AICRP- MAIZE

Objective

Pantnagar is one of the 32 research centers working under AICRP- Maize, and has been engaged in maize improvement and evaluation activities since September 1961, with following objectives:

- To develop early and medium maturity composites single cross hybrids.
- To develop and diversify germplasm
- Maintenance and seed production of released hybrids and composites
- Development of agronomic practices to enhance productivity and profitability of maize
- Screening of germplasm and test entries against BLSB and BSR and development of IDM practices
- Survey and surveillance of diseases in the state
- Supporting maize farmers through technological intervention

A. Maize Breeding

1. Significant achievements:

i) Development of composite varieties

Pantnagar has its name in composite breeding. In past, about a dozen composite maize varieties have been developed and released for general cultivation by the farmers in different maize growing areas (table 1). These composite varieties of maize are highly yielding, tolerant to major diseases and adapted to different climatic conditions. Seeds of these composites have always been in high demand because of the high yield and adaptability.

Table 1. Composite varieties of maize developed at Pantnagar

Sl. No.	Variety	Year of release	Maturity (days)	Grain yield (Q/ha)	Area of adaptation
1.	Protina	1971	90-95	30-35	All maize growing areas
2.	Tarun	1977	85-90	45-50	Indo – Gangetic plains
3.	Navin	1979	80-85	45-50	Uttar Pradesh
		1992	80-85	45-50	Himanchal Pradesh
4.	Shweta	1980	85-90	45-50	Uttar Pradesh
5.	Kanchan	1982	75-80	45-50	Uttar Pradesh
6.	D- 765	1984	75-80	35-40	Across the country
7.	Surya	1988	75-80	35-40	Across the country
8.	Gaurav	1999	80-85	40-45	North- western plains of Punjab, Delhi, Haryana & Uttar Pradesh
9.	Amar	2000	85-90	45-50	Maharashtra, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Rajasthan, Madhy Pradesh and Gujrat.
10.	Pragati	2003	80-85	45-50	North- eastern plains of Uttar Pradesh, Bihar, Jharkhand and Orissa.
11.	Pant Sankul Makka – 3	2008	80-85	45-50	Maharashtra, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Rajasthan, Madhy Pradesh and Gujrat.

Table 2. Composite varieties of maize developed at Pantnagar

Sl. No.	Variety	Year of release	Maturity (days)	Grain yield (Q/ha)	Area of adaptation
1.	Pant Sankar Makka- 1	2007	80-85	45-50	Plains of Uttarakhand
2.	Pant Sankar Makka - 2	2015	80-85	45-50	Plains of Uttarakhand
3	Pant Sankar Makka-4	2015	80-85	45-50	Plains of Uttarakhand

ii. Maize hybrid development (Early)

With the change in seed production and supply chain and awareness about the hybrids, development of maize hybrid was initiated since 1997. After the development of inbred lines of maize, crosses were made to identify promising high yielding single cross hybrids of maize for further boosting production and productivity of maize and also increasing farmer's income. Pant Sankar Makka-1, Pant Sankar Makka-2 and Pant Sankar Makka-4 were developed after testing in multilocation trials for cultivation in Uttarakhand.

iii) Development of medium maturity maize hybrids DH-291, DH-296 and DH-300

Maize has now become more of industrial crop. Because of increasing industrial uses and back-bone of ever increasing poultry industry, maize demand is increasing day by day at a faster rate. Maize production and productivity enhancement through deployment of medium maturity heterotic

hybrids is one of the rewarding options. To ensure the availability of potential maize hybrids to farmers for maximizing productivity and production, research work on development of medium maturity germplasm and high yielding hybrids were initiated by the University. In a short period of time three hybrids having potential of 65-70 q/ha grain yield have been identified based on the multi-location evaluation trials. In addition to high grain yield potential, these hybrids were also possessing high starch (73%), bold grain (desirable for industrial processing) and other quality parameters, and based on these parameters three hybrids namely **DH-291**, **DH-296** and **DH-300** were grouped as 'Grade A' by a major industry Roquette Ridhi-Sidhi, Sidcul Rudrapur.

