AICRP- RAPESEED-MUSTARD

Objectives

1. Development of high yielding and high oil content early maturing toria, yellow sarson and mustard with resistance to major diseases and insect pests and acceptable grain yield and oil quality for irrigated, rainfed and foot hills and hill region of Uttarakhand.
2. To study the grain and oil yield potential, nutrient response and nutrient use efficiencies of promising toria, yellow sarson, mustard and hybrids under high and low input management.
3. To develop cost effective protection technologies for the management of diseases and insect pests of rapeseed mustard.
4. To develop package of practices for new and resource efficient technologies for rapeseed mustard.

A. Genetics & Plant Breeding

1. Salient Achievements:

1. Varieties released since inception to 2018

Variety	Years of release/ notification	Number and date of notification	Pedigree	Seed yield (q/ha)	Days to maturity	Oil content (%)	Special feature
Toria							
Pant Toria-303	1985/1985	SO.832(E) Dt: 18.11.85	B-54×DSH 17 MD	9-11 (RF) 15-16 (IR)	90-95	42	High yielding for sowing in first fortnight of September in hills as well as in plains. Tolerant to AB, WR and DM diseases. Suitable for all *toria* growing areas of the country
Pant Toria-30	1985/1987	SO.165(E) Dt: 06.03.87	Polycross	14-16	90-95	42	High yielding for sowing in early September in Tarai and Bhabhar regions.
Pant Toria-507	1990/1990	SO.386(E) Dt: 15.05.90	HC-507 B develop from local population UP 74	8-12 (RF) 14-16 (IR)	85-90	43	Suitable for sowing under irrigated as well as rainfed conditions, especially in eastern parts of India
Uttara	2008/2010	SO.211(E) Dt: 29.01.10	Recurrent selection	9-11 (RF)	93-97	43	Medium maturity, high yielding tolerant to AB,

			from PT-303	15-18 (IR)			WR and DM diseases, suitable for sowing in 1st fortnight of September in plains of Uttarakhand.
Pant Toria-508	2015/2017	SO.1007(E) Dt: 30.03.17	(PT 507 × Bhawani) × PT 303	16-19	91-96	42	High yielding, suitable for sowing in September under irrigated conditions Uttarakhand plains
Pant Hill Toria-1	2015/2017	SO.1007(E) Dt: 30.03.17	PT-9719 × TS-50	12-Sep	122-134	42	High yield, suitable for sowing under rainfed conditions in Uttarakhand hills.
			Yellow Sarson				
Pant Pili Sarson-1	2005/2010	SO.211(E) Dt: 29.01.10	PT-9719 × TS-50	15-19	100-110	44	High yielding, suitable for sowing in October under irrigated conditions, tetralocular pendant bearing Uttarakhand plains
Pant Sweta	2015/2017	SO.1007(E) Dt: 30.03.17	PYS-841 ×PYS-7	16-20	105-110	45	High yielding, suitable for sowing in October under irrigated conditions, tetralocular upright bearing and cream colour flowers Uttarakhand plains
Pant Girija	2018	——	NDYS-123 × Ragini	14-17	92-128	45.3	Medium maturity, yellow flowered upright, bilocular siliqua bearing. Suitable for plains of Uttarakhand.
			Mustard				
Kranti	1982/1983	SO. 2 (E) Dt: 03.01.83	Sel. from Varuna	22-28	125-130	41	High yielding, stable, medium maturity, tolerant to *Alternaria* blight and mustard aphid. Suitable for timely sown irrigated conditions. All mustard growing areas of the country.
Krishana	1983/1984	SO.596(E)	Sel. from	22-28	130-132	40	High yielding,

		Dt: 13.08.84	Varuna				medium maturity, tolerant to frost, suitable for irrigated conditions in frost prone-areas. All mustard growing areas of the country.
Pant Rai-19	2012/2012	SO.1708(E) Dt: 26.07.12	Krishna-2-1×HS-027-1	20-25	110-115	40	High yield, suitable for early sown conditions, high temperature tolerance during early stages of the crop. Haryana, Punjab, Parts of Rajasthan, New Delhi
Pant Rai-20	2012/2015	SO.2680(E) Dt: 01.10.15	Pure line selection from Kranti'	25-30	122-128	40	High yield, medium maturity, bold seeded, suitable for irrigated/ rainfed timely sown conditions. High temperature tolerance at maturity. Uttarakhand plains
Pant Rai-21	2015/2017	SO.1007(E) Dt: 30.03.17	(Varuna × Pusa Bold) ×BSIPS-23	25-30	122-125	40	High yield, medium maturity, bold seeded, long siliqua, long main raceme, suitable for irrigated timely sown conditions. Uttarakhand plains
			Karan Rai				
Kiran	1997/1998	SO.401(E) Dt: 15.05.98	Selection from HC-1	18-22	160-170	39	Bold, yellow seeded suitable for rainfed conditions in plains.

2. Germplasm registered:

Germplasm	Number and Years of registration	Pedigree	Specific feature
PAB 9511	06041 (2006)	[(RC 78 × Krishna) × (PHR-1 × Poorbiraya)]	Tolerant to *Alternaria* blight
PRQ-2005-1	06013 (2006)	-	Low erucic acid in oil (1.08%) and yellow seeded
PRB-2006-5	INGR-10108 (2010)	(Kranti×LPIPS-2) × BSIPS-11	Seed boldness

PHOP-2-2	07033	-	High oleic acid (70.1%) coupled with low erucic acid (0.2%) and brown seed
PHOT-8-2-11	07034	-	Low linolenic acid (3.03%) and brown seeded
PT-141	INGR-17018 (2017)	Collection from Uttarakhand hills	Earliness of maturity & earliness of flowering

3. Mustard variety **"Kranti'** identified as Landmark Variety by Indian Society of Genetics and Plant Breeding in 2017.

2. Research Publications:

Bhim Jyoti; Ram Bhajan and Pant,Usha. (2018). Tolerance against ageing in different varieties of Brassica rapa var toria, *B. rapa* var yellow sarson and *B. juncea* (L.). *Journal of Applied and Natural Science* 10 (1): 171 – 177.

Dahiya, Neha; Ram, Bhajan; Rashmi and Pant, Usha (2018). Heterosis and combining Pandey, Deepankar,; Singh, S.P.; Jeena, A.S.; Khan, K.A.; Tabassum, Negi, A.S.; Koujalagi, D. (2018). Study of Genetic Variability, Heritability and Genetic Advance for various yield and quality traits in sugarcane genotypes (*Socchorum officimoru*). Int. Carr. Microbio. App. Sci, 7 (4).

ability for different traits in local germplasm and varietal crosses in *Brassica juncea* L. *International Journal of Chemical Studies.* 6(1): 1884-1887.

Pant Usha and Khanna V K (2018). Diversity analysis and Hybridity test of drought responsive wheat cultivars and their F1's on the basis of SDS-PAGE profiles. Int. J Curr. Microbiol.App. Sci.7 (6):1157-1162.

Pant Usha, Kour Anupreet and Khanna V.K. (2018).Study of Post-fertilization developments in wheat- maize system of haploid production. Int. Journal of Chemical studies.

Bairwa, A.K.; Ram, R.; Neetu, Jeena, A.S.; Singh, K. and Singh, S.P., (2017). Estimation of the extent of variability for different morphological and juice quality characters among early generation sugarcane clones. Int. J. Curr. Microbio. App. Sci. 6(2): 1272-78.

Rashmi, Ram Bhajan, Lohani, Preeti, Dahiya, Neha, Adhikari, Sneha and Pant, Usha. 2017. Influence of Cyto-Nuclear Interactions on Heterosis and Combining Ability for Yield Contributing Traits in Indian mustard (*Brassica juncea* L.). *Int. J. Curr. Microbiol. App. Sci.* *6*(12): 4248-4267.

Negi, A.S.; Singh, S.P.; Jeena, A.S.; and Tallha, M. (2017). Estimation of variability progenies of sugarcane (*Sacchorum Species complex*). International J. Agriculture Innovations and Research. 6(1): 188-190.

Bhim Jyoti and Usha Pant (2016). Effect of harmo-priming on the physiological parameters of seed quality in tomato. *Progressive Horticulture* 48(1): 92-94.

Jitendra Meena, Harsha and Usha Pant (2016). Analysis of genetic components and other genetic parameters for seed yield and its contributing traits in Indian mustard, Brassica Juncea (L) Czern and Coss. International Journal of Farm Sciences 6(2) : 31-36, 201.

Singh, Vikrant; Pant, U and Ram Bhajan (2016). Physiological Traits versus Seed Yield Derived Parameters Based Heat Stress Study in Indian mustard. *SABRAO Journal of Breeding and Genetics*. 48(2): 127-135. NAAS: 4.00

Vineet Kumar, D P Pant and Usha Pant (2016). Combining ability and heterosis for seed yield and its component in Indian mustard [*Brassica juncea* (L.) Czern and Coss]" in

Environment and Ecology 34 (3B): 1382-1388

Harsha; Kumar, Vineet; Ram Bhajan, Singh, A.K. and Pant Usha. (2016). Genetic diversity revealed by morphological descriptors among yellow sarson germplasm under timely and late sown conditions. *Applied Biological Research*. 18(1):23-29.

Chaurasia, R. K. and Ram Bhajan. 2015. Genetics of Alternaria Leaf Blight Resistance in Indian mustard [*Brassica juncea* (L.) Czern and Coss.]. *Trends in Biosciences*. 8(3): 651-Meena, Jitendra; Harsha; Pant, Usha and Ram Bhajan. 2016. Combining ability analysis for yield attributing characters in Indian mustard [Brassica juncea (L.) Czern & Coss]. Green Farming. 7: 1-4.

Singh, Vikrant and Ram Bhajan. 2016. Evaluation of Indian mustard genotypes to heat stress in irrigated environment-Seed Yield Stability and Physiological Model. *J. Crop Sci. Biotech*. 19(5): 333-352.

Singh, Vikrant; Ram Bhajan and Pant, Usha. 2016. Molecular diversity analysis of Indian mustard genotypes through SSR markers. *Environment & Ecology*. 34(3A): 1212-1217. NAAS: 4.09.

Chaurasia, R. K. and Ram Bhajan. 2015. Genetic Diversity for Seed Yield and Component Traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. *Trends in Biosciences*. 8(1), 151-156.

Bhim Jyoti, Ram Bhajan and Pant Usha (2014). Influence of storage period on the seed quality parameters in Toria (*Brassica rapa* var. toria). *International Journal of Basic and Applied Agricultural Research*. 12(3): 361-364.

Sharma, M.D., Dobhal, U., Singh, P., Kumar, S., Gaur, A.K., Singh, S.P., Jeena, A.S., Khosy, E.P. and Kumar, S. (2014). Assessment of genetic diversity among sugarcane cultivars using novel microsatellite markers. *African J. Biotech.*, 13(13):1441-1451.

Mayuri Agrawal, V K Khanna J P Jaiswal and Usha Bhatt (2013). Molecular analysis of wheat genome by use of Random amplifiec polymorphic DNA (RAPD) markersIndian J. Agric Res. 47(2): 151-156.

Nandita Limbu, S P Singh and Usha Pant (2013).Seed protein profiling of advanced generation of two families in Indian mustard through SDS –PAGE. International j. of Basic and Applied Agricultural Research. Vol.11 (3): 361-364.

Nandita Limbu, Singh, S.P. and Pant, D.P. (2013). Seed protein profiling of advanced generations of two families in Indian mustard SDS, PAGE. *International J. of Brassicuna Applied Agricultural Research*. 1(3):361-364.

