeseed-mustard crop and is found all over the country. The adult moth is gray or brown in colour with light brown anterior wings having three yellow spots and the forewing having white triangular spot, which look like a row of diamonds and hence the name given as diamond back moth. The insect makes tunnel and holes in the leaves and feed on the mesophyll. A moderate temperature is conducive to the insect development and the insect remains active throughout the year except December-January.

Management

- Collect and destroy insect infested leaves.
- Conserve *Cotesia plutelfae,* as it is an important parasitoid for diamond back moth.
- *Diadegma insulare* is the most important parasitoid of the diamond back moth.
- Foliar spray of 4% NSKE.
- Spray the crop with malathion 50 EC @ 1.0 litre / ha in 600-800 litre of water.

Termite or white ant (*Odontotermus obesus*)

Termites severely attack the *Brassica* crops all over the country, especially under rainfed conditions. Termites are highly polyphagous in nature and remain active throughout the year on crop debris and stubbles. The insect is small, soft, creamy in colour and wingless with biting and chewing type of mouthparts. Infested plants initially turns yellow and finally dries due to extensive root damage.

Management

- Destruction of plant debris in and around the fields.
- Deep summer ploughing.
- Use only well decomposed farm yard manure.
- Frequent irrigation helps in reduction of termite infestation.
- Arthropod predators of termites are scorpions, frog, snakes, cricket, spiders, dragonflies, wasps and beetles. Some birds are also found to feed on alates swarmers, which consume about 10 to 30 per cent of swarmers.
- Entomopathogenic fungi like *Beauveria bassiana* 1kg multiplied in 50kg FYM/compost can effectively control the termites.
- Application of chlorpyriphos 20 EC @ 4 litre/ ha during last ploughing and properly mixing in soil minimize the termite infestation.

Disease Management

Diseases to a large extent are responsible for low and unstable production of rapeseed-mustard and cause the yield losses up to 90 per cent. More than 22 diseases have been reported to affect rapeseed-mustard group of crops in India. Among these, the important diseases affecting the production and productivity of rapeseed-mustard in Assam are Alternaria blight, white rust, downy mildew, powdery mildew, Sclerotinia stem rot, club root, bacterial rot and phyllody.

Alternaria blight or leaf spot *(Alternaria brassicae)*

Alternaria blight or leaf spot disease is found throughout the rapeseed-mustard growing areas of the country. The disease is characterized by the formation of prominent, light brown to black round spots with concentric rings of various sizes on leaves, stem and siliquae leading to subsequent blighting and defoliation. The disease appears on leaves after one month of sowing and progress from lower leaves with small sized spots and later covers almost the entire leaf. Later at maturity, round to linear black spots appear on siliquae and stem of toria, yellow and brown sarson and brownish black spots with a distinct gray centre on mustard siliqua, which later elongate. The seeds in the siliqua may become small, shrivelled and rotten. The disease is more severe in yellow sarson where it can cause yield loss up to 70 per cent. Moist (>70% RH) and warm weather (12-25°C temp) with intermittent rains favour the development of Alternaria blight.

Management

- Timely sowing (first fortnight of October) of healthy and certified seeds
- Collect and burn the diseased plants debris and remove weeds to minimize the spread.
- Avoid irrigation at pod formation stage.
- Spraying of Iprodione @ 2 g per litres of water or mancozeb (dithane M-45) @ 2.5 kg/ha at 15 days interval with a maximum of three sprays, normally at 45, 60 and 75 days after sowing or Tebuconazole 50%+ Trifloxystrobin 25% 1 g /lit of water at 45 and 75 DAS (use 700-800 lit. water/ha).

White rust (*Albugo candida*)

White rust disease is found throughout the rapeseed-mustard growing areas of the country, very often in association with downy mildew disease. Small white or creamy yellow raised pustules, which later coalesce to form patches, are found scattered on the lower surface of the leaves. The part of upper surface corresponding to the lower surface is tan-yellow, which enable recognition of the affected leaves. Rust pustules are also observed on surface of well-developed siliquae. In systemic infection or infection through stem or flower, hypertrophy and hyperplasia are observed, which result in formation of stagheads. Affected flowers become malformed, petals become green like sepals and stamens may be transformed to leaf-like club-shaped sterile structures. Ovules and pollen grains are usually atrophied leading to complete sterility. Whole plant infection at very early stage due to systemic infection of white rust in association with downy mildew results in stunted and thickened plant without any branching.The white rust and downy mildew mixed infection can cause yield loss up to 37 % in Indian mustard. Moist air (> 75% RH), cool weather (5-12° C) and short days (2-6 hours sunshine) favour the disease development.