iv) Development of popcorn hybrid DPCH-306

A popcorn hybrid developed at Pantnagar and evaluated across the country in All India Maize Evaluation trial for three years was identified by Variety Identification Committee of ICAR for release. DPCH-306 has been recommended for release in **Northern Hill Zone (Zone I)** includes Jammu & Kashmir, Himachal Pradesh, Uttarakhand (Hills) and NE Hill Region (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura), and **PZ (Zone IV)** includes Tamil Nadu, Karnatka,

Andhra Pradesh, Telangana, Maharashtra. It has high yield potential of 3975 kg/ha in Zone-I and 4997 kh/ha in Zone-IV exhibiting yield superiority of 34.79% to 22.53%, respectively over the best existing variety.

v) Diversification of maize germplasm

Pantnagar centre took lead in diversification and enhancement of maize germplasm using wild relative and most probable progenitor of maize teosinte (*Zea mays* ssp *parviglumis*) (Fig. 1.). Crosses and back crosses were to develop mapping populations for mapping of QTLs related with biotic and abiotic stresses. Teosinte has also been used in development of inbred lines with tolerance different biotic and abiotic stresses and also in development of specialty maize.

vi) Registration of varieties under PPV & FRA

Six varieties have been registered with PPV and FRA. (Table 3)

vii) Pantnagar Maize programme contributing 6-7 experimental hybrids/varieties each year for testing in All India Coordinated Maize evaluation trials.

viii) Pantnagar Maize programme also contributing 7-8 experimental hybrids/varieties each year for testing in SVT (plains) and SVT (Hills).

ix) Every year 150-200 new experimental hybrids are being developed and evaluated in Station trials and promising hybrids are promoted for testing in Coordinated maize trials across the zones.

x) All the populations including landraces, pools and

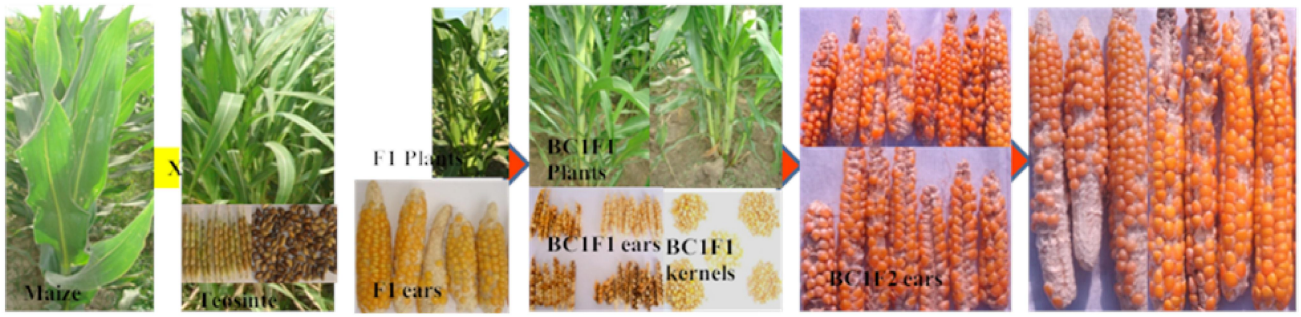

Fig. 1 Use of teosinte (*Zea mays* ssp *parviglumis*) in maize improvement programme.

Table 3. Varieties registered under PPV and FRA

Sl. No.	Hybrids/ composites	Notification No. & Date	Registration No. & Date
1	Gaurav	425(E),08/09/1999	162of 2009/21.12.09
2	Amar	92(E),02/02/2001	7of 2010/20.10.10
3	Pragati	642(E),31/05/2004	127of 2009/21.12.09
4	Pant Sankar Makka-1	2817(E), 19/09/2013	3807/2013
5	Pant Sankul Makka-3	2458(E),16/10/2008	259 of 2016
6	Pant Sankar Makka-4	1007(E),30/03/2017	3-52/2016 of 09.03.2017

released varieties are being maintained using maintenance breeding approaches for nucleus seed production and multiplication.