Ram Bhajan; Sachan, J.N.; Pant, D.P.; Singh, S.P.; Bhatt, Usha and Singh, A.K. 2011. PRB-2006-5 (IC573439; INGR10108), a mustard (*Brassica juncea*) germplasm with bold seed. *Indian J. Pl. Genetic Resources*. 24(1): 147.

Verma, O. P.; Kumar, K.; Ram Bhajan; Maurya, K. N.; Singh, N. K. and Singh, H. K. 2011. Heterosis in relation to genetic diversity and combining ability in Indian mustard *Brassica* juncea (L.) Czern and Coss. *Pantnagar J. Res.* 9(2): 189-193.

Bhatt Usha and Khanna VK. (July 2010). Pollen tube study in relation to haploid production in wheat maize crosses. Pantnagar Journal of Research, 8(1):39-42.

Singh, S.P.; Jeena, A.S.; Meenu; Rakesh Kumar,; Sachan, J.N. and Pant, D.P. (2001). Glucosinolate determination in *Brassica* species by Enzyme Method. *Agric. Biol. Res.* 17: (1&2): 17-20.

Singh, Basudeo; Sachan, J.N.; Singh, S.P.; Pant D.P.; Khan, R.A. and Rakesh Kumar (2001). Correlation among fatty acids of *Brassica* and

related species. *Cruciferae News Letter*. 23: 6-7.

Sachan, J.N.; Singh, Dhirendra; Singh, A.K.; Singh, S.P. and Pant D.P. (2007). Characterization of alloplasmic male sterile lines of *Brassica carinata.* Agric. Bio. Res. 23(2): 100-105.

Meena S.S. and Sachan, J. N. (2006). Inheritance of seed coat colour in Indian-mustard (*Brassica juncea* (L.) Czern & Coss. *Pantnagar J. of Research.,* 42(2): 77-78.

Meena S.S. and Sachan, J. N. (2006). Studies on seed dormancy behaviour in *Brassica* species and effects of different seed treatments to overcame in *B. juncea* (L.) Czern & Coss. *Pantnagar Journal of Research* 42(2): 86-89.

Singh, A.K.; Singh Basudeo and Sachan, J.N. (2006). Heterosis and inbreeding depression in Indian mustard (*Brassica juncea* (L.) Czern & Coss). *Agricultural & Biological Research.* 22(1):36-42.

Bhatt U., Singh, S.P. & Singh Basudeo (2005). Heterotic response for important traits in Brassica juncea (L.) Czern & Coss. Agric. & Biol. Res. 21(2) 169-172.

Bhatt U., Singh, S.P.& Singh Basudeo (2005).Combining ability for important economic traits in Brassica juncea (L.) Czern & Coss. Agric. & Biol. Res. 21(1) 79-84

Sachan, J.N., Singh B., Singh A.K., Singh D.P. and Kumar R. (2004). Fatty acid profile in S_3 lines selected for high oleic acid in toria (*Brassica rapa* var. *toria*). *Pantnagar Journal of Research.* 2(1): 20-21.

Sachan, J.N., Singh D., Singh Basudeo., Singh A.K., Pant D.P. and Singh S.P. (2004). Principal Component Analysis (PCA) for genetic divergence of seed yield and its components in Indian mustard (*B. juncea* L. Czern & Coss). *Pantnagar Journal of Research*. 2(2): 33-35.

Sachan, J.N., Singh, B. Singh, A.K.; Singh, S.P.and Pandey, Sharad 2003. Development of low linolenic acid toria (Brassica rapa) National Seminar on Advances in Genetics & Plant Breeding-Impact of DNA Revolution. Oct. 30-31 at UAS., Dharwad Abstract No. 70. Page No. 51-52.

Singh, S.P.; Jeena, A.S.; Meenu; Rakesh Kumar,; Sachan, J.N. and Pant, D.P. (2001). Glucosinolate determination in *Brassica* species by Enzyme Method. *Agric. Biol. Res.* 17: (1&2): 17-20.

Singh, A.K.; Singh Basudeo and Sachan, J.N. (2005). Choice of parents and combining ability for yield and yield component characters in Indian mustard (*Brassica juncea* (L.) Czern & Coss*). Agri. Sci. Digest* 25 (2): 90-94.

Chaudhary, A.K. Singh, S.P. and Pant, D.P. (2004). Variability in quality parameters in

Indian Mustard (*Brassica juncea*) *Cruciferae Newsletter* No. 25: 67-68.

Sachan J.N., Singh A., Kolte S.J., Prasad K., Singh B. (2004). Evaluation of Indian mustard (*Brassica juncea* (L.) Czern & Coss) crosses and segregating generations against downy mildew (*Peronospora parasitica*). *Cruciferae Newsletter* 25: 85-86.

Sachan J.N., Singh A., Kolte S.J., Prasad L., Singh B. (2004). Evaluation of mustard germplasm against *albugo condida*. *Cruciferae Newsletter* 25: 87-88

Sachan J.N., Singh A., Kolte S.J., Prasad L., Singh B. (2004). Evaluation of Indian mustard (*Brassica juncea* (L.) Czern & Coss) breeding lines against alternaria blight. *Cruciferae Newsletter* 25: 89-90.

Shiv, Dayal, and Sachan, J.N. (2004). Introgression of desaturate suppressor gene from C-genome of *Brassica napus* to *B. rapa*. *Pantnagar Journal of Research*. 2(1): 36-37.

Singh, A.K.; Singh Basudeo and Sachan, J.N. (2004). Genetics of component of variation for seed yield, harvest index and oil content in Indian mustard. *Cruciferae News Letter* 25:59-60.

Sachan, J. N., Singh Basudeo and Singh Anshuman (2003). Metroglyph analysis in mustard. *J. Oilseeds res.* 20 (2): 272-273.

Singh, A.K. Singh Basudeo and Sachan, J.N. (2003). Diallel analysis for combining ability for yield and its component and oil content in Indian mustard. *J. Oilseeds Res.* 20 (2): 269-271.

Singh, Y and Sachan, J. N. (2003). Combining ability analysis for seed yield and its components in Indian-Mustard (*B. juncea* (L) Czern & Coss).

Singh, S.P.; Jeena, A.S.; Rakesh Kumar and Sachan, J.N. (2002). Variation for quality parameters and fatty acids in *Brassica* and related species. *Agric. Sci. Digest.* 22(3): 205

Kashyap, V.; Bajpai, G.C.; Upadhyaya, S.K. and Singh, S.P. (2001). Genetic diversity for quality traits in pigeon pea. Legume Res. 28(3): 191-193.

Sinha, P.; Singh, S.P. and Pandey, I.D. (2001). Character Association and Path Analysis in *Brassica* species. *Indian Journal of Agricultural Research*. Vol. 35, No. 1, 63-65.

Kashyap, Y.; Bajpai, G.C.; Upadhyaya, S.K. and Singh, S.P. (2000). Chemical composition of disease and insect resistant donor lives of pigeon peas. Legume Res. 23(3): 192-194.

Singh, S.P.; Singh, P.P. and Dwivedi, J.L. (1991). Field Screening of advance lines of rice against natural flooding, IRRI, Newsletter. Vol. 16.I.

Dwivedi, J.L; Singh, S.P. and Jha, G.N. (1988). Screening for drought resistant in Rice, IRRI Newsletter Vol. 13.I.

Sachan J.N. Kolte, S.J. and Singh Basudeo 1995. Genetics of resistance to white rust (Albungo candida race – 27 in mustard (*Brassica juncea*, L.) Czern & Coss. *IX International GCIRC Rapeseed Congress* held on July 4-7, 1995 at Cambridge, U.K. Vol. 4, 1295-97.

Singh, Basudeo, Sachan, J.N. and Pant D.P. 1995. Identification of parents for hybridization through combining ability analysis in toria (*B. campestris*). *IX GCIRC Rapeseed Congress* July 4-7, 1995 at Cambridge, U.K. 4-7 July 1995, Vol. 3: 723-25.

Singh, Dhirendra and Sachan, J.N. 1999. Effect of sucrose concentration on embryogencies of anthers of *Brassica* species in liquid medium. *Crop Improve*. 26: 19-22.

Sachan J.N. 1989. Status of breeding researches on Brassica oil crops at Pantnagar, India IDRC II Brassica Sub Network Meeting held at Pantnagar Jan 4-6.

Sachan, J.N. 1989. Status of breeding researches on *Brassica* oil crops at Pantnagar, India. *IDRC Manuscript Report MR* 252e: 30-34.

Verma, N.K. Singh, Basudeo and Sachan, J.N. 1989. Combining ability and heterosis in yellow sarson. *J. Oilseeds Research*, 6 (1): 32-40.

Tyagi, D.V.S. and Verma, R.B., 1985. Functional male sterility in toria. *Indian J. Genet.* 45: 219-223.

Sachan, J.N. and Singh, Basudeo 1988. Genetic analysis of primary and secondary branches in Indian mustard *Brassica juncea* (L.) Czern & Coss *Oil Crops Newsletter,* 5: 33-36.

Ram Bhajan; Kumar, K. and Chauhan, Y. S. 1988. Some unraveled features of national varieties of mustard. *Seed & Farms.* 14 (12): 123-124.

Sachan, J.N. and Singh, Basudeo 1987. Generation mean analysis for flowering and maturity in

Indian mustard *Brassica juncea* (L.) Czern & Coss. *Theor, Appl. Genet.* 73: 571-574.

Sachan, J.N. and Singh, Basudeo 1987. Generation mean analysis for yield and yield components in Indian mustard (*Brassica juncea* (L.) Czern & Coss). *VIIth International Rapeseed Congress, Poznan, Poland*, Vol. 2: 330-340.

Singh, Basudeo, Sachan, J.N. and Singh, S.P. 1987. Male sterility in yellow sarson, *Oil Crops Newsletter*, 4: 31-32. Ram Bhajan; Chauhan, Y.S. and Kumar, K. 1988. A note on prickle like formation in mustard. *N.D. J. Agric. Res.* 3 (2): 192-194.

Chauhan, Y.S.; Kumar, K. and Ram Bhajan, 1987. Extent of out crossing in Indian mustard *(Brassica juncea* L. Czern & Coss). *Eucarpia Cruciferae Newsletter.* No. 12: 44.

Ram Bhajan and Singh, Basudeo, 1987. Crossability in relation to self-incompatibility levels and genetic differences between varietal forms in (*Brassica campestris* L.). *J. Oilseeds Res.* 5 (1): 54-58.

Singh, Daroga, Sachan, J.N.; and Singh S.P. (1987). Inheritance of male sterility in yellow sarson (*Brassica campestris* L. var. yellow sarson) Oil Crops Newsletter 4: 31-32

Singh, Basudeo, Sachan, J.N. and Singh, S.P. (1986). Research on rapeseed-mustard breeding Pantnagar. Oil Crops Newsletter 3: 13-15.

Sachan, J.N. and Singh, Basudeo 1986. Linked epistasis for six quantitative traits in Indian Mustard *Brassica juncea* (L.) Czern & Coss. *Thero. Appl. Genet.* 71: 644-647.

Singh, Basudeo, Sachan J.N. and Singh, S.P., 1986. Research on rapeseed-mustard breeding at Pantnagar. *Oil Crops Newsletter*, 3: 7-15.

Ram Bhajan, Chauhan, Y. S. and Kumar, K. 1988. Shattering resistance in Indian mustard. *Eucarpia Cruciferae Newsletter.* 13: 40-41.

Ram Bhajan; and Singh, Basudeo, 1988. Gene effects for flowering and maturity in crosses between yellow *sarson* and *toria*. *J. Oilseeds res.* 5 (2): 195-197.

Tyagi, D. V. S., Rai, B. and Verma, R. B. 1983. A note on bunchy dwarf mutant in toria. *Indian J, Genet.* 43 (3): 374-377.