Downy mildew *(Hyaloperonospora parasitica)*

Downy mildew disease in rapeseed-mustard has been reported extensively from Assam and adjoining states. The disease usually appears 10-15 days after sowing as small creamy white spots on the leaves in the seedling stage and at times could be even restricted to these leaves with subsequently emerging leaves not showing any symptom. White

downy (cottony) growth of the fungus appear on leaves and spread to stems and stag heads formed by white rust pathogens in the moist (>90% RH) and cool (10-20^{0}C temp) weather. Swollen malformed floral parts usually show mixed infection of downy mildew and white rust.

Management of white rust and downy mildew

- Timely sowing (Before October 15) of healthy and certified seeds from stag head free plants.
- Treat the seed with Metalaxyl- 35 SD (Apron- 35 SD) @ 6 g/ kg seed.
- Collect and burn the diseased plants debris including stag heads and remove weeds to minimize the spread.
- Spray the crop (maximum two) with Ridomil MZ 72 WP @ 2 kg/ha dissolved in 800 litres of water soon after disease appearance and repeat at 15 days interval.
- Avoid irrigation at pod formation stage.

Sclerotinia rot *(Sclerotinia sclerotiorum)*

Sclerotinia rot disease is emerging as one of the important disease of rapeseed-mustard in the country. Earlier Sclerotinia rot was considered as a minor disease in India. Yield losses up to 39 per cent has been observed due to this disease. It is a soil borne disease and mono cropping of rapeseed-mustard favours its development. Based on the symptoms, the disease has also been called as white blight, white rot, stem blight, stalk break, stem canker etc. Symptoms on the stem become visible as elongated water-soaked lesions, which later on covered by a cottony mycelial growth of the pathogen. When the stem is completely girdled by such lesions, the plant wilts and dries. Sometimes the infection is restricted to a smaller area of pith, which results in stunting of the plant and premature ripening rather than the sudden collapse of the affected plants. Such plants, under field conditions can be easily identified because of premature ripening. Premature ripening may also cause additional yield loss due to shrivelled seeds. The affected stem tends to shred; and numerous black, spherical sclerotia appear either on the surface or in the pith of the affected stem. In some infected plants grain formation does occur. The disease also affects the seed quality adversely. When the crop is at maturation stage, the affected plants tend to lodge, bringing the siliquae in contact with soil. Such plants, though remaining free from stem or aerial infection throughout, show rotting of the siliquae with profuse fungal growth along with sclerotial bodies just above the soil level.

Management

- Collection and burning of the diseased plants along with sclerotia.
- Deep ploughing during summer.

- Follow crop rotation with non-host crops like wheat, barley and maize.
- Sowing of healthy seeds free from the sclerotial bodies.
- Irrigation management (no irrigation during 25 Dec-15 Jan).
- Seed treatment with *Trichoderma* 10g/kg seed.
- Foliar spray of carbendazim 2g or tebuconazole @ 1 ml/lt of water at 60-70 DAS (use 700-800 lit. water/ha).

Bacterial rot (*Xanthomonas campestris)*

This disease is reported in sporadic form in Assam. This is a soil and seed borne disease. The symptoms of the disease are visible when plants are about 40-50 days old and significant infection occurs in warm and humid weather. At initial stage, dark colour streaks develop on stem from the ground level, which girdle the stem making it very soft and hollow due to rotting. The lower leaves show midrib cracking, browning of veins and withering. Profuse exudation of yellowish fluid from the affected stem and leaves may also occur. This disease does not cause any disagreeable odour as found in bacterial stalk rot.

Management

- Follow 3-4 years crop rotation.
- Spray carboxin or Copper oxychloride @ 2.5 kg/ ha dissolved in 800 litre of water. If required, repeat the spray at 15 days interval.
- Collection and burning of the diseased plants and their residue.

Club root *(Plasmodiophora brassicae)*

It occurs frequently in poorly drained (high soil moisture) acidic soils under humid weather. At the initial stages, the affected plants show normal healthy growth, but as the disease develops (60 DAS), the plants become stunted showing pale-green or yellowish leaves. The plant may be killed within a short time or less number of flowers, siliquae and seeds are formed and siliqua may be curved.