xi) Approximately 220 inbred lines of indigenous and exotic inbred lines are maintained through controlled pollination.

xii) Population derived from crossing between maize and teosinte are being advanced.

xiii) Winter Maize Nursery, IIMR, Hybderabad is being used for advancing the generation and seed multiplication of experimental hybrids under test along with their parental lines.

xiv) All station, zonal, coordinated and international (CIMMYT) trials (approximately 20-22 trials) are conducted in both *kharif* and *rabi* crop seasons.

xv) Complying with DAC indent and centre is breeder seed of composite varieties and CM lines.

xvi) The thesis research experiments of PG (M.Sc. and Ph.D.) students are conducted during both the crop seasons as usual. The materials developed and the results obtained from these experiments are utilized in the on – going breeding programme.

xvii) Research activities on sweet corn and popcorn are also in progress here at this station.

2. Research publications:

1. Jha, S. K., Singh, N. K. and Agarwal, P.K. 2019. Modified backcross breeding method for rapid conversion of field corn line to *shrunken2* (*sh2*) gene-based sweet corn line. *Indian J. Genet*., 79(1): 34-39

2. Tufchi, M., Rashmi, and Singh, N. K. Singh. 2018. *In silico* prediction of 3D structure of *Opaque-2* protein in maize. Res. on Crops. 19: 526-536

3. Singh, N.K., Kumar, A., Chandra, H., Pla, K. and Verma S.S. 2017. Enhancement of Maize Allelic Diversity using Wild Relative Teosinte (*Zea mays ssp. Parviglumis*). *Indian J. Plant Genet. Resour. 30: 253-257.*

4. Tufchi, M., Rashmi, Hussain F. and Singh, N. K. Singh. 2017. Effect of recurrent background on the protein Quality of QPM lines developed through marker Assisted backcross breeding (MABB). *International Journal of Agriculture and Environmental Research, 3:3937-3947.*

5. Jha, S.K., Singh, N.K. and Agrawal, P.K. 2016. Complementation of sweet corn mutants: a method for grouping of sweet corn genotypes. J. Genetics, 95:183–187.

6. Barh, A., Singh, N.K., Verma, S. S., Kumar, M. 2016. Heterosis and combining ability studies for selection of parental lines and derived test crosses in maize. Ecology, Environment and Conservation, 22:195-202 (Suppl. Issue).

7. Bhaskar, Jitendra and Verma, S.S. 2016. Phenotypic stability for yield and other desirable characters in high quality protein maize (*Zea mays* L.). International Journal of Basic and Applied Agricultural Research, Vol. 14(1), January-April, 2016:33-38.

8. Tufchi, M., Rashmi, Jha, S.K. and Singh, N.K.

2015. Effect on tryptophan content in opaque - 2 gene introgressed $BC_2F_{2:3}$ population of maize. Indian Journal of Genetics and Plant Breeding, 75(4): 453-458.

9. Mishra, Priyanka, Tripathi, Saurabh and Verma, S.S. 2016. Analysis of genetic components of variance and other quantitative characters in high-lysine maize composite, DQPMC-4 (w) at two plant densities. International Journal of Basic and Applied Agricultural Research, Vol. 14(1), January-April, 2016:24-32.

10. Devi EL, Verma SS, Kumar S and Singh NK. 2016. Genetic variability studies for yield and contributing traits under two plant densities and molecular diversity analysis in maize (*Zea mays* L). Maydica, 60(37): 1-11.

11. Zunjare, R., Hossain, F., Muthusamy, V., Choudhary, M., Kumar, P., Shekhar, J.C., Guleria, S.K., Singh, N. K., Thirunavukkarasu, N. and Gupta, H. S. 2015.Popping quality attributes of popcorn hybrids in relation to weevil (*Sitophilus oryzae*) infestation. Indian **Journal of Genetics and Plant Breeding,** 75(4): 510-513.

12. Barh, A., Singh, N.K., Verma, S. S., Jaiswal, J.P. and Shukla, P.S.2015. Combining ability analysis and nature of gene action for grain yield in Maize hybrids. International Journal of Environmental & Agriculture Research, 1(8):1-5.