Singh, B., Sachan, J. N., Ram Bhajan, Singh, S. P. and Singh, Daroga 1984. Male sterility in Indian rapeseed (*Brassica campestris* L. var toria). *Oil Crops Newsletter*. 1: 25-26.

Singh, B.; Sachan, J. N.; Ram Bhajan, Singh, S. P. and Singh, Daroga, 1984. Current status of Indian rapeseed and mustard breeding research at G.B. Pant University of Agric. & Tech., Pantnagar (Nainital). *Oil crops Newsletter.* 1: 62-67.

Singh, Basudeo, Sachan, J.N. Ram Bhajan Singh, S.P. and Daroga Singh, 1984. Current status of Indian Rapeseed and Indian mustard research at G.B. Pant Univ. Agric. And Tech., Pantnagar U.P., India. *Oil Crops Newsletter,* 1: 62-67.

Singh, Basudeo, Sachan, J.N. Ram Bhajan, Singh S.P. and Daroga Singh, 1984. Male sterility in Indian rapeseed Brassica campestris (L.) var. toria, *Oil Crops Newsletter,* 1: 25-26.

Singh, Basudeo, Sachan, J.N.; Ram Bhajan, Singh, S.P. and Daroga Singh (1984). Male sterility in Indian Rape (*Brassica campestris* L. var. toria) Oil Crops Newsletter 2: 25-26.

Singh, Basudeo, Sachan, J.N.; Ram Bhajan, Singh, S.P. and Daroga Singh (1984). Current status of Indian rapeseed and Indian mustard research at G.B. Pant Oil Crops Newsletter 1: 62:67.

Singh, Daroga, Sachan, J. N., Ram Bhajan; Singh Basudeo and Singh, S.P. 1984. Combining ability in Indian mustard. *J. Oilseeds Res.* 3 (1): 1-7.

Singh, Daroga, Sachan, J.N., Ram Bhajan, Singh Basudeo and Singh S.P. 1984. Combining ability in Indian mustard *J. Oilseeds Res.* 3 (1): 1-7.

3. Thesis Research:

M.Sc.

1. Mr. Sameer Chaturvedi (2018). Identification of superior parents and crosses using combining ability analysis for improvemen of yellow sarson (*B. rapa* var. yellow sarson. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
2. Preeti Lohini (2018). Determination of morpho-molecular genetic diversity and drough response among advance lines of *B. carinata*. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
3. Ms. Shikha Joshi (2018). Pre-fertilization barriers, crossability, meiotic abnormalities and phenotypic characterization of inter-specific hybrids among *Brassica* species. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
4. Sanchika Snehi. (2017). Determining genetic worth of local germplasm of yellow sarson (*Brassica rapa* var. *yellow sarson* Prain) using test cross performance. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.
5. Ms. Sneha Adhikari (2016). Studies on selection parameters, combining abilty and Heterosis for seed yield and its components in Indian Mustard (Brassica juncea L. czern & Coss). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
6. Ms. Sanjana Pathak (2016). Heterosis and gene effect studies for seed yield and related traits in Indian Mustard (*Brassica juncea* L. Czern & Coss). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
7. Mr. Narendra Singh (2015). Studies on Epistasis, combining ability and heterosis in Indian mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
8. MS. Philanim W. S (2014). Generation mean analysis for seed yield and related traits in *Brassica juncea*. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
9. Ms. Harsha (2013). Studies on Genetic diversity for quantitative and qualitative traits and molecular polymorphism among germplasm lines of Yellow sarson. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
10. Mr. Jiterndra Kumar Meena (2013). Studies on protein profiling (SDS-PAGE), combining ability and Heterosis in Indian mustard (*Brassica juncea* L. Czern & coss). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha PantMs. Iram Saba (2012). Studies on Crossability Among Seven Species of Genus Brassica. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
11. Ms. C. Visalakshi Chandra (2011). Molecular and Morphological Characterization of Alternaria Blight Tolerant Recombinant and Exotic Lines of Mustard *(Brassica juncea* L. Czern & Coss). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Usha Pant.
12. Tamoli, Promod (2011). Studies on Molecular diversity, combining ability and heterosis in Indian-mustard (*Brassica juncea* L. Czern & Coss). Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.
13. Singh, Sangeeta (2008). Diallel analysis and hybridity test-using SDS-PAGE for yield and quality traits in *Brassica juncea* L. Czern & Coss. *Thesis M.Sc. (Ag.)*, Genetics & Plant Breeding. GBPUA&T., Pantnagar. 170 p. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

14. Khan, R.A. (1998). Genetic analysis for yield and its component traits in Indian mustard (*B. juncea* (L.) Czern & Coss.

15. Singh, Dhirendra, (1996). Triple test cross analysis for important quantitative traits in Indian mustard (*B. juncea* (L.) Czern & Coss and embryo genesis in another culture of *Brassica species*.

16. Singh, P.K., 1995. Studies on genetic divergence and path analysis in Indian mustard (*B. juncea* (L.) Czern & Coss Verma S.K. (1992). Genetic variability, path coefficient analysis and genetic divergence in Indian mustard (*B. juncea* (L.) Czern & Coss.

17. Dastidar, N.G., (1993). Gene action, combining ability and heterosis in Indian mustard (*B. juncea* (L.) Czern & Coss.

18. Bhakar, O.P., (1991). Variability, character association and path-analysis in yellow sarson (*B. campestris var.* yellow sarson Prain).

19. Bhanu Kumar, (1990). Inheritance of important economic characters in Indian mustard (*B. juncea* (L.) Czern & Coss.

20. Rana, Debashis, (1989). Studies on heritability, path coefficients and genetic divergence in *Brassica species*.

21. Dwivedi, D.C., (1989). Genetic analysis of important quantitative characters in Indian mustard (*B. juncea* (L.) Czern & Coss.

22. Dwivedi, R.N. (1988). Line × tester analysis in Indian mustard (*B. juncea* (L.) Czern & Coss).

Ph.D.

1. Neha Dahiya. (2018). Genetics of white rust resistance, seed yield and its component characters in *Brassica juncea* L. Ph.D. Thesis, Genetics & Plant Breeding. G. B. P. U. A. & T. Pantnagar. Uttarakhand. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

2. Rashmi. (2017). Studies on alloplasmic and euplasmic heterosis in *Brassica juncea*. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

3. Joshi, Reena (2015).Genetic analysis of seed yield and resistance to *Alternaria* blight and white rust diseases in Indian mustard *(Brassica juncea* L.). Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

4. Singh, Vikrant (2013). Studies on molecular diversity, heterosis, combining ability and high temperature tolerance in *Brassica juncea* L. Czern & Coss. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

5. Bhim Jyoti (2013). Effect of aging on biochemical and physical parameters of seed quality and seed yield in oilseeds Brassicas. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

6. Chaurasia, Ramesh Kumar. (2009). Studies on inheritance of disease resistance, combining ability and heterosis in *Brassica juncea* (L.) Czern & Coss. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. Ram Bhajan.

7. Satendra Kumar, (2006). Studies on heterosis and combining ability for important economic traits and gene action for erucic acid in low erucic lines of Indian mustard (*B. juncea* (L.) Czern & Coss). Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. J.N. Sachan.

8. Meena S.S., (2006). Inheritance of seed coat colour, fatty acids and total glucosinolate contents in Indian-mustard (*B. juncea* (L.) Czern & Coss. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. J.N. Sachan.

9. Tanu Johri (2006), Discrimination of high and low erucic acid lines based on morphological and molecular markers. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. J.N. Sachan.

10. Shiv Dayal, (2004). Mutagenesis and inter-specific hybridization for selecting high oleic, low linolenic and high erucic line (s) of toria. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. J.N. Sachan.

11. Pourdad, S.S., (2001). Combining ability and heterosis and inheritance of erucic acid and glucosinolates in *B. napus*. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. J.N. Sachan.

12. Singh, Yogeshwar, (1999). Non-allelic interactions for important economic attributes and characterization of hybrids and their parents by SDS-PAGE in *B. juncea* (L.) Czern & Coss. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. J.N. Sachan.

4. Future Thrusts:

1. Characterization, identification and cataloguing of germplasm for unique traits.
2. Breeding for quality mustard (0/00).
3. Inter-specific hybridization for creation of novel variability
4. Gene pyramiding for the major diseases.
5. Use of tissue culture techniques (haploid breeding and protoplast fusion) to speed up the improvement through breeding procedure.
6. Marker assisted breeding for improvement of important traits.

B Agronomy

1. Significant Achievements:

1. Extensive surveys made in the districts of Pauri, Udham Singh Nagar, Nainital, and Haridwar to identify major weeds infesting the crop of rapeseed-mustard in the state of Uttarakhand; and Cyprus rotundus, Argemone mexicana, Polypogon monspeliensis, Cirsium arvense and Cynodon dactylon were found to be the major species along with some others.
2. The optimum time of sowing of Indian mustard and yellow sarson has been ascertained to be the 2nd week of October instead of the 1st week of the month in tarai region of Uttarakhand under changing climate scenario.
3. Application of the balanced dose of the major nutrients (N_{120}: P_{40}:K_{20}) along with the basal application of ZnO (15 kg), Borax (10 kg), and sulphur (20 kg) per ha found productive in Indian mustard and yellow sarson.
4. In cereal based cropping systems, mustard crop responds up to 120 kg N and 40 Kg S apart from the recommended doses of P and K nutrients.
5. Integrated nutrient management has been found to be the most productive in long term fertility experiments.
6. Giving two foliar sprays of 2% urea at 20 and 40 days after sowing has been found to save 25% of the recommended dose of nitrogen increasing the seed yield over the recommended dose in Indian mustard in station trials.
7. Transplanting 20-25 days old seedlings of Brassica carinata and B. napus in 60X60 cm planting geometry significantly out yielded the conventionally line sown crops of the Brassica at Pantnagar.

2. Research Publications:

1. Jadhav, T.A. ; Shukla, A. and Prajapat, K. 2012. Effect of cultivars and fertility levels on growth and yield of *toria* (*Brassica rapa var. toria*) under *tarai* region of Uttarakhand. *Annals of Agricultural Research.* 33(1&2): 7-13.
2. Singh, Harpreet; Deol, M.S. and Singh, R.P. (2008). Yield, quality and economics of Indian mustard (*Brassica juncea* L.)as affected by nutrient management practices under late sown condition. *Indian J. Ecology 35 (1). pp 31-34.*
3. Yesh Pal; Singh, R.P.; Sachan, R.S. and Pandey,

P.C.(2008). Effect of integrated nutrient management practices on yield, nutrient uptake and economics of mustard (*Brassica juncea* L.*)* grown in the rice-mustard cropping system. *Pantnagar Journal of Research.* 6(2). pp 199-204.

4. Kumar, Rajesh; Singh, R.P.; and Yesh Pal (2008). Yield and quality of *Brassica species* as influenced by different dates of sowing and varieties. *Pantnagar Journal of Research.* 6(1). pp 6-11.

5. Yesh Pal; Singh, R.P.; Sachan, R.S. and Pandey, P.C.(2008). Effect of integrated nutrient management practices on yield, nutrient uptake and economics of mustard (*Brassica juncea* L.*)* grown in the rice-mustard cropping system. *Pantnagar Journal of Research.* 6(2). pp 199-204.

