Technical Bulletin

RESEARCH HIGHLIGHTS OF OPIUM POPPY UNDER AICRP

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All India Co-ordinated Research Project on Medicinal and Aromatic Plants
National Research Centre for Medicinal and Aromatic Plants
Boriavi, Anand, Gujarat 783 310

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Foreword

Opium poppy was known to have sleep inducing properties recognised by the Greeks in third century B.C. It is considered as an oldest and perhaps the best known drug for pain relief used since time immemorial. Modern pharmacopoeia also describes preparation of a number of drugs such as analgesic, sedative, antispasmodic, hypnotic, anaesthetic, etc. using opium. The plant possesses about 40 alkaloids of which morphine, codeine, thebaine, narcotine and papaverine are of commercial importance.

It is believed that poppy was introduced in India in 7th century A.D. but, it received considerable importance in commercial cultivation by the British. India is the largest supplier of opium in the international market and it is cultivated through licensing. To meet the internal demand and export, the estimated opium requirement is about 1000 m ton per year. Since productivity is increasing there is reduction in area of cultivation in the crop. At present about 52 kg /ha of opium is harvested in Madhya Pradesh and Rajasthan and 42 kg /ha in Uttar Pradesh. ICAR initiated Opium poppy research through AICRP on Medicinal and Aromatic Plants during 1980 by creating three centres in the Opium poppy growing states. The project has generated very useful information on various aspects of its cultivation and six new high yielding varieties have been released. Plant protection measures and schedule have been developed for effective disease management. Phytochemistry in relation to important alkaloids has been worked out. This publication is an attempt to compile all useful information generated in the AICRP on Medicinal and Aromatic Plants

on Opium poppy research in the form of a technical bulletin. I am sure that this bulletin will be of immense value to the growers, planners, students and scientists engaged in Opium poppy research.

I complement Dr. S. Maiti, Project Co-ordinator (Medicinal and Aromatic Plants) and Director, NRC for Medicinal and Aromatic Plants, Anand and his team for this painstaking compilation and look forward to receive many such publications.

S. P. Ghosh

(S. P. Ghosh)

Preface

Opium poppy is cultivated in India only in three states viz. Madhya Preadesh, Uttar Pradesh and Rajasthan. The cultivation is through licensing from the Central Bureau of Narcotics, Government of India. Since India is major supplier of the opium in the international market, it was our constant endeavour to maintain the prime status by increasing the productivity. Indian Council of Agricultural Research took the lead of Opium poppy research in the country by creating three centres of All India Co-ordinated Research Project on Medicinal and Aromatic Plants at JNKVV, Mandsaur; NDUAT, Faizabad and RAU, Udaipur in 1980. The project initiated research work for overall increase of the productivity by way of developing new high opium yielding varieties, standardization of agrotechnique, disease management strategies etc. So far six new high latex yielding varieties have been released. This efforts have amply reflected in the latex productivity of the crop. In 1980 the latex production was about 14 kg /ha which has gone steep up to about 50 kg /ha by 1997-98.

The project has also made large collections of germplasm assembly having wide variability in terms of leaf morphology, flower colour and morphology, capsule shape and size, seed colour, latex recovery, alkaloid content and reaction to insect pest and diseases. Various components of production technology have been worked out in relation to high latex yield, such as plant population, irrigation, fertilizer doses, micronutrient, weed control, disease management, etc. A large number of promising cultures are in the pipe line for varietal release.

The priorities of research is also changing from time to time. So far we were looking for varieties having high morphine content. But now demand for high thebaine content is arising in the international market. Pharmaceutical application of poppy flower morphine for cancer patient is also a new emerging line. As a result of these, our research priorities are also need to be altered to match the demand.

We tried here to consolidate the research information generated on Opium poppy under the AICRP on Medicinal and Aromatic Plants over the years. Results of one year experiment, statistically nonsignificant and having doubtful

interpretations are carefully avoided in this bulletin. We hope that this bulletin will serve the planners, researchers and development agencies as a base document for their future planning in this crop.