When the plants are pulled, overgrowth (hypertrophy/ hyperplasia) of the main and lateral roots becomes visible in the form of small or spindle or spherical-shaped knobs,

calledclubs containing large numbers of resting spores. The older, more particularly the larger, clubs disintegrate before the end of the season.

Management

Apply chemical amendment lime @ 3 ton/ha along with compost before sowing in the infested soil so as to increase the soil pH to 7.2 and save the crop.

Phyllody *(Mycoplasma like organism)*

Phyllody disease has been reported from Assam and develops under warm and dry climate. The disease has been observed particularly on toria and yellow sarson and is transmitted through insect vector like leaf hopper. Up to 90 % yield losses have been reported on the individual plants and losses in yield could be substantial under field conditions, if the percentage of the diseased plants is high. The symptoms include, transformation of floral parts into leafy structures, green and sepaloid petals, indehiscent stamens, ovary without ovules and leafy structures on false septum. Plant parts are malformed into numerous shoots as bushy or broom shaped.

Management

- Sowing of toria should be done by mid September.
- Rouging of the affected plants at early stage.
- Spray Oxydemeton methyl (Metasystox) 25 EC or Dimethoate (Rogor) 30 EC @ 800 ml dissolved in 800 litre of water/ha at appearance of the disease.

Powdery Mildew *(Erysiphe Cruciferarum)*

The dirty white, circular powdery patches develop on leaves, stems and pods. As the disease advances, the whole plant looks to be dusted with powder like white talcum. The severely affected plants remain poor in growth and produce less silliquae. Severely diseased siliquae remain small in size, produce seeds, which are small in size and show shriveling. Such siliquae produce few seeds at the base with twisted sterile tips.

Management:

Spray of 1 kg dinocap or 2 kg wettable sulphur/ha dissolved in 800 liters of water at the incidence of the disease is effective to control the disease.

Weed management

Weeds are one of the major deterrents in sustaining the productivity of rapeseed-mustard and as they compete with the crop for soil moisture and nutrients, efficient weed management is therefore, very necessary to check the losses caused by weeds and to increase the productivity of the crop. Weeds reduce productivity, deplete nutrients and soil moisture, harbour pests and diseases and nematodes, reduce quality of farm products, affect health of animals and quality of products, increase production and processing cost, affect human health, reduce land value and crop choice. Weeds have been reported to cause yield reduction up to 70 per cent. They can also remove significant quantity of nutrients from the soil (up to 48 kg N, 14 kg P and 82 kg K/ha). The critical period of crop-weed competition in rapeseed-mustard has been identified from 15 to 40 days after sowing.

An integrated approach combining cultural practices, preventive measures and chemical control should be adopted for ensuring proper control of weeds in the field. Use of weed-free crop seed, well-decomposed manure, clean machinery/implements, screens to filter irrigation water, removal of weeds near irrigation ditches and fence rows and restricting livestock movement are the preventive ways of weed management. Tillage, crop rotation, soil solarization, maintenance of optimum plant population, optimum planting date, optimum planting geometry, use of 'live mulches' or smother crops, intercropping, nutrient and water management are the cultural method of weed management. Pendimethalin @ 1.0 a.i./ha as pre-emergence is the recommended herbicides for control of the weeds of rapeseed-mustard crop. Manual and mechanical methods (hand weeding and hoeing) are still the most commonly used methods for weed control in mustard cultivation. However, the major limitations are that the operation needs to be repeated, does not control weeds in crop rows, may damage crop roots and may result in soil compaction. The increasing labour wages and shortage of labour at peak times and tediousness of manual weeding also lead to low adoption of manual weeding. In Assam, two hand weedings; 15-25 DAS and 35-40 DAS are recommended for proper weed control. A short discussion on the parasitic weed called Broomrape, which is a serious problem in rapeseed-mustard is appended below.