6. Singh, Harpreet; Deol, M.S. and Singh, R.P. (2008). Yield, quality and economics of Indian mustard (*Brassica juncea* L.*)*as affected by nutrient management practices under late sown condition. *Indian J. Ecology 35 (1). pp 31-34.*

7. Singh, S. M.; Shukla, Anil; Chaudhary, Sumit; Chandra Bhushan; Negi, M. S. and Mahapatra, B.S (2008). Influence of irrigation scheduling and hydrogel application on growth and yield of Indian mustard (*Brassica juncea*). *Indian Journal of Agronomy* 63 (2):

8. Jadhav, T.A. ; Shukla, A. and Prajapat, K. (2012). Effect of cultivars and fertility levels on growth and yield of *toria* (*Brassica rapa var. toria*) under *tarai* region of Uttarakhand. *Annals of Agricultural Research.* 33(1&2): 7-13.

9. Yesh Pal; Singh, R.P.; Sharma, N.L. and Sachan, R.S. (2007). Effect of integrated nutrient management practices on rice (*Oryza sativa* L.) in a Mollisol. *Pantnagar Journal of Research.*5(2) pp23-28.

10. Yesh Pal; Singh, R.P.; Sharma, N.L. and Sachan, R.S. (2007). Effect of integrated nutrient management practices on yield, N,P,K uptake and economics of rice (*Oryza sativa* L.) in a Mollisol. *Pantnagar Journal of Research.* 5(2). pp 29-33

3. Thesis Research:

M.Sc.

1. Tomar Aparna (2018). Response of Indian mustard cultivar RH-749 to different fertility levels under *Tarai* conditions of Uttarakhand. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. M.S. Negi.

2. Sinha Rajni (2015). Managing Nitogen Requirements through Foliar Application in Mustard (*Brassica juncea* L. Czernj and Cosson). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. M.S. Negi.

3. Alok Devliyal Performance of promising yellow Sarson (*Brassica rapa var. yellow Sarson*) genotypes at different fertility levels. . M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Singh.

4. Mhd. Ikman Ali Effect of fertility level and harvesting time on yield & quality of yellow sarson (*Brassica rapa)*. . M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Singh.

5. Promod Kumar. Effect of bio-power and bio-force on mustard productivity. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Singh

Ph.D.

1. K. Tripathi. Effect of integrated nutrient management on growth, yield and quality of Indian mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Singh

2. Harpreet Singh. Effect of nutrient management practices on yield and quality of Indian mustard (*Brassica juncea* L.) under late sown condition. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Singh

3. Archna Kumari. Evaluation of hybrid varieties of mustard (*Brassica juncea* L.) under different sowing time and spacing. Ph.D,Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Singh

4. Future Thrusts:

1. Characterization & identification of rapeseed cultivars suitable for hill region.
2. Screening of rapeseed-mustard varieties for different thermal regimes.
3. Identification of different rapeseed & mustard cultivars suited in different cropping systems, particularly in low and mid hills.
4. Optimization of alternative establishment methods for exploring the potential of rapeseed-mustard beyond the realized limits.
5. Agronomic manipulation for improvement in quality of rapeseed-mustard.
6. Modifications in schedule and methods of nutrient management for enhancing input use efficiency.
7. Standardization of seed rates to enable hill farmers for managing green forage requirements in the process of thinning rapeseed-mustard as per the traditions in the green forage starved hill tracts of Uttarakhand.
8. Development of the package of practices for rapeseed-mustard production under rain fed conditions of Uttarakhand.

C. Plant Pathology:

1. Significant Achievements:

1. Survey-surveillance of important diseases and new outbreaks:

Regular surveys to know the prevalence and distribution of diseases at farmers' field, front line demonstration trials and the University farms were made during crop seasons. **Four major (**Alternaria blight, white rust, downy mildew and Sclerotinia rot**) and five minor diseases** (seedling blight, bacterial rot and powdery mildew) have been observed to affect the rapeseed-mustard crop in Uttarakhand.

2. Identification of resistant sources against major diseases of rapeseed mustard

i. Thousands of *Brassica* breeding materials, were evaluated under Initial Varietal Trials (IVT), Advanced Varietal Trial (AVT- I, AVT-II), Uniform disease nursery (UDN) and National disease nursery **(**NDN) to identify resistant sources against downy mildew, white rust, *Alternaria* blight, and *Sclerotinia* rot diseases. As a result of extensive research efforts made at this university, several genotypes of Brassica, possessing resistance have been selected against downy mildew and white rust, while few against *Sclerotinia* rot and few possessing moderate resistance against Alternaria blight. The centre has been recognized hot spot for the screening of resistant donors/breeding materials against white rust, downy mildew and Alternaria blight diseases.

ii. **Divya** (PPMS-1 ,mustard *Brassica juncea*) developed in Oilseeds Pathology programme has been registered by the Plant Germplasm Registration Committee (NBPGR, New Delhi) in its XVII meeting as a source of dwarfness, early maturity, lodging resistant, moderately resistant against Alternaria blight , White rust , Downy mildew , Powdery mildew and Sclerotinia rot, suitable for intercropping with autumn sugarcane and potato. This cultivar has a distinct plant character as whorl around the axis. It has been provided with National Identity (IC 553910) and Registration Number (INGR No. 08028).

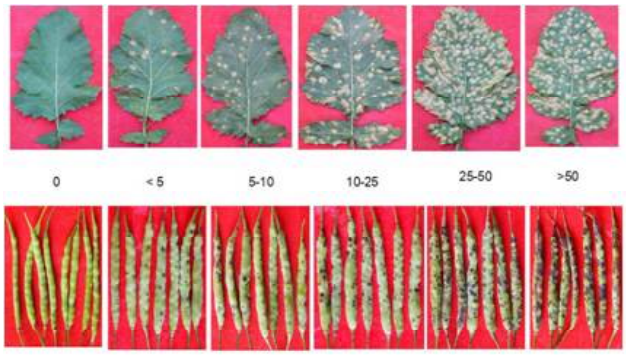
iii. Identified some single and double low oilseed *Brassica* lines which showed resistance against white rust and downy mildew, Alternaria blight and *Sclerotinia* rot.

iv. **Developed photographic** rating scales for the measurement of Alternaria blight and white rust and diseases

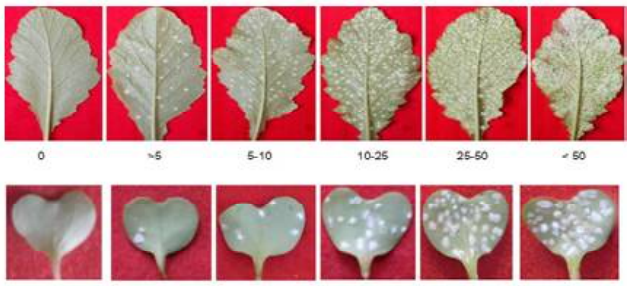
3. **Developed methods of inoculation techniques** for downy mildew, white rust, Alternaria blight and Sclerotinia rot diseases under *in vitro* and *in vivo* conditions.

4. **Study of pathogen variability and selection of host differentials**

- ***Albugo Candida* (white rust disease):** *A. candida* isolates (07 no.) were grouped on the basis of expression of symptoms, virulence and aggressiveness.
- ***Alternaria brassicae* (Alternaria blight disease):** *Alternaria brassicae* isolates (20 no.) were grouped on the basis of morphological, pathogenic and molecular characterization. Host pathogen interaction including toxin specificity has been established among 12 isolates of *A. brassicae* and 14 differential hosts of *Brassica species.*
- ***Sclerotinia sclerotiorum* (Sclerotinia stem rot):** *Sclerotinia sclerotiorum* isolates (12 no.) were grouped on the basis of cultural,



Photographic scale for the screening of germplasms against Alternaria blight



Photographic scale for the screening of germplasms against White Rust

morphological and mycelial compatibility.

- **Identification of host differentials for *A. candida*:** Based on **d**isease reaction of different *A. candida* isolates (07 no. from 07 states) on 20 different Brassica genotypes at cotyledonary and true leaf stage the Brassica genotypes were classified in four different groups as host differentials for the differentiation of *A. candida* isolates.

6. Interaction between white rust and downy mildew and screening techniques against white rust pathogen

- The response of different genotypes of *B. juncea/ rapa* in relation to interaction between *Hyaloperonospora brassicae* and *Albugo candida* isolates revealed that resistance of *Brassica* genotypes are broken down by pre-infection of *A. candida* and induced susceptibility to *Hyaloperonospora brassicae.* The stag head phase in *B. juncea* is due to infection with *A. candida* rather than *H. brassicae.* Tissue at this phase appeared to be more susceptible to *H. brassicae* than normal tissue of the same plants.

- **Developed screening techniques for the confirmation of resistance sources in Brassica spp. against white rust pathogen:** The genotypes found resistant in field under artificial epiphytotic conditions should be further tested in glasshouse conditions under artificial inoculation conditions first at cotyledonary stage then at true leaf stage for the confirmation of resistant sources

7. Epidemiology of Alternaria blight, white rust and downy mildew diseases- Predisposing factors for the development of rapeseed-mustard diseases

- **Alternaria blight:** A max. temp. of 18-26°C, min. of 12-18°C with a mean of >15°C along with a max. RH of 90 %, min. of 40% and a mean of >70% favours development of Alternaria blight on leaves. However, a max. temp. of 20-30°C, min of 12-18°C with a mean of >18°C along with a max. RH of > 90 % and mean of 75 % in connection with > 9 hrs of sunlight and >10 hrs of wetness period on pod favours Alternaria blight on pods.

- **Downy mildew and white rust:** A max. temp. of 16-24°C, min. of of 10-15°C with a mean of >12°C along with max. RH of >95%, min. of > 40% and a mean of >75 % in connection with foggy weather favours development of DM and WR on leaves as well formation of staghead.

- Early sowing of mustard (1st week of October) reduces the disease severity of rapeseed-mustard

8. Developed PCR and microscopy detection techniques to detect white rust pathogen in plants 7-10 days before appearance of the symptoms

9. Developed package and practices and IDM module for the management of Rapeseed Mustard diseases:

- Cost effective IDM strategies is developed for

the management of rapeseed-mustard for the growers i.e. application of balanced N_{100}: P_{40}:K_{40}; early October sowing (1st week); Soil application with ZnO (15 kg) , Borax (10 kg) and sulphur (15 kg) per ha as basal dose; Seed treatment with Apron 35 SD @ 6g/ kg seed; Three foliar sprays 1st with Ridomil MZ @ 0.25% at 60 DAS, 2nd at 70 DAS, & 3rd with Mancozeb+ Carbendazim (2:1) @ 0.3% at 75 DAS for the management of major diseases (white rust, downy mildew and Alternaria blight) of rapeseed mustard. If downy mildew appears at cotyledonary stage then a need of foliar spray with Ridomil MZ @ 0.2% at 15 DAS.

- **A new fungicide** Nativo 75 WG (Trifloxystrobin 25%+Tebuconazole 50% WG) was found very effective for the management of Alternaria blight disease of rapeseed mustard
- **Disease management under organic cultivation:** Early October sowing; Seed treatment with garlic bulb extract (2%) and *Trichoderma* (10g/kg seed) followed by three foliar spray 1st with *Eucalyptus globosus* leaf extracts+ cow urine (each 5%), 2nd with *Trichoderma* + *Pseudomonas* (each 1%), and 3rd with garlic bulb extract (2%) +cow urine (5%), at 60, 75 and 85 and 85 DAS was effective in reducing rapeseed-mustard diseases and increasing pollination.