I take this opportunity to express my sincere thanks to Dr. S. P. Ghosh, Deputy Director General (Horticulture) and Dr. R. N. Pal, Assistant Director General for their persuasion and encouragement for this publication. I am thankful to Dr. S. K. Pareek, Dr. R. C. Mishra, Dr. J. Prasad and Dr. P. C. Bordia for their contributions to clarify certain points. Thanks are also due to Mr. Kunal Mandal, Scientist (Plant Pathology) for supervising the publication and to Mr. Suresh Patelia for providing secretarial assistance.

Anand — Satyabrata Maiti

August 29, 2000

INTRODUCTION

Opium poppy (*Papaver somniferum* L.) is one of the most important medicinal plants known and used by the Greeks in 3rd century B.C. This plant is chief source of commercial opium and cultivated for extraction of latex from the fully grown capsule. Latex contains a number of alkaloids such as morphine, codeine, thebaine, narcotine, papaverine, etc. which are used in preparation of modern medicines prescribed as analgesic, sedative, hypnotic and antispasmodic. It is also grown as a source of edible seeds and seed oil used in culinary. Poppy seeds contain about 52% oil, rich in linoleic acid (68%) which makes it desirable for lowering cholesterol level in the blood to prevent coronary heart trouble. India is having its legal cultivation controlled by Narcotics Department, Government of India and is one of the largest producer of opium alkaloids. Besides fulfilling the domestic demand, a large quantity of opium is exported every year. The estimated requirement of opium to fulfil the internal and export demand is about 1000 m ton per year. Data on production, productivity and export of opium are presented in Table 1. At present its cultivation is confined to three states only viz. Uttar Pradesh, Madhya Pradesh and Rajasthan. The area under Opium poppy cultivation is divided into 12 opium divisions by the Narcotics Department covering districts of Faizabad, Barabanki, Bareilly, and Shahjehanpur in Uttar Pradesh; Neemuch I and II, Mandsaur I and II and Ratlam in Madhya Pradesh; and Kota, Chittorgarh and Jhalawar in Rajasthan.

Table 1. Production, productivity and export of opium in India

Year	Production in m ton	Productivity in kg per ha	Export in m ton
1994-95	1071	46.974	488
1995-96	1077	47.652	555
1996-97	1289	51.710	537

Source: Central Bureau of Narcotics, Govt. of India

HISTORY

All India Coordinated Research Project on Medicinal and Aromatic Plants initiated Opium poppy research during sixth plan period after receiving request from the Narcotics Department of the Union Ministry of Revenue to increase the productivity and reduce crop loss from downy and powdery mildew diseases. Three new centres were created to cater the need of Opium poppy growing states of Madhya Pradesh, Uttar Pradesh and Rajasthan.

OBJECTIVES

In the beginning, objectives of the Opium poppy research were to undertake research on collection of germplasm, various aspects of crop improvement for increasing productivity and disease management to reduce losses mainly due to downy mildew. Crop production research was also taken up to provide cost effective package of practices to the farmers.

LOCATION OF RESEARCH CENTRES

The centres are located in Jawaharlal Nehru Krishi Vishwa Vidyalaya at Mandsaur, Acharya Narendra Dev University of Agriculture & Technology at Faizabad and Rajasthan Agricultural University at Udaipur. The centres continued to work on Opium poppy research in seventh, eighth and ninth five year plans. Over the years the Opium poppy research centres have made very significant contributions in germplasm assembly, release of high opium and seed yielding cultivars and development of cost effective package of practices giving recommendations on population density, irrigation, fertilizers, weed control, crop rotation, disease management, etc.