13. Kumar, P., Singh, N. K. and Jha, S.K. Jha. 2015. Multi-environments evaluation for determining grain yield, combining ability, heterosis and their interrelationships in maize. SABRAO J. Breeding and Genetics, 47:366-374

14. Behera, C., Singh, N. K., Devi, E. Lamalakshmi, Singh, M. and Singh, A. 2015. Allelic diversity for kernel carotenoids in short duration inbred lines of maize (*Zea mays* L.). Ecology, Environment and Conservation, 21:1885-1889.

15. Tufchi, M., Rashmi, Singh, N.K. and Kumar, A. 2015. Characterization of maize population for pro-vitamin A carotenoids using TLC. International Journal of Basic & Applied Science (Pantnagar J Res), 13:179-182.

16. Zunjare, R., Hossain, F., Muthusamy, V., Jha, S.K., Kumar, P., Shekhar, J.C., Guleria, S.K., Singh, N. K., Thirunavukkarasu, N. and Gupta, H. S. 2015. Genetics of resistance to stored grain weevil (*Sitophilus oryzae* L.) in maize. Cogent Food & Agriculture,1: 1075934

17. Kumar, P. and Singh, N.K. 2015. Determining behaviour of maize genotypes and growing environments using AMMI statistics. SAARC J. Agriculture, 13: 162-173

18. Rashmi; Tufchi, M., Shastry, M. Singh, NK. 2014. Phenotyping of maize inbred lines for beta-carotene and determining relationship with total carotenoids and kernel colour in maize. Indian J. Genet. 74:631-37.

19. Dosad, S. and Singh, N.K. 2014. Stability and adaptability of kernel carotenoids in maize. The Bioscan, 9:1747-1751.

20. Mishra, Priyanka and Verma, S.S. 2014. Estimation of components of variances for yield and its components in an open-pollinated maize composite, DQPMC-4 (w). International Journal of Basic and Applied Agricultural Research. Vol. 12(1), January-April 2014: 35-40.

21. Jha, S. K., Singh, N. K. and Agrawal, P. K. 2013. Studies on exploitable heterosis in sweet corn under assured rainfed situation of North-Western Himalayas. Karnataka J. Agric. Sci. 26:308-10.

22. Jha, S. K., Singh, N. K., Arun Kumar, R., Agrawal, P. K., Bhatt, J. C., Guleria, S. K., Lone, A. A., Sudan, R. S., Singh, K. P. and Mahajan, V. 2013. Additive main effects and multiplicative interaction (AMMI) analysis for grain yield of short duration maize hybrids in North-Western Himalayas. Indian J. Genet. 73:29-35.

23. Das, A.K. and Singh, N.K. 2012. Carotenoid and SSR marker-based diversity assessment among short duration maize (Zea mays L) genotypes. Maydica, 57:106-113.

24. Mishra, P. & Singh, N. K. 2012. Allelic diversity for kernel carotenoids in short duration maize (Zea mays L.). Madras Agricultural Journal, 99:232-236.

25. Chandrashekara, C., Jha, S. K., Agrawal, P. K., Singh, N.K. and Bhatt, J. C. 2012. Screening of Extra Early Maize Inbred under artificial epiphytotic condition for North-Western Himalayan region of India. MNL 86

26. Devi, P. & Singh N.K. 2011. Heterosis, molecular diversity, combining ability and their interrelationships in short duration maize (*Zea mays* L.) across the environments. Euphytica 178:71-81.

27. Mishra, P & Singh, N.K. 2010. Spectrophotometric and TLC based characterization of kernel carotenoids in short duration maize. Maydica 55:95-100.

28. Devi, P, & Singh, N.K. 2010. Environmental influence in determination of correlation structures in short duration maize (*Zea mays* L.). Environ. Ecol. 28:1872-1874.

29. Singh, N. K., Devi, P. and Mishra, P. 2009. Expression of unusual characters in ear shoot and tassel of maize. MNL, 83:32-34.

30. Devi, P and Singh, N. K. 2009. Studies on secondary traits of maize inbred, hybrids and composites across environments. MNL, 83: 32.