2. Research Publications:

1. Gairola, K., Tewari, A. K. Ram Bhajan and Pant, U. (2017): Sources of resistance in *Brassica juncea* lines against *Albugo candida*. *Journal of Hill Agriculture* 8 (4): 436-441
2. Prateeksha Mehra; A.K.Tewari and Gohar Taj (2017). Studies on cultural, morphological, pathogenic and molecular variability of *Alternaria brassicae*, the causal agent of blight disease of rapeseed-mustard. *Journal of Oilseed Brassica*, 8 (2): 1-11.
3. Kalpana G, Tewari AK. (2017). Evaluation of brassica germplasm for resistance against white rust of Indian mustard. *International J of Environ Agri and Biotechnol*. 2(3):1215-1226
4. Pandey, V.; Tewari, A. K. and Saxena Deepika (2017). Activities of defensive antioxidant enzymes and biochemical compounds induced by bioagents in Indian mustard against Alternaria blight". *Proceedings of the National Academy of Sciences, Biological Sciences (NASB). Biological Sciences.* DOI 10.1007/s40011-017-0888-2: 1-12
5. Pandey, Puja, Tewari, A. K. (2017). Selection of host differentials for the identification of *Albugo candida* pathotypes". *Indian Phytopathology 70 (3):378-380.*\
6. K. S. Bisht and A. K. Tewari (2016). Effect of Some Fungicides on Management of Alternaria Blight and White Rust Diseases of Mustard. *Advances in Life Sciences. 5(2): 678-682.*
7. Sharma, V; Tewari, A.K. and Bisht, K.S. (2016). Screening of some putative lines for resistance to white rust disease of rapeseed mustard. Advances in Life Sciences. 5(12): 4894-4897
8. B. S. Bhatiya, K. S. Bisht, Pankaj Rautela, R. P. Awasthi and A. K. Tewari (2015). Pathogenic variability among *alternaria brassicae* isolates infecting brassica sp. *Trends in biosciences 8 (19):* 5437-5441.
9. Bisht, K. S. Meenakshi rana, kalpana gairola, B. C. Sharma, A. K. Tewari and R. P. Awasthi (2015) Screening of brassica germplasm for resistance to Major diseases of rapeseed-mustard *The Bioscan* 10(4): 2111-2119.
10. Bisht, K.S.; Tewari, A.K.; Rautela, Pankaj and Awasthi, R.P. (2015). Screening of Brassica germplasm for resistance to downy mildew disease of rapeseed-mustard. *Trends in biosciences*. 8 (15): 3996-4000.
11. Upadhyay, pooja, Tewari, A. K. and Bisht, K.S. (2015) Cultural, morphological, pathogenic

variability and mycelial compatibility among the isolates of *Sclerotinia sclerotiorum* (lib.) De bary the cause of Sclerotinia rot. *The Bioscan.* 10 (4): 1813-1817

12. Pandey, P. Tewari, A.K.; Bisht, K.S. and Deepika Saxena (2014). Differential responses of Brassica genotypes to different isolates of *Albugo candida* at true leaf stage *Trends in Biosciences,* 7 (11): 1093-1096.

13. Pandey, P.; Tewari, A. K.; Saxena, D. and Bisht, K. S. (2014). Effect of different suspension media on sporangial germination and development of white rust symptoms caused by *Albugo candida. Trends in Biosciences.* 7 (11): 1097-98.

14. Pandey, Puja, Tewari, A.K and Awasthi, R.P. (2013). Morphological and pathogenic variability of *Albugo candida* isolates causing white rust in rapeseed-mustard, *The Bio Scan,* 8 (3): 835-838

15. Awasthi, R.P.; Nashaat, N.I.; Kolte, S.J.; Tewari, A.K.; Meena, P.D. and Bhatt, R. (2012). Screening of putative resistant sources against Indian and Exotic isolates of Albugo candida inciting white rust in rapeseed –mustard, *Journal of Oil seed Brassica,* 3(1): 27- 37.

16. Goswami, K.; Tewari, A. K. and Awasthi, R. P. (2012) Cultural, morphological and pathogenic characteristics and carpogenic germination of *Sclerotinia sclerotiorum,* the cause of Sclerotinia rot of rapeseed-mustard. *Pantnagar Journal of Research*, 10(1): 40-45.

17. Khulbe, Anjani, Awasthi, R.P. and Tewari, A.K. (2011) Morphological and cultural diversity in isolates of *Alternaria brassicae* infecting Rapeseed and Mustard. *Pantnagar Journal of Research*, 9 (2): 206-209.

18. Bhatt, R., Awasthi, R.P. and Tewari, A.K. (2009). Management of downy mildew and white rust diseases of mustard. Pantnagar Journal of Research, 7 (1): 54-59.

19. Chandra, Bipin; Awasthi, R.P. and Tewari, A.K. (2009). Eco-friendly disease management of Alternaria blight (*Alternaria brassicae*) of rapeseed and mustard. *Environ and Ecology, 27* (2A): 906-910.

20. Mishra, K. K., S. J. Kolte, N. I. Nashaat and R. P. Awasyhi (2009). Pathological and biochemical changes in *Brassica juncea* (mustard) infected with *Albugo candida* (white rust). *Plant Patology.*58:80-86

21. Bhatt, R., Awasthi, R.P. and Tewari, A.K. (2009). Management of downy mildew and white rust diseases of mustard. Pantnagar Journal of Research, 7 (1): 54-59

22. Goswami, Kiran, Tewari, A.K. and Awasthi, R.P. (2008). Cultural, morphological and pathogenic variability in isolates of *Sclerotinia sclerotiorum. Journal of Mycology & Plant Patholoy,*38 (3): 650—652.

23. Goswami, Kiran, Tewari, A.K. and Awasthi, R.P. (2008). Comparative study of inoculation methods in *Sclerotinia sclerotiorum* in rapeseed-mustard. *Journal of Mycology & Plant Pathology,*38 (3): 667-668.

24. Goswami, Kiran, Tewari, A.K. and Awasthi, R.P. (2008). Cultural, morphological and pathogenic variability in isolates of *Sclerotinia sclerotiorum. Journal of Mycology & Plant Patholoy,*38 (3): 650—652.

25. Bhatiya, B.S. and R.P. Awasthi (2007). *In vitro* evaluation of some antifungal plant extracts against *Alternaria brassicae* causing Alternaria blight of rapeseed-mustard. *J. Pl. Dis. Sci.* 2(2): 126-131.

26. Adhikari, M., C.S. Patni and R.P. Awasthi (2006). Evaluation of *Brassica juncea* genotypes against downy mildew and white rust under artificial inoculation conditions. *Ad. Plant Sci.* 19:397-400.

27. Patni, C. S., S. J. Kolte and R. P. Awasthi (2006). Screening of *Brassica juncea* genotypes against downy mildew and white rust diseases of mustard using Photoacoustic spectroscopy. *Journal of Ecofriendly Agriculture*, Vol. 1(1): 43-48.

28. Patni, C. S., S. J. Kolte and R. P. Awasthi (2006). Screening of *Brassica juncea* genotypes against downy mildew (*Peronospora parasitica*) using Photoacoustic spectroscopy. *Environment and Ecology*. Vol. 24 (1): 1-9.

29. Chatopadhyay, C. and R.P.Awasthi (2005). Epidemiology and forcasting of Alternaria blight of oilseed *Brassica* in India- a case study. *J. Plant Diseases and Protection*. 112(4): 351-365

30. Patni, C. S., S. J. Kolte and R. P. Awasthi (2005). Screening of Indian mustard [*Brassica juncea* (Linn) Czern and Coss] genotypes to *Alternaria brassicae* (Berk) Sacc. Isolates based on infection rate reducing resistance. *J. Interacad*. 9(4): 498-507.

31. Patni, C. S., S. J. Kolte and R. P. Awasthi (2005). Screening of some mustard (*Brassica juncea*) genotypes for resistance to Alternaria blight with the help of a biophysical method photoacoustic spectroscopy. *Journal of Plant Disease Sciences*, 1(1): 107-113.

32. Patni, C. S., Anita Singh and R. P. Awasthi (2005). Variability in *Albugo candida* causing white rust disease of rapeseed-mustard. *Journal of Research* SKUAST-J, Vol.4 (2):184-191.

33. Patni, C. S., S. J. Kolte and R. P. Awasthi (2005). Cultural variability of *Alternaria brassicae* causing Alternaria blight of mustard *Ann Plant Physol*.19:231-242.

34. Patni, C. S., S. J. Kolte and R. P. Awasthi (2005). Efficacy of botanicals against Alternaria blight (*Alternaria brassicae*) of mustard. *Indian Phytopath*. Vol. 58 (4): 426-430.

35. Patni, C. S., S. J. Kolte and R. P. Awasthi (2005). Inhibitory effect of some plant extracts against *Alternaria brassicae*, causing Alternaria blight of mustard. *Journal of Research* SKUAST-J, Vol.4 (1): 71-79.

36. Patni, C.S., S.J.Kolte and R.P.Awasthi (2005). Effect of some botanicals on management of Alternaria blight and White rust diseases of mustard. *Journal of Plant Disease Sciences*, 1(1): 58-62.

37. Singh, A., C. S. Patni and R. P. Awasthi (2005). Effect of temperature and pH on sporangial germination of *Albugo candida*. *Journal of Plant Disease Sciences*, Vol. 1(1): 92-97

38. Gupta, R, R. P. Awasthi and S. J. Kolte (2004). Effect of sowing date and weather on development of white rust (*Albugo candida*) in rapeseed-mustard. *.J.Mycol.Pl.Pathol*, 34 (2):441- 444.

39. Gupta, R, R. P. Awasthi and S. J. Kolte (2004). Influence of sowing dates and weather factors on progress of Alternaria blight of rapeseed-mustard. *Indian Phytopath*. 56: 398-402

40. Gupta, R, R. P.Awasthi and S. J. Kolte (2004). Effect of Nitrogen and sulfer on incidence of Sclerotinia rot of mustard. 2004. *Indian Phytopath*. 57(2): 193-194.

41. Gupta, R, R. P.Awasthi and S. J. Kolte (2004). Influence of sowing dates on incidence of Sclerotinia rot of rapeseed-mustard. *Annals of Plant Protection Sciences*, 12(1): 223-224.

42. Patni, C.S., S. J. Kolte and R. P. Awasthi (2004). Detection of Inter and Intraspecific Variability among Alternaria isolates with Photoacoustic spectroscopy. *Indian Phytopath*. 57 (1):73-75.

43. Nashaat, N.I.; Heran,A.; Awasthi,R.P. and Kolte,S.J. (2004). Differential response and genes for resistance to *Peronospora parasitica* (downy mildew) in *Brassica juncea*(mustard). *Plant Breeding*. 123: 512-515.

44. Patni, C.S.; Kolte,S.J. and Awasthi, R.P.(2004). Detection of Inter and intraspecific Variability among *Alternaria* isolates with Photoacoustic spectroscopy. *Indian Phytopath* 57(1): 73-75.

45. Gupta, Ruchi., Awasthi, R.P. and Kolte, S.J. (2004). Effect of Nitrogen and Sulphur on incidence of Sclerotenia rot of mustard. *Indian Phytopath*. *57(2): 193-194*

46. Gupta, Ruchi, Awasthi, R.P. and Kolte, S.J. (2003). Influence of sowing dates and weather factors on development of Alternaria blight of rapeseed-mustard. *Indian Phytopath* 56(4):398-402.

47. Kaur, A., Kolte, S.J. and Singh, U.S. (2003). Effectiveness of phylloplane fungi in Induction of localized resistance against foliar diseases of mustard. *Ann.Pl.Protec.Sci.* 11(1):86-89.

48. Khan,R.U. and Kolte, S.J. (2002). Some seedling diseases of rapeseed-mustard and their control. *Indian Phytopath* 55(1):72-73.

49. Singh,U.S.; Nashaat, N.I.; Doughty,K.J. and Awasthi, R.P. (2002). Altered phenotypic response to *Peronospora parasitica* in *Brassica juncea* seedlings following prior inoculation with avirulent or virulent isolate of *Albugo candida. European J.Pl.Pathol.* 108: 555-564.