RESEARCH ACHIEVEMENTS

Genetic Resources Management

A National level germplasm collection of Opium poppy was initiated by National Bureau of Plant Genetic Resources (NBPGR), New Delhi during 1979 in the Opium poppy growing states of Madhya Pradesh, Uttar Pradesh and Rajasthan. This programme included the participation of the Agricultural Universities located in respective states and National Botanical Research Institute, Lucknow. They made a total of 127 collections of which 50 were from Madhya Pradesh, 38 from Uttar Pradesh and 36 from Rajasthan. Heterogenity analysis of these collections revealed the presence of maximum variability from Kota district of Rajasthan. In 1982, an attempt was again made for exhaustive germplasm collection from Kota region as a collective endeavour by the Opium poppy research centres of AICRP and 57 more accessions were added to the previous collection, totalling it to 184 national collections. These national collections along with the local collections made by the AICRP centres independently became the basic material for developing new varieties of Opium poppy.

A total of 90 germplasm lines at Mandsaur, 58 at Faizabad and 80 at Udaipur were evaluated and catalogued and are maintained. A wide spectrum of variability was noticed in these collections in terms of leaf morphology, flower colour, capsule shape and size, latex yield, disease and insect pest reactions and alkaloid content (Fig. 1 & 2).

The study conducted revealed that latex yield was a complex phenomenon and was contributed by a number of traits such as number of capsules per plant, number of leaves per plant, length x breadth of the sixth leaf, etc. These could be taken as valuable selection indices. Sibling mating technique was used successfully to maintain the genetic diversity in the germplasm stock.

Fig. 1. Variability in flower colour and petal type

Fig. 2. Variability in capsule shape and size

Crop Improvement

Crop improvement in Opium poppy was initiated in three AICRP centres during 1980-81 in addition to NBPGR (the then AICRP Head Quarters). Selection carried out at different centres resulted in development of a number of high latex and seed yielding cultures with moderate resistance to downy mildew. These were tested under the multi-location co-ordinated trials over the years and a total of six varieties were released (Table 2). Important characteristic features of released varieties are presented in Table 3.

Table 2. Released varieties of Opium poppy

Variety	Source	Year of release	Centre
Jawahar Aphim	MOP 16	1984	Mandsaur
Chetak Aphim	UO 285	1989	Rajasthan
Trisna	IC 42	1989	Delhi
Kirtiman	NOP 4	1990	Faizabad
Jawahar opium 539	MOP 539	1997	Mandsaur
Jawahar opium 540	MOP 540	1998	Mandsaur

Table 3. Characteristic features of the released varieties

Plant Character	Jawahar Aphim	Chetak Aphim	Trisna	Kirtiman	Jawahar opium 539	Jawahar opium 540
Plant height (cm.)	95-100	90	90	106-108	75-80	91.1-95.0
Leaf type	Serrated	Deeply serrated	—	Serrated	Deeply serrated	Serrated
Flower colour	White	White	Pink	White	White	White
Petal type	Deeply serrated	Serrated	—	Serrated	Serrated	Serrated
Days to flower	80-85	91-97	—	80-90	80-85	85-90
Days to first lancing	110	100-105	—	115-120	105	110
Number of capsules per plant	2-3	1	5-7	2-3	2	2
Latex yield (kg/ha)	60-65	52.7	49-53	45-50	65	75
Seed yield (kg/ha)	1226	1000	—	1000-1200	1740	1788
Morphine content	12.26 %	12.50%	14.78 %	12.00 %	14.85%	13.00%
Disease reaction	Susceptible	Moderately resistant	Moderately resistant	Moderately resistant	Moderately resistant	Moderately resistant

Besides these, single plant selection, hybridization and mutation breeding were also carried out in the centres to develop high latex yielding varieties with resistance to downy mildew and insect pests. A number of promising cultures were developed and they are under different stages of evaluation at present (Table 4). Experiments on utilization of hybrid vigour have shown great promise in this crop and work has been initiated in this direction.