31. Mishra, P. and Singh, N. K. 2009. Kernel carotenoids in 37 maize lines. MNL, 83:35.

32. Devi, P. and Singh, N.K. 2008. Behaviour of maize inbreds and hybrids across diverse environments. Indian Agric. 52: 169-173.

3. Thesis Research:

1. Rajendra Singh. 1970. Evaluation of inbred lines for lodging resistance in maize submitted for M. Sc. to GBPUAT under supervision of Dr. R. L. Paliwal.

2. Manmohan Singh. 1970. Estimation of components of genetic variance for yield and other quantitative traits in two varieties of maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal

3. C.D.R. Reddy. 1971. Timing patterns of developmental stages and its relationship with grain yield in maize submitted for M. Sc. to GBPUAT under supervision of Dr. B. P. Pandya.

4. M.P. Pandey. 1971. Effect of dwarfing genes on yield and other agronomic characters, and the association of characters contributing to stalk lodging in maize submitted for Ph. D. to GBPUAT under supervision of Dr. V. L. Asnani.

5. Maha D. Arha. 1971. Studies on combining ability for yield and other quantitative characters in nine dwarf in bred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. V.L. Asnani.

6. Bhola Nath. 1970. Effect of brachytic 2 gene on yield and other agronomical characters in single cross hybrids and inbred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. B. D. Agarwal.

7. D. Shivshankar. 1972. Studies with dosage effects of opaque-2 gene in four inbred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. V.L. Asnani.

8. D. Shivshankar. 1972. Studies on the dosage effect of opaque-2 gene in 4 inbred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. V.L. Asnani.

9. P.R. Reddy. 1973. Studies on yield, yield components and kernel moisture content in the normal and opaque-2 version of maize submitted for M. Sc. to GBPUAT under supervision of Dr. V. L. Asnani.

10. K.K. Avadhani. 1973. Lysine and tryptophan improvement in maize by incorporating opaque-2 and flowery-2 gene submitted for Ph. D. to GBPUAT under supervision of Dr. V. L. Asnani.

11. K.P. Rao. 1973. Studies on developmental stages, heat units and black layer development in maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

12. G.S.S. Setty. 1974. Studies on effect of erect leaf orientation in light transmission and grain yield in corn submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

13. G.L.K. Reddy. 1974. Studies on black layer and development stages in maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

14. B. S. Shukla. 1974. Effect of leaf orientation on yield and other agronomic characters in maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

15. P.R. Maurya. 1975. Studies on the dosage effects of opaque-2 gene in two inbred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

16. Hari Singh. 1975. Physiological basis of yield expression in dwarf and tall inbred lines and their single cross hybrids in maize submitted for Ph. D. to GBPUAT under supervision of Dr. B.Rai.

17. M.K. Pandey. 1975. Combining ability studies for some quantitative characters in maize submitted for M. Sc. to GBPUAT under supervision of Dr. I.S. Singh.

18. S.M. Hussain. 1978. Modified ear to row selection in semi-opaque-2 maize composite submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

19. Pheru Singh.1979. Inheritance studies on stalk rot caused bu Erwinia pathotype zea in maize submitted for Ph. D. to GBPUAT under supervision of Dr. V.L. Asnani

20. R.K. Srivastava. 1979. Effect of full-sib family selection on yield and other characterstics in two populations of maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

21. S.P. Singh. 1980. Inheritance studies on grain yield, kernel vitreosity and other characters in opaque-2 maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

22. K.H.P Reddy. 1982. Development of heterotic pools in maize submitted for M. Sc. to GBPUAT under supervision of Dr. I.S. Singh.

23. D.K. Mishra. 1982. Genotypic, phenotypic and environmental correlations between seed vigour, field emergence, yield and yield components of inbred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. R.L. Agarwal.

24. R.P.S. Verma.1983. Genetic analysis of heterosis in eight population crosses of maize submitted for M. Sc. to GBPUAT under supervision of Dr. I.S. Singh.