50. Kumar, B. and Kolte, S.J. (2001). Progression of Alternaria blight of mustard in relation to components of resistance. *Indian Phytopath*.54 (3):329-331.

51. Kaur, A. and Kolte, S.J. (2001). Control of Powdery mildew of mustard with some non-conventional chemicals. *Brassica*. 3(5&6):38-41.

52. Kaur, A. and Kolte, S.J. (2001).Protection of mustard plants against the stagehead phase of white rust disease by foliatr treatment with Benzothiadiazole, an activator of Plant defence system. *J.Mycol.&Plant Pathol.* 31(2): 133-138.

53. Kolte, S.J., R.P. Awasthi and Vishwanath (2000). Divya mustard : a useful source to create Alternaria black spot tolerant dwarf varieties of oilseed brassicas. *Plant varieties & Seeds* (U.K.), 13: 107-111.

54. Singh M.P. and Kolte, S.J. (1999) Differential reactions of various host crucifer species against different isolates of *Peronospora parasitica. J. Mycol. and Plant Pathol.,* 29 (1) : 118-121.

55. Singh, U.S., Doughty, K.J., Nashaat, N.I., Bennett, R.N. and Kolte, S.J. (1999). Induction of systemic resistance to *Albugo candida* in *Brassica juncea* by pre or co-inoculation with an incompatible isolate. *Phytopathology,* 89: 1226-1232.

56. Vishwanath, Kolte, S.J.; Singh, M.P. and Awasthi, R.P. (1999). Induction of resistance in mustard (Brassica juncea) against Alternaria black spot with an a virulent Alternaria brassicae isolate D. *European J. Plant Pathol.* (Netherlands) 105: 217-220.

57. Vishwanath and Kolte, S.J. (1999) Methods of inoculation for resistance to Alternaria blight of rapeseed -muatard. *J. Mycol. and Plant Pathol.,* 29 (1) : 96-99.

58. Vishwanth and Kolte S.J. (1999). Evaluation of oilseed brassica germplasm for resistance to Alternaria blight. *J. Mycol. Pl. Pathol.,* 29 (2) : 147-152

59. Nashaat, N.I., Heran, A., Mitchell, S.E., and Awasthi, R.P. (1997). New genes for resistance to downy mildew (Peronospora parasitica) in oilseed rape (Brassica napus sap. oleifera). *Plant Pathology* 46: 964-968.

60. Nashaat, N.I. and Awasthi, R.P. (1995). Evidence for differential resistance to *Peronospora* parasitica (downy mildew) in accessions of Brassica juncea (mustard) at the cotyledon stage. *J. Phytopathology* 143: 157-159.

61. Kolte, S.J., Awasthi, R.P. and Vishwanath (1994). Divya mustard: A Unique Plant type and developmental trials in disease management. *Eucarpia cruciferae News L.* 16: 128-129.

62. Awasthi, R.P. and Kolte, S.J. (1994). Epidemiological factors in relation to development and prediction of Alternaria blight of rapeseed and mustard. *Indian Phytopath.* 47 (4): 395-399.

63. Conn, K.L, Tewari, J.P. and Awasthi, R.P. (1990). Disease assessments key for Alternaria black spot

in rapeseed and mustard. *Can. Pl.Dis. Survey* 70:19-22.

64. Kolte, S.J., Awasthi, R.P. and Viswanath. (1989). Management of rapeseed and mustard and groundnut diseases in Uttar Pradesh. *Indian Phytopath*. 42(2): 316.

65. Awasthi, R.P. and Kolte, S.J. (1989). Variability in Alternaria brassicae effecting rapeseed and mustard. *Indian Phytopath*. 42(2): 275

66. Kolte, S.J., Awasthi, R.P. Sharma, K.D. and Vishwanath. (1989). A note on reaction of some rapeseed and mustard cultures to staghead phase of white rust. Oilseeds Newsl. 11 : 91-92.

67. Kolte, S.J., Awasthi, R.P. and Vishwanath. (1987). Assessment of yield losses due to Alternaria blight in rapeseed-mustard. *Indian Phytopath*. 40(2): 209-211.

68. Kolte, S.J., Awasthi, R.P. and Vishwanath. (1986). Effect of planting dates and associated weather factors on staghead phase of white rust and downy mildew of rapeseed and mustard. *Indian J. Mycol. & Plant Path.* 16: 94-102.

69. Kolte, S.J., Awasthi, R.P. and Vishwanath. (1985). Field performance of improved rapeseed toria (Brassica campestries var toria) varieties against Alternaria blight, downy mildew and white rust diseases. *Indian J. Mycol. & Pl.Pathol*. 15: 211-213.

70. Kolte, S.J., Balasubrahmanyam, N. Tewari, A.N. and Awasthi, R.P. (1979). Field performance of fungicides in the control of Alternaria blight of sunflower. *Indian J. Agric. Sci*. (ICAR) 49(7): 556-559.

71. Kolte, S.J. and Awasthi, R.P. (1979). Some observations on occurre3nce of groundnut rust in the Nainital Tarai region of Uttar Pradesh. *Indian Phytopath*. 32(1): 155-56.

72. Kolte, S.J., Tewari, A.N. and Awasthi, R.P. (1978). Chemical control of cercospora leaf spot of ground. Pesticides 12(12): 21-25.

73. Kolte, S.J., Tewari, A.N. and Awasthi, R.P. (1977). Sources of resistance to Cercospora leaf spot of groundnut. *Indian Phytopath*. 30(3): 4211-22.

3. Thesis Research:

M. Sc.

1. Ladhu Ram (2013). Estimation of yield losses due to major diseases in improved varieties of Rapeseed-Mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

2. Joshi, Pooja (2013). Studies on the responses of exotic and indigenousgermplasm of Indian-Mustard (*Brassica Juncea* (L.) Czern & Coss.) against major diseases and yield potential. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R. P. Awasthi.

3. Bisht, Khajan Singh (2013). Management of major diseases of rapeseed mustard using different approaches for the development of IDM module. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 90.

4. Pandey, Puja (2011). Variability and identification of host differentials for *Albugo candida* in oilseed *Brassicas.* M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 64

5. Upadhayay, Pooja (2010). Studies on management of Sclerotinia rot of mustard caused by *Sclerotinia sclerotiorum* (Lib.) de Bary. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 65

6. Kiran Goswami (2008). In vitro studies on Sclerotinia Sclerotium caused of Sclerotinia rot of mustard. . M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A.K. Tewari.

7. Bhawna Rana (2005). Studies on host reaction

of some single low (O) and double low (00) *Brassica napus* Genotypes against *Alternaria brassicae*. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

8. Shweta Singh (2005). Evaluatin of improved mustard (*Brassica juncea*) genotypes for resistance against *Alternaria* blight (*Alternaria brassicae*).

9. Amarendra Kumar (2003). Effect of some Non-conventional chemicals on control of Alternaria Blight of Mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

10. O.P. Bhatt (2004). Effect of seed treatment with fungicide Azotobacter on seedling growth of mustard and Infection due to *S. rolfsii* .and *Rhizoctonia solani*. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

11. R. Bhatt (2003). Effect of seed treatment with fungicide X. Azotobactor on seedling ...at mustard and infection due to sclerotium rolfsii and rhizoctonia. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

12. S. Sarath Babu (2003). Studies on the efficacy of Ridomil Gold 68 WP for the control of downy mildew of Rapeseed mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

13. K.K. Mishra (2002). White Rust of Mustard: Some comparative difference in disease components and biochemical constituents between resistant and Susceptible genotypes. M.Sc.. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

14. Pankaj Sharma (2000). Assessment of yield losses of some Alternaria blight and while rust tolerant *Brassica juncea* genotype. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

15. Meeta Adhikari (1998). The study on Downy mildew and white Rust complex in oliferous *Brassira* species. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

16. Anita Singh (1996). White rust disease of rapeseed-mustard, evaluation of germplasm and chemical control. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

17. Ruchi Gupta (1998). Alternaria blight and Sclerotinia stem rot of Rape seed mustard: Evaluation of some exotic and indigenous accessories. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

18. Bhargava, N. (1992). Studies on variability among three isolates *Alternaria brassicae* (Brek.) Sacc. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

19. Bhargava, N. (1992). Studies on variability among three isolates *Alternaria brassicae* (Brek.) Sacc. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

20. Adhikari, Sharma, B.P. (1991). Studies on Alternaria blight of rapeseed and mustard evaluation of components of resistance. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

21. Vishwanath (1987). Studies on some fungicides and micronutrients in the control of three important diseases of Toria (*Brassica campestris* var. *toria*). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

22. Singh, D. (1987). Studies on sclerotium rot of Groundnut: Effect of some agrochemicals, aminoacids, vitamins and screening for resistance. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

23. Thakur, Rajat (1985). Studies on growth and sporulation of *Alternaria brassicae* (Brek)

Sacc. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

24. Khan, R.U. (1985). Studies on seedling diseases of rapeseed and mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

25. Sharma, K.D. (1980). Symptomatology, yield losses and control of Downy mildew and white rust of Rapeseed & mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte

Ph.D.

1. Gairola, Kalpana (2017). Early detection and management of white rust of rapeseed mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 110.

2. Mehra, Prateeksha (2016). Studies on variability of *Alternaria brassicae* isolates of rapeseed-mustard and host differentials. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 126.

3. Sharma, Vinod (2016). Studies on variability of *Albugo candida* causing white rust of rapeseed-mustard and development of host differentials. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 128

4. Ravi, Sanjeev (2014). To study the interaction between white rust (*Albugo candida*) and downy mildew (*Hyaloperonospora brassicae*) of *Brassica juncea* (L). Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

5. Pandey, Vandana (2013). Studies on Biotic Induced Resistance against Alternaria Blight of Mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. A. K. Tewari. p 115

6. Bhatt, Renu (2012).Studies on pathological and biochemical aspects and management of white rust and downy mildew in rapeseed-mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

7. Geeta Devi (2012). Variability among Alternaria brassicae isolates and their effects on different genotypes of rapeseed-mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

8. Bangari, Geetanjali (2011). Ecofriendly strategies for disease management in Indian mustard with special reference to Sclerotinia stem rot and variability among *Sclerotinia sclerotiorum* (Lib.) de bary isolates. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

9. Anjani Khulbe (2009). Variability in alternaria brassicae (Berk.) Sacs., the causal agent of black spot of rapseed mustard and evaluation of different components of host resistance. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

10. Rashmi Bhatt (2007). Management of downy mildew whit rust and *Alternaria* blight diseases of rapeseed mustard evaluation of germplasm, botanicals, bioagents and fungicides. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

11. C.S. Patni (2003). Alternaria blight of mustard: variability in *A. brassicae*, host resistance and effect of some botanicals in disease management. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

12. Ruchi Gupta (2002). Studies on epidemiology of AB, DM, WR, and SSR of Rapeseed-Mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. R.P. Awasthi.

13. Arvind Kumar (2000). Characterization of biotically and Abiotically induced Host Response of Mustard against *Albugo candida*, *Peronospora parasitica* and *Alternaria brassicae*. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

14. Brijesh Kumar (1999). Alternaria blight of mustard caused by *Alternaria brassica* (BERC)Sacc.: Epidemiological components, Disease progression and yield of some genotypes Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of S.J. Kolte.