Crop Production

Plant Population on latex, seed and husk yield

Plant population study was conducted for four years in three centres located at Mandsaur, Faizabad and Udaipur in addition to NBPGR. Increased latex, seed and husk yield were observed in a population of 4.4 lakh plants per ha in all locations, compared to 3.3 lakh plants per ha. Though the results were not found consistant in all the four years, the increased

Table 4. Promising cultures under testing at different AICRP centres

Selection criteria	Cultures	Developed by
Latex and morphine yield	NOP1	Selection
	NOP 549	Selection
	ND 1002	Selection
	UO 601	Selection
	UO 201	Selection
	UO 185	Selection
	MOP 541	Selection
	MOP 278	Selection
	NC 57913	Selection
	NC 57968	Selection
	IC 42 x UO221	Hybridization
	JA 16 x IC 27-7	Hybridization
	NBRI 2 x Soya Pankhi	Hybridization
	IC 42 x IC 7	Hybridization
	IC 42 x IC 319	Hybridization
	IC 42 x MOP 307(NBPGR 3)	Hybridization
	MOP 3(Mutant) x JA 16	Hybridization
Dwarf, early maturing	MOP 3	Mutation
Downy mildew resistance	MOP 541	Selection
	UO 285 x Ghazipur Local	Hybridization
	UO 285 x MOP 539	Hybridization
	UO 285 x IC 27-7	Hybridization
	UO 285 x IC 15-2	Hybridization
	NOP 4 x MOP 539	Hybridization
Frost resistance	MOP 503	Selection

trend in 4.4 lakh plant population was observed in all locations for two or more than two years (Fig. 3 & 4).

Effect of position of capsule and number of lancing on latex yield and quality

The experiment conducted at Udaipur showed that the latex yield was obtained maximum (68.5 kg/ha) from the terminal capsules. Effect of number of lancing on latex yield showed that highest yield was recovered from first lancing of capsules irrespective of their position. Similar trend was also observed for morphine content. Latex yield and morphine content gradually declined in subsequent second and third lancing (Table 5).