Broomrape (*Orobanche aegyptiaca*)

Orobanche aegyptiaca, a total root parasite is endemic in India and is found in many states including Assam. The infestation of orobanche is more severe under rainfed situations. It parasitizes the *rabi* season crops like rapeseed-mustard, cabbage, cauliflower, turnip, brinjal, tomato, tobacco, carrot and many other cruciferous and solanaceous plants having taproot system.The farmer becomes aware of the problem only after the emergence of the parasite above the soil and by that stage, considerable damage to the crop has already occurred. It causes a yield loss of 25-30% in rapeseed-mustard. The broomrape draws the nutrients and water from the host under the soil surface for about 60 days, whereas

emergence, flowering and seed setting of the parasite may last for only 15-20 days. The parasite appears as clumps of whitish, yellowish, brownish or purplish broom arising from the base of the mustard stem at ground level. It is totally devoid of chlorophyll and is unable to produce its own food, hence draws total nourishment from the host plant. *Orobanche* consists of a stout flashy stem, 25-35 cm high and covered by small thin and brown scaly leaves. Flowers appear in the axils of leaves and are white and tubular. The fruits are capsular and contain numerous tiny seeds. The seeds are very small and black in colour. Usually broomrape has very high seed production potential and shed the seed about 10 days before the mustard harvest. The seeds can remain dormant up to 20 years in the soil. The seeds are disseminated to new areas by means of wind, water, birds, animals (grazing), seeds of the host plants and human activities. Mechanical methods (uprooting) are not very successful because the parasite emerges so close to the host that the host can also sustain damage.

Management

- Deep summer ploughing may cause desiccation of the seeds of the parasite and place the seeds below the root zone, which prevents the germination of the parasite. Further, the dry heat exposure may destroy the seeds of the parasite and considerably reduce their viability. However, as the broomrape seeds remain viable in the soil for up to 20 years, deep ploughing may not be effective in the long run.
- Trap crops are the non-host plants that can stimulate the germination of broomrape seeds but they themselves are not parasitized. Some of the trap crops for broomrape are sorghum, pearl millet, maize, chilli, castor, sesamum, niger, soybean, linseed, amaranthus, turmeric, greengram, horsegram, cowpea, redgram, blackgram, lucerne and sunhemp. These trap crops reduces the soil seed bank of the parasite considerably. Taking sorghum or pearl millet as preceding crop of mustard can reduce its infestation.
- Soil solarization by using 0.1 mm thick transparent polyethylene sheet for a period of 40 days during summer effectively controls this weed. Solar heating is achieved by covering pre-irrigated fields with transparent polyethylene sheet. This technique results in heating the covered soil by 8-14°C more than the uncovered soil. This method is however, costly due to the high cost of polyethylene.
- ·Soil fumigation with methyl bromide (350 kg/ha) prior to planting provides effective control of broomrape.

Potential of Improved Rapeseed-Mustard Production Technology in Assam

The adoption of improved technologies can enhance both yield and farm income in the state. The results of the frontline demonstrations under whole package conducted in the state during the period 2019-20 clearly demonstrate this fact. The average yield improvement recorded over the farmer practice in the demonstrations was 36.6 per cent under the rainfed conditions. The additional net monetary benefits arising from adoption of whole package in Assam in this period under various crop situations was Rs 6699/ha. This indicates that the yield impact of technology adoption could be maximum in those districts where rapeseed-mustard is grown rainfed conditions.

Key Strategic Interventions to Enhance Productivity of Rapeseed-Mustard

The difference in actual yield of rapeseed-mustard in the farmers' fields and the yield attainable as demonstrated in the frontline demonstrations is of substantial magnitude. Concerted effort is required to enhance the productivity in the state. The following specific interventions are to be accorded high priority to attain higher productivity of rapeseed-mustard in Assam.

- Replacement of old/obsolete varieties
- Application of improved agro-techniques
- Trapping areas under rice-fallows in Eastern states for mustard
- Production of quality seeds in participatory mode
- Maximize area under the plant protection umbrella
- Organizing FLDs for pure/intercropping system with improved varieties
- Distribution of large number of FLDs containing seed, fertilizers, seed dressers
- Distribution of literature on package of practices
- Training of field level extension workers and farmers
- Remunerative price incentives for rapeseed-mustard crop
- Keeping honey bee boxes in rapeseed-mustard fields to improve pollination
- Application of 40 kg S /ha be done. In addition, Zinc and Boron be applied, in deficient areas, on the basis of soil health card.


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REGIONAL AGRICULTURAL RESEARCH STATION
SHILLONGANI, NAGAON-782002
ASSAM AGRICULTURAL UNIVERSITY
প্রদর্শনমূলক ভ্রমণ
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under
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Date: 9-10 Feb., 2021
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ICAR-Directorate of Rapeseed-Mustard Research

सेवर, भरतपुर – 321 303 (राजस्थान)

Sewar, Bharatpur-321 303 (Rajasthan)

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