15. M.P. Singh (1996). Induced Host resistance against Alternaria blight, white rust and downy mildew of Rapeseed, Role of micronutrient, growth regulations and organic Acids. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

16. Vishwanath (1995). Alternaria blight of Rapeseed/mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

17. Singh, Dalganjan (1993). White rust of Rapeseed mustard and variability in *Albugo candida* screening tech. and components of host resistance. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

18. Sharma, S.R. (1992).Effect of host nutrition on management of Alternaria blight of toria (*Brassica campestris* var. toria) Dutb. and Full. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

19. Bardoloi, D.K (1990). Serological studies on different isolates of *Alternaria brassicae* and Albugo *candida* affecting rapeseed and mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

20. Sawant, S.D. (1986). Studies on systemicity, persistence and effectiveness in disease control of metalaxyl in rapeseed and mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

21. Awasthi, R.P. (1988) A comparative study of some exotic and indigenous oleiferous *Brassica* crop species in relation to their reaction to three *Alternaria* spp. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. S.J. Kolte.

4. Future Thrusts:

1. Survey of different agro-ecological regions to indentify major diseases of rapeseed mustard and under climate change and development of cost effective IDM strategies
2. Evaluation of new genotypes and Re-evaluation of resistant genotypes of rapeseed mustard against major diseases for the confirmation of resistant sources against major diseases under climate change
3. Study of pathogen diversity of A. candida pathogen for the selection of wide range of resistant mustard genotypes and selection of host differentials for the differentiation/ identification of *A. candida* isolates
4. Early detection and development of IDM modules for the Sclerotinia rot pathogen a threatening problem in major mustard growing region in India
5. Epidemiological studies and development of forecasting module for major diseases under climate change

D. Entomology:

Rapeseed and mustard crop is severely attacked by insect-pests at different stages of crop growth. Mustard sawfly (*Athalia proxima*), Painted bug (*Bagrada cruciferarum*) and Flea beetle (*Phyllotreta cruciferae*) damage the crop in early growth stage, *i.e.*, seedling to rosette. Painted bug has the potential to damage the crop from seedling to maturity, and that way it may be coined as a seed to seed pest. Leaf miner (*Chromatomyia horticola*) damages the crop from seedling stage to vegetative stage while, Tobacco caterpillar (*Spodoptera litura*) and Bihar hairy caterpillar (*Spilarctia obliqua*) are the pests of vegetative stage. The mustard aphid (*Lipaphis erysimi K.*) damages the crop from vegetative to siliquae formation stage and causes a heavy loss to the crop, thus, known as the key pest of oilseed *Brassica*.

1. Significant Achievements:

1. The biopesticide formulations *viz.*, Lipel (*Bacillus*

thuringiensis), Mealiki (*Verticillium lecanii*), Racer BB (*Beauveria bassiana*), Pacer MA (*Metarhizium anisopliae*), Kalichakra (*Metarhizium anisopliae*) and Daman (*Beauveria bassiana*) and a local isolate of *Beaueria bassiana* found effective against major insect-pests of mustard.

2. Pathogenicity of different fungal strains of *B. bassiana* (Pantnagar, 4109, 5408 and 4668) and *V. lecanii* (MTCC-956) found virulent against *Spilarctia obliqua, Liphaphis erysimi* and *Pieris brassicae*.

3. Profenophos, Triazophos and Quinalphos found potent with both the entomogenous fungi, *B. bassaina* and *V. lecanii* for managing *S. obliqua*.

4. Formulation of the fungi *B. bassiana* with talc and sorghum flour stored at 4^0 C effective in maintaining spore viability for longer duration.

5. Radioisotope uptake by hydroponic culture method the best one.

6. The trend of uptake and distribution of ^{32}P within parts of the mustard plant found in the order of stem> leaves> roots and stem> roots> leaves.

7. Using radiotracer technique *Brassica campestris* c.v. BSH-I found to be susceptible to aphid infestation as compared to *B. napus, B. alba, B. carinata, B. juncea* cv. Varuna & Krishna, and *Eruca sativa* which showed lesser amount of activity.

8. Highest transfer of activity of ^{32}P in *B. carinata* while the lowest in *B. juncea* cv. Varuna.

9. Timely sown crop generally escapes/has less aphid population.

10. Pantnagar isolate of *Beauveria bassiana* found virulent as compared to other isolates for control of *Spilarctia obliqua.*

11. The population for *L. erysimi* was observed having a negative correlation with maximum & minimum temperatures, rainfall, wind velocity, evaporation while being in a positive correlation with afternoon & morning relative humidity.

12. Integrated crop management (ICM) module instrumental in getting high crop yields.

2. Research Publications:

1. Goswami, V.; Khan, M.S. and Srivastava, P.2014. Association of different insect pollinators and their relative abundance on the blossoms of mustard (*Brassica juncea* L.). *Environment and Ecology*, 32 (1A): 368-371

2. Goswami, Vimla and Khan, M.S. 2014. Impact of honey bee pollination on pod set of mustard (*Brassica juncea* L.: Cruciferae) at Pantnagar. *The Bioscan*, 9(1): 75-78.

3. Kunjwal, Neha; Kumar, Yogesh and Khan, M.S. 2014. Flower-visiting insect pollinators of brown musturd, *Brassica juncea* (L.) Czern and Coss and their foraging behaviour under caged and open pollination. *African Journal of Agricultural Research*, 9(16): 1278-1286.

4. Hasan, W. and Singh, C. P. 2009. Efficacy of cow urine decoctions of botanicals against mustard saw fly. *Annals of Plant Protection Sciences*, 17(1): 234-235.

5. Hasan, W. and Singh, C. P. 2008. Biology of diamond back moth, -*Plutella Xylostella* (L.) (Lepidoptera: Yponomeutidae) on cabbage and Indian mustard. *International Journal of Agricultural Sciences*, 4(2): 684-686.

6. Hasan, W. and Singh, C. P. 2008. Differential feeding of mustard saw fly, *Athalia lugens proxima* Klug. on *Brassica* species and Indian mustard varieties. *Journal of Oilseeds Research*, 25(2): 220-222.

7. Hasan, W.; Gupta, A. K. and Singh, C. P. 2008. Biology of cabbage butterfly, *Pieris brassicae* (L.) (Lepidoptera: pieridae) on cabbage and Indian mustard. *Journal of Oilseed Research*, 25(1): 104-105.

8. Gupta, A. K.; Singh, C. P. Dalakoti, N. and

Hasan, W. 2007. Growth and development of *Lipaphis erysimi* (Kaltenbach) on different varieties of Indian mustard, *Brassica juncea* under laboratory conditions. *Journal of Aphidology*, 21 (1&2): 43-48.

9. Panwar, S. S. and Singh C.P., 2006. Comparative study of reproductive potential of *Lipaphis erysimi* (Kaltenbach) between field collected and laboratory acclimatized populations. *Journal of Aphidology*, 20(2):31-32.

10. Panwar, S. S. and Singh C.P., 2006. Fitness cost of resistance to chlorpyrifos in *Lipaphis erysimi* (Homoptera: aphididae), *Journal of Aphidology.* 20(2):31-32.

11. Panwar, S. S. and Singh C.P., 2006. Stage specific vulnerability of the laboratory populations of *Lipaphis erysimi* (Kaltenbach) to some conventional insecticides. *Progressive Research, 2(1/2):181-182.*

12. Panwar, S. S. and Singh C.P., 2006. Time specific threshold in activity of *Coccinella septempunctata* in mustard field. *Progressive Research, 2(1/2):161-162.*

13. Singh, C.P., Kumar, S., Gupta, A.K. and Mittal, V. 2006. Effect of different plant extracts on growth and development of tobacco caterpillar, *Spodoptera litura* (Fabricius). *Environment & Ecology*, 24S (4): 979-982.

14. Singh, C.P., Mittal, V, Kumar, S. and Gupta, A.K. 2006. Antifeedant activity and toxic effect of some bioactive plant extracts against *Spodoptera litura* (Fabricius). *Environment & Ecology*, 24S(3): 611-616.

15. Shama, R.K., Saxena K. and Singh, C.P., 2005. Antifeedant activity of some plant extracts against *Spodoptera litura. Indian Journal of Applied Entomology.* 19(1) : 45-49.

16. Singh, C. P.; Sachan, G. C. and Singh, R.P. 2004. Population dynamics of *Lipaphis erysimi* (Kalt.): arrival and migration pattern in *Tarai*, Pantnagar ,India. *Bulletin GCIRC* No.20:79-82.

17. Singh, C.P.; Viswakannan, P. Singh, S.P. and Chhibber, R.C. 2004.Relationships between glucocynolate and the population of *Lipaphis erysimi*(Kalt.) on *Brassica* species. *Bulletin GCIRC No*.20: 102-105.

3. Thesis Research:

M.Sc.

1. Rohila Sikha (2017). Bioactivity and shelf life of crude extract of some plants against *Lepaphis erysimi* (Kaltenbach) and Pieris brassicae (L.). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

2. Yadav Usha (2011). Screening of Rapeseed Mustard fermplasm against *Lepaphis erysimi* (Kaltenbach). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

3. Kumar Sanjeev (2011). Screening of Okra, *Abelmoschus esculentus* (L.)Moench Germplasm against Its major insect pests. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

4. Kunjwal, Neha (2011). Impact of honeybee pollination on yield and quality of mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. M.S. Khan.

5. Negi Pramod (2010). Pathogenicity of some biopesticide formulations against major insect pests of Mustard. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

6. Mathur Vaibhav (2009). Effect of cow urine, decoction of some plants on growth and development of *Lepaphis erysimi* (Kaltenbach). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

7. Kumar, Vinod (2008). Studies on diversity of Insect visitors and their potential as pollinators in mustard crop. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. M.S. Khan.

8. Kumar Raja (2008). Studies on diversity of non-apis bees and their potential as pollinators in different crops. M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. M.S. Khan.

9. Joshi Basant (2006). Bioefficacy of medicinal and aromatic plant oils against Bihar Hairy Caterpillar, *Spilarctia oblique* (Walker). M.Sc. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

Ph.D.

1. Patel Shweta (2017). Development of forecasting model for *Lepaphis erysimi* (Kaltenbach) and population dynamics of insects associated with Rapeseed Mustard. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

2. Hasan Wajid (2009). Study on life table of *Lepaphis erysimi* (Kaltenbach) a key pest of *Oleiferous beassicas.* Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

3. Gupta Ajay Kumar (2008). Studies on Parthenogenicity and infection process against *Spilarctia oblique* (Walker); Genetic variability, compatibility with chemical pesticides and mass multiplication of *Baeveria bassiana* (Balsamo), *Verticilium.* Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

4. Panwar, S.S. (2006) Genetics of Insecticide tolerance capacity in *Lepaphis erysimi*(Kaltenbach); Studies on levels of esterase (S) in Tolerant and susceptible population. Ph.D. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. C. P. Singh.

3. Future Thrusts:

1. Survey of different agro-ecological regions to indentify major insect pest of rapeseed mustard in relation to climate change

2. Evaluation of available genotypes against major insect pests for the resistant sources

3. Bio-ecological studies and development of forecasting module for major insect pests

4. Development of bio intensive management against major insect pest in different agro-ecological regions

5. Studies on pollination requirements of promising advance lines and conservation of major insect pollinators

E. Biochemistry:

1. Significant Achievements:

1. **Blended Mustard Oil and its biochemical attributes:** Blending mustard oil with palm oil and rice bran oil resulted in oil blends with improved physico-chemical and bio-chemical characteristics .The healthier and stable blends using fresh crude mustard oil (MO), crude palm oil (PO), and crude rice bran oil (RBO). Blend A (40:40:20) showed highest scavenging activity than that of the other blends, and can be categorized as the oil with the highest antioxidant potential. It contained mustard oil which has adequate amount of omega 3 fatty acids, and the rice bran oil in appreciable amount which is rich in antioxidants. Polyunsaturated fatty acids (PUFA), which are supposed to be more susceptible to oxidation than monounsaturated fatty acid (MUFA), were low in this blend A. Oil stability index proved palm oil and blend A to be highly stable. Minimum peroxide value and increase in free fatty acids was observed in mustard oil and blend A. Highest DPPH radical scavenging activity and total antioxidant capacity were displayed by mustard oil and blend A. blend A (40:40:20) has better stability, nutritional value and contained adequate amount of omega 3 fatty acid than that of the individual oils and their other blends.