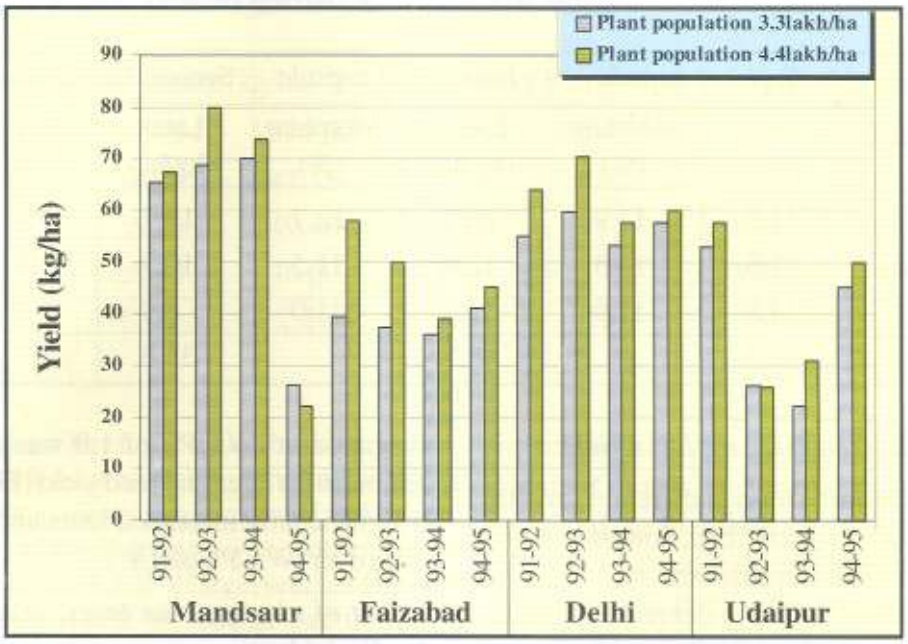

Fig. 3. Effect of population density on latex yield

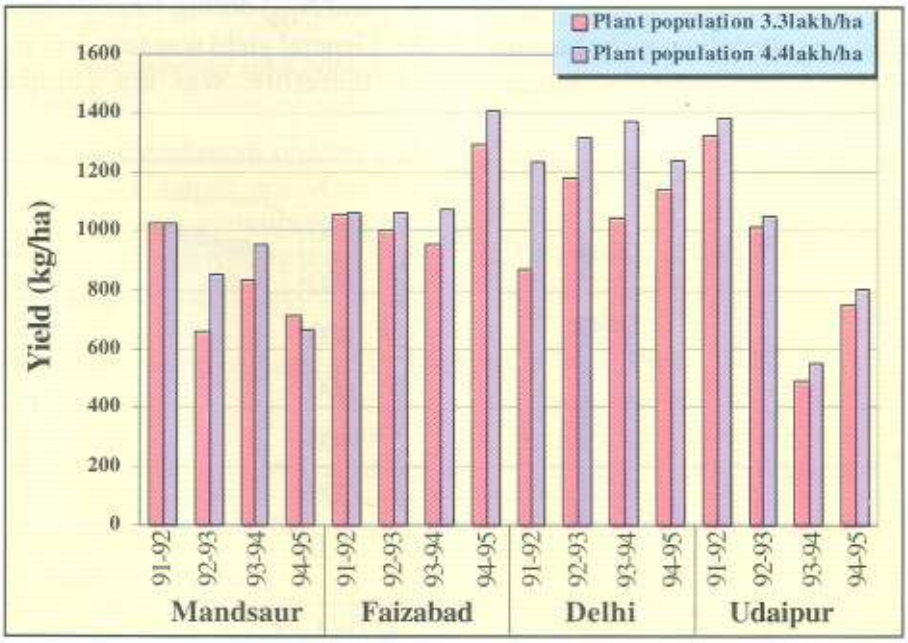

Fig. 4. Effect of population density on seed yield

Table 5. Effect of position of capsule and number of lancing on latex yield and quality

No. of lancing	Terminal capsule		First lateral capsule		Second lateral capsule	
	Latex (kg/ha)	Morphine (%)	Latex (kg/ha)	Morphine (%)	Latex (kg/ha)	Morphine (%)
First	31.2	13.9	20.8	12.7	15.7	11.5
Second	22.5	13.3	12.6	11.5	10.9	10.5
Third	14.8	11.9	11.7	11.0	8.9	9.8
	68.5		45.1		35.5	

Effect of irrigation on latex yield

Moisture stress at different growth stages such as rosette, bud, flowering, early capsule, late capsule and bud + early capsule was found to decrease the seed and husk yield at Mandsaur. Maximum reduction upto 29% was observed in moisture stress given at bud + early capsule stage.

Irrigation scheduling on the basis of different IW:CPE was done at Mandsaur. Irrigation at IW:CPE of 1.0 was found optimum for latex and seed yield (Fig. 5). It significantly increased latex and seed yield over IW:CPE of 0.8.

Effect of nitrogen on latex, seed and husk yield

An experiment was conducted at Udaipur with three doses of nitrogen (N_{90}, N_{120} and N_{150}) during 1993-94 and 1994-95. General yield was very low in 1993-94, therefore, was not comparable.

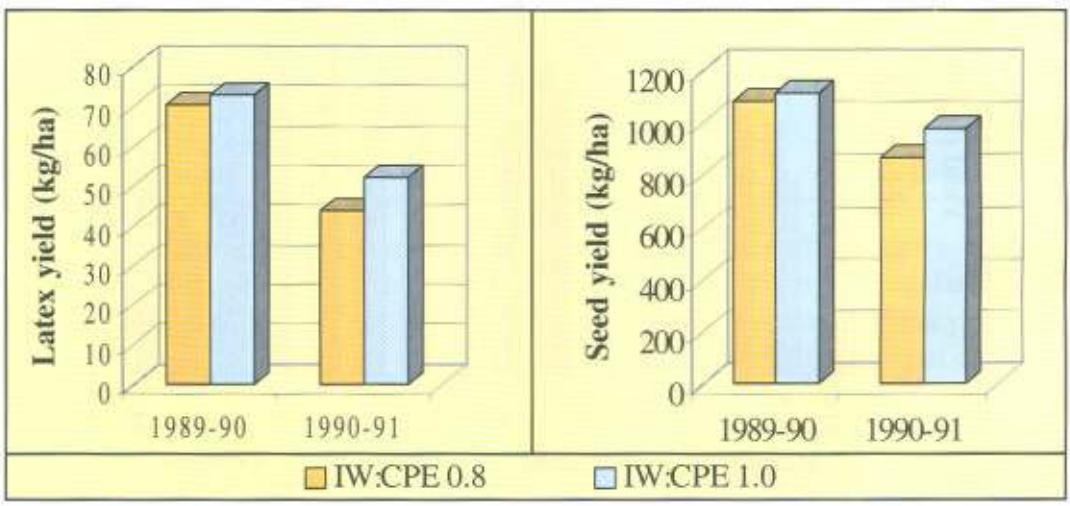

Fig. 5. Latex and seed yield in relation to different IW:CPE

Table 6. Effect of nitrogen levels on latex, seed and husk yield at Udaipur

N level	Latex (kg/ha)		Seed (kg/ha)		Husk (kg/ha)	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
N_{90}	24.90	47.15	430	762	330	739
N_{120}	26.20	49.48	550	787	380	813
N_{150}	28.30	46.60	570	777	390	793
CD (P=0.05)	3.00	2.26	130	020	060	050

However, latex, seed and husk yield in 1994-95 showed that N_{120} treatment was the best in increasing latex, seed and husk yield in comparison to the other two treatments. Yield of latex, seed and husk either declined or was at par in N_{150} treatment (Table 6). Experiment conducted on effect of foliar spray of urea at flowering and early capsule formation showed that application of 3% urea increased about 14.3% seed yield.

Effect of phosphorous and potassium on latex yield

Effect of phosphorous on latex yield was studied at Udaipur and Mandsaur. Response of phosphorous upto 40 kg per ha depending upon the fertility status of the soil was observed and about 14.2% increase in latex yield was recorded at Udaipur (Table 7). Similar results were obtained at Mandsaur also. Morphine content was unaffected by application of phosphorous. Potassium was found non-significant to increase latex yield.

Weed control

Experiment conducted showed that application of 0.375 kg a.i. of Isoproturone per ha + one hand weeding at 30 days after sowing (DAS) effectively reduced the weed population with an increased latex, seed and husk yield at Faizabad. However, at Mandsaur, 0.250 kg a.i. of Isoproturone per ha + one hand weeding at 30 days

Table 7. Effect of phosphorous on latex yield

Treatments	Udaipur Latex yield (kg/ha)		Mandsaur Latex yield (kg/ha)	
	1985-86	1986-87	1985-86	1986-87
P_0	36.69	46.46	40.63	64.52
P_{20}	38.90	50.30	46.06	72.87
P_{40}	41.80	53.18	46.29	80.82
CD (P=0.05)	2.75	3.87	4.79	6.04