2. **Biochemical parameters in response to *Alternaria* blight infection:** Total phenol and o-dihydroxy phenol were found to be higher in the leaves of PHR-2, EC-399313 and EC-399296, EC-399299 at both healthy and infected stages as compare to other verities. The total

phenol and o-dihydroxy phenol contents increase with increase in infection. The flavonol content decreases with increase in infection. The enzyme activities such as Phenylalanine ammonia lyase (PAL), Peroxidase, Catalase and Polyphenol oxidase have been observed during infection of *A. brassicae* in *Brassica juncea* genotypes. Peroxidase, polyphenol oxidase and PAL activities were observed higher in infected leaves as compared to the healthy ones. The enzymatic activites of peroxidase, PAL and polyphenol oxidase increased with increase in infection, whereas the catalase activity decreased.

3. **Evaluation of anti-nutritional factors and antioxidative activity of *Brassica* genotypes:** Some promising genotypes were analysed having low erucic acid and low glucosinolate contents. Some promising genotypes having low glucosinolates were RLC5, PDZ-5, NUDB-26-11, RLC3, PDZ3, EJ8-379, PDZ-4, RLC4, EJ8-118, PDZ-1, CJRB-1661, PDZ-8, EJ8-369 , PDZ-10, PDZ-9, RLC-6. Some promising genotypes having low erucic acid content were PM-29, LES-55, PM-30, PDZ-7, CJRB-1661, PDZ-8, PDZ-4, PM-21, PDZ-1, PDZ-5 , RLC-3, PM30, PDZ-10, PDZ-9, LES-54 , LES-56, RLC-6. Some promising genotypes observed to have high antioxidant activity were Kranti, RLC-3 LES 50, PDZ-6, PDZ-7 LES-55, RLC-2 and maximum DPPH activity observed for PDZ 2, PDZ4, LES49, RLC5 , PDZ-7, Kranti, PDZ-4, CJRB-1661.The national check Kranti, a still high yielding variety from Pantnagar, was analysed with high anti-oxidant and DPHH activities.

2. Research Publications:

1. Heena Dhanik, H Punetha, Om Prakash, GC Joshi. 2018. Biochemical characterization of blended mustard oils and their physico-chemical attributes for nutritional enrichment. *Journal of Oilseed Brassica*. 9(1), 77-83.
2. Himanshu Punetha, Usha Pant, Amit Verma. 2018. Yeild Attributing Agromorphological Traits of Promising Genotypes of Indian Mustard (Brassica juncea). *Open Science Journal of Bioscience and Bioengineering*. 2018; 5(2): 17-20.
3. H. Punetha, Heena Sagar, Swati Panwar, Usha Pant and Om Prakash. 2017. Study on phytochemicals and antioxidative capacity of selected genotypes of Brassica juncea. *Res. Environ. Life Sci*. 10(4) 373-377
4. Papola Poonam, H Punetha and Prakash Om. 2017. Antioxidative potential of defatted meal from exotic collections of Indian mustard (Brassica juncea). *Electronic Journal of Plant Breeding*. 8(2) :437-443.
5. Dinesh Pandey, H Punetha, Anil Kumar. 2017. Annexin Signaling In Plants. *Biotech Today: An International Journal of Biological Sciences*. 7 (1), 52-57
6. Poonam Papola, H Punetha, Usha Pant and Om Prakash. *December* 2016 correlation study among yield and yield attributing agromorphological discriptors in exotic collections of *Brassica juncea* (indian mustard). *Agric Res J* 53 (4): 580-582.
7. Poonam Papola, H. Punetha , Sonal Tripathi, A.K Pant and Om Prakash.2016. Quantification of glucosinolate and mineral content in exotic collection of *Brassica juncea*. Res. Environ. Life Sci. Vol. 9, No.3/4, March/ April - 2016. Vide Ref. No.: RELS/ACC-490/944/ 2015 Date: 02/11/2015
8. H.Punetha, M Chandra, S. Bhutia, Sonal Triphati and Om Prakash. 2015. Antioxidative properties and mineral composition of defatted meal of oileferous Brassica germplasm. *Journal of Biologically Active Products from Nature*. 5:1, 43-51, DOI: 10.1080/22311866.2014.983974
9. Mishra, D.Pandey, H. Punetha, R. Prabhusankar, A.K. Gupta, G.Taj and A.Kumar. Online 27 March, 2015.Expression analysis of MAP K4 and MAP K6 during pathogenesis of Alternaria blight in susceptible and tolerant genotypes of *Brassica juncea*. *Eur.J.Plant Pathol*. DOI

10.1007/s10658-015-0641-8.

10. H.Punetha, Dinesh Pandey, Pooran Bhatt, Heena Sagar and B.Rawat.2015. Biochemical investigation on antioxidative and antinutritional characters of yellow seeded Brassica genotypes for quality assessment. *International Journal of Agriculture, environment and Biotechnology*. 8(2): 253-264 June 2015.

11. Papola Poonam, Punetha H, Pant Usha , Pant A.K and Prakash Om. September (2015) Phytochemical Screening and Nutritional potentials of some High oil Yielding Exotic collections of Brassica juncea. Research Journal of Chemical Sciences. 5(9), 66-71.

12. Dinesh Pandey, Anil Kumar, G.K.Garg, H.Punetha and K.C.Bansal. 2012. Agrobacterium mediated transformation of brassica juncea with Arabidopsis annexin (*annAt* 1) gene. *International Journal of Agriculture, environment and Biotechnology.* 5(1), 45-52.

13. Pankaj singh Parihar, Om Prakash and H.Punetha. 2012. Investigation on defensive enzymes activity of *Brassica juncea* genotypes during pathogenesis of Alternaria blight. *Nature and science*. 2012: 10(2), 63-68.

14. Ahire Tushar Prakash, H.Punetha and Rakesh Mall. July-December 2012. Investigation on metabolites changes in *Brassica juncea* (Indian mustard) during progressive infection of *Alternaria brassicae*. *Pantnagar J. of research.* 10 (2).

15. Om Prakash, H.punetha, M.Pandey and A.K.Pant.2012. Investigating the role of phenolics and antioxidative defense machinery of *Brassica juncea* (Indian mustard) during progressive infection of Alternaria blight. *Journal of biologically active products from nature.* 2:5,265-274. DOI: 10.1080/ 22311866.2012.10719134.

16. P. Mathpal, H. Punetha, A.K. Tewari and S. Agrawal. Jul 2011. Biochemical defense mechanism in rapeseed-mustard genotypes against Alternaria blight disease. *Journal of oilseed Brassica*. 2(2): 87-94.

17. P.Kannan, Dinesh Pandey, Atul K. Gupta, H.Punetha, Gohar Taj and Anil Kumar. September 2011. Expression analysis of MAP2K9 and MAPK6 during pathogenesis of Alternaria blight in *Arabidopsis thaliana* ecotype Columbia. *Molecular Biology Reports.* DOI 10.1007/s11033-011-1232-1.

3. Thesis Research:

M.Sc.

1. Neha Sajwan (2018) Evaluation of brown and yellow seeded quality germplasm of oilseed Brassica for their potential nutrients. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. H. Punetha.

2. Heena Sagar (2015) Study on phytochemicals and antioxidative capacity of selected genotypes of Brassica. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. H. Punetha.

3. Swati Panwar (2015). Biochemical analysis and assessment for double zero characters of selected genotypes of Brassica. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. H.Punetha.

4. Urvashi Duggal (2014) Characterization of bioactive principles and phenotypic screening of selected genotypes of *Brassica juncea* (Indian Mustard). Thesis submitted GBPUAT, Pantnagar under guidance of Dr. H. Punetha.

5. Bhupendra Singh Rawat (2013) A Study on biochemical characterization of yellow seeded Brassica genotypes for quality determining traits. Thesis submitted GBPUAT, Pantnagar under guidance of Dr. H. Punetha.

6. Kumar Saurabh (2013). Biochemical investigation of oleiferous brown seeded Brassica genotypes for quality characters Thesis submitted GBPUAT, Pantnagar under guidance of Dr. H.Punetha.

7. Swati Sharma (2002). Biochemical characterization for antinutritional & antioxidative factors and element profiling of defatted meal of some oleiferous Brassica genotypes.

8. Prabusankar R. (2012). Study on expression analysis of MAP Kinase 4 and MAP Kinase 6 during pathogenesis of Alternaria Blight in *Brassica juncea*

9. Pankaj Singh Parihar (2011). Investigation on defensive enzymes and antioxidant activity of Brassica juncea genotypes during pathogenesis of *Alternaria brassicae*

4. Honour/Awards:

1. Pantnagar AICRP-RM center has been awarded with **Best Research Main Center** for the year 2011-12 by Directorate of Rapeseed-Mustard Research.

2. Fellow award to Dr. Usha Pant Assistant Professor, Genetics & Plant Breeding by Society for Rapeseed-mustard research in **4th International Brassica conference** held at CSAUA&T, Kanpur, Feb. 1-3rd 2019.

3. **Best PhD Thesis Award** (Rashmi) on "Studies on alloplasmic and euplasmic heterosis in *Brassica Juncea*" by Society for Rapeseed-mustard research in **4th International Brassica conference** held at CSAUA&T, Kanpur, Feb. 1-3rd 2019.

4. **Best PhD Thesis Award** (Kalpana Gairola) on "Early detection and management of white rust disease (*Albugo candida*) in rapeseed-mustard" by Society for Rapeseed-mustard research in **4th International Brassica conference** held at CSAUA&T, Kanpur, Feb. 1-3rd 2019.

5. **Best M.Sc. Thesis Award** (Preeti Lohani) on "Determination of morpho-molecular genetic diversity and drought response among the advanced lines of *Brassica carinata*" by Society for Rapeseed-mustard research in **4th International Brassica conference** held at CSAUA&T, Kanpur, Feb. 1-3rd 2019.

6. **Best Ph.D. Thesis award** (Prateeksha Mehra) on "Studies on cultural, morphological, pathogenic and molecular variability of *Alternaria brassicae*, the causal agent of blight disease of rapeseed-mustard at **3rd National Brassica Conference** on "Enhancing Oilseed Brassica Production through Climate-Smart Technologies". IARI, Pusa New Delhi, Feb. 16-18, 2017.

7. **Young Scientist Award** (Pooja Upadhyay, Ph.D. student) on "Morphological and pathogenic variability among different *Albugo candida* isolates causing white rust disease in rapeseed mustard". In: **12th Uttarakhand State Science and Technology (UCOST) Congress** held at Dehradun from 07-09 March, 2018.

5. Future Thrusts:

1. Evaluation of health promoting phytochemicals of mustard meal and Brassica vegetables and assessment of it's nutritional attributes.

2. Evaluation of quality varietal trials and advanced breeding material for high oil content.

3. Profiling for antioxidative and antinutritional factors in seed meal and oil of promising breeding material.

4. Assessment of mineral composition of selected genotypes of mustard for poultry and animal farms.

5. Evaluation of Fatty acid composition of blended mustard oil to meet the recommendation of WHO

Fig-1 Pictorial view of Rapeseed –Mustard Varieties

PT-508

PT-508

Pant Sweta

PR-21

Pant Girija

PR-20

PR-19

Kranti

Pant Pili S-1

Uttara

Kranti

Kranti

PT-303

PT-507

PT-30

System of Root Intensification (SRIM)