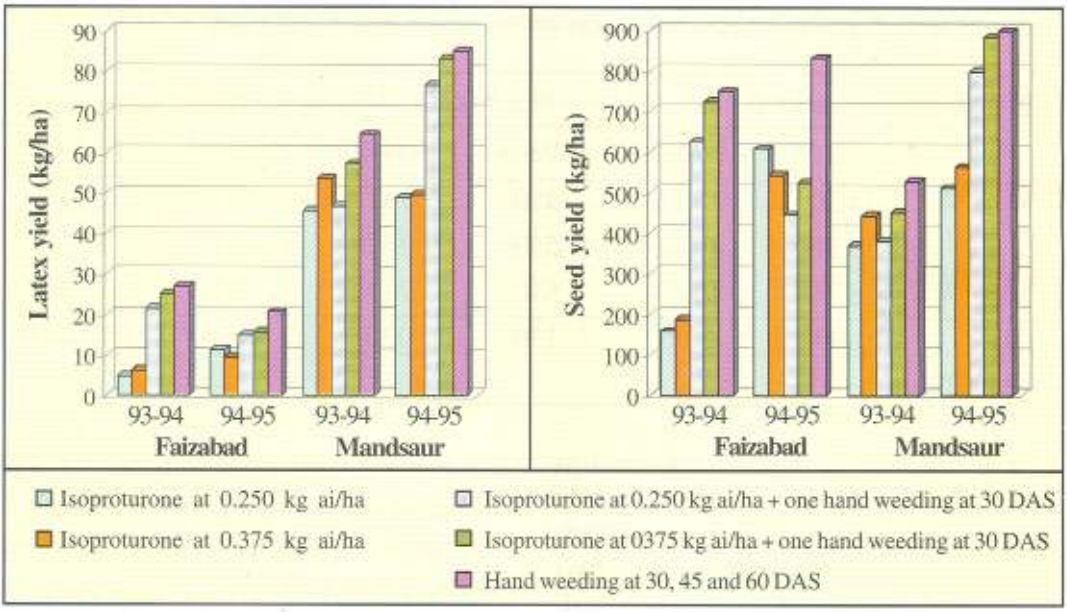

Fig. 6. Effect of Isoproturone and hand weeding on latex and seed yield

after sowing was found to be an effective treatment for weed control. These treatments were at par with three hand weedings at 30, 45 and 60 days after sowing (Fig. 6).

Crop rotation

Three crop rotations, Maize (*Zea mays*) - Opium poppy, Black gram (*Phaseolus mungo*) - Opium poppy and Groundnut (*Arachis hypogea*) - Opium poppy were studied to find out an effective Kharif crop rotation. Black gram - Opium poppy and Groundnut - Opium poppy were found to be superior to Maize - Opium poppy rotation at Udaipur. However, at Faizabad Black gram – Opium poppy was found to have the superior effect over the other two rotations when latex production was considered. For seed production, Maize-Opium poppy was also found equally effective.

Plant Protection

Disease survey

A disease survey was conducted in the Opium poppy growing areas of Madhya Pradesh, Uttar Pradesh and Rajasthan during 1986-87. The major diseases recorded in the crop were downy mildew (Fig. 7) caused by *Peronospora arborescens* (Berk.)de Bary and powdery mildew caused by *Erysiphe poligoni* D.C.

Downy mildew infection was recorded in a range of 40-70%. A positive correlation was found between downy mildew incidence and rainfall, number of rainy days, relative humidity, maximum day-temperature, nitrogenous

fertilizer, high population density and late sowing. Powdery mildew caused an yield loss of 20-30 %. The disease appeared first in late sown crop. Symptoms appeared 14-16 weeks after sowing coinciding to flowering stage. The crop, sown before the second week of October, was less affected by the disease.

Screening for disease and insect pest resistance

The available germplasm was evaluated for resistance against downy mildew, powdery mildew and aphid infestation. At Mandsaur, results revealed that out of the total available germplasm 4.2 % was resistant and 11.4 % was moderately resistant. MOP 539 (Jawahar opium 539), MOP 540 (Jawahar opium 540) and MOP 539 x JA 16 were found as moderately resistant to downy mildew. Sick plot technique was found as the most suitable method for screening downy mildew. Culture, MOP 539 was also found moderately resistant to aphid.

Genetic analysis of resistance against downy mildew conducted at Mandsaur revealed the presence of both additive and non-additive gene action for expression of disease symptoms. Dominant genes with over-dominance and without inter-allelic interaction governed the disease severity.

Downy mildew control

Seed treatment with metalaxyl (Apron 35-SD) at 10 g/kg seed and 3 sprays of 0.2 %

Fig. 7. Infection of downy mildew

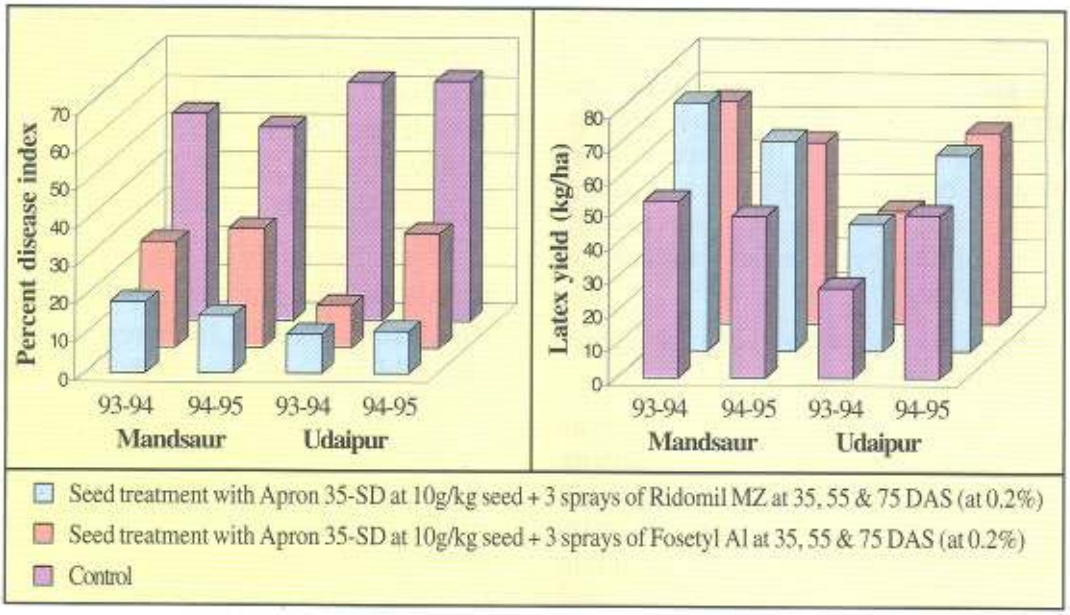

Fig. 8. Effect of fungicide treatments on downy mildew control

metalaxyl (Ridomil MZ) at 35, 55 and 75 days after sowing were highly effective in controlling the disease at Mandsaur and Udaipur (Fig. 8). Latex yield increased by about 36% and 51% over control at Mandsaur and Udaipur, respectively.

Aphid control

Methyl dematon at 0.05 % was found to be the most effective against aphids and increased 58.8 % more latex yield over control. Comparing to monocrotophos, this treatment proved to have a prolonged effect.

Capsule borer control

The attack of the capsule borer (*Heliothis armigera*) causes a serious yield loss in the crop (Fig. 9). The infestation of this pest is observed on the capsules at ripening stage during March-April. At Mandsaur, it was found

Fig. 9. Damage caused by capsule borer

that, spraying of Endosulfan 35 EC (0.05 %) or monocrotophos 40 EC (0.2 %) or Fenvalrate 20 EC (0.01 %) on 75th day followed by 2-3 more sprays at 15-day interval controlled capsule borers effectively.

Phytochemistry

A comparative study of the major five alkaloids at different stages of capsule maturity conducted at Delhi showed that the percentage of each alkaloid increased with the growth of capsule consistantly. The alkaloid content of the lanced capsule was worked out and it was found that lancing reduced the alkaloids in general, except codeine. A simpler method for solvent extraction of alkaloid from Opium poppy husk was also developed. The dried and powdered capsule (1 g) was extracted with 25 ml of 5 % glacial acetic acid for 20 minutes using a shaker. The extract was filtered and residue was extracted similarly three times more. The pH of the total extract was adjusted to 9.0-9.5 with aqueous ammonia solution (25 %). The liberated alkaloids were repeatedly extracted with a mixture of chloroform : isopropanol in 3:1 ratio. The extract dried over anhydrous sodium sulphate and evaporated to dryness under vacuum at 50°C, redissolved in 5 ml of methanol and 5 ml of this solution was injected into HPLC to get five major peaks in order of morphine, codeine, thebaine, narcotine and papaverine.

At Udaipur, it was found that combination of chloroform and isopropanol (3:1) was most suitable for the extraction of morphine and gave a better result in comparison to benzene, butanol combination (1:1). The recovery was about 95 %.

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