25. J.M. Srivastava. 1983. Phenotypic variability in parental lines of some released maize hybrids submitted for M. Sc. to GBPUAT under supervision of Dr. B. D. Agarwal

26. S. J. Singh. 1983. Determination of maturity parameters in some varietal crosses of maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

27. J. P. Shahi. 1983. Genetic architecture of an early yellow flint composite of maize submitted for Ph. D. to GBPUAT under supervision of Dr. I.S. Singh.

28. D.N. Singh. 1984. Evaluation of early generation inbreds of maize submitted for M. Sc. to GBPUAT under supervision of Dr. I.S. Singh.

29. M.Z.K. Warsi. 1984. Studies on inheritance of resistance to maize stem borer submitted for Ph. D. to GBPUAT under supervision of Dr. B.D. Agarwal.

30. S.K. Mishra. 1985. Genetic analysis of yield and other characterstics in a random mating population of maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

31. S.S. Verma. 1985. Response to four cycles of modified ear to row selection for yield and other characters in three populations of maize submitted for Ph. D. to GBPUAT under supervision of Dr. B.D. Agarwal.

32. A.V.S.R. Swamy. 1985. Studies on combining ability, stability and rank correlations in crosses

of maize submitted for Ph. D. to GBPUAT under supervision of Dr. B.D. Agarwal.

33. O.S. kanwar. 1986. A study on genotypic and Environmental correlation and combining ability in maize submitted for M. Sc. to GBPUAT under supervision of Dr. B.D. Agarwal.

34. R. K. Singh 1988. Estimation of genetic parameters in an early composite population of maize submitted for Ph.D. to GBPUAT under supervision of Dr. I. S. Singh

35. J.K Roy 1990. Studies on evaluation of inbred lines fom four sources for top cross performance in maize submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

36. P. Ashok Nair. 1991. Studies on phenotypic variability in some composite varieties of maize submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

37. S.K. Ghosh. 1994. Studies on coorelation, heterosis and genetic advance in single and double crosses of maize submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

38. Sukhdev Singh. 1994. Combining ability and heterosis in diallel crosses of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S. N. Mishra.

39. Animesh Sinha. 1995. Variety cross diallel analysis of quantitative traits in maize submitted for M. Sc. to GBPUAT under supervision of Dr. S. N. Mishra.

40. Parag Agarwal. 1995. Stability of three way hybrids for certain quantitative traits in maize submitted for M. Sc. to GBPUAT under supervision of Dr. SS Verma.

41. K.P.S. Tomar. 1995 Line x Tesyer analysis in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

42. Saurabh Banerjee. 1996. Studies on combining ability of local varieties of maize submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

43. Sanjeev Kumar. 1996. Efficacy of s1 family selection for improvement of two populations of maize submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

44. Amajit Mukherjee. 1997. Line x Tester analysis for certain agronomic traits in early maturing inbred lines of maize submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

45. S. K. Bhatt. 1998. Genetics of resistance to Erwinia stalk rot and certain other quantitative traits in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S.N. Mishra

46. V.K. Tiwari. 1998. Genetic variability for baby corn in maize submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

47. K. Pradhan. 1999. Classification and characterization of inbred lines of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S. N. Mishra.

48. Shailesh tripathi. 2000. Studies on screening of inbred lines for water logging tolerance in maize submitted for M. Sc. to GBPUAT under supervision of Dr. MZK Warsi.

49. M.K. Kandpal. 2000. Combining ability and heterosis analysis for grain yield and its components in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

50. Saurabh Shukla. 2001. Estimates of genetic variance in an open pollinated variety of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S.C. Mani.

51. Ashish Srivastava. 2002. Heterosis, combining ability and phenotypic stability studies in exotic x indigenous single cross hybrids of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. I.S. Singh.

52. K.P.S. Tomar. 2002. Studies of heterosis, combining ability and phenotypic stability analysis involving indigenous and exotic inbred lines of maize (*Zea mays* L.) submitted for Ph. D. to

GBPUAT under supervision of Dr. MZK Warsi.

53. Manpreet Bajaj. 2002. Evaluation of quality protein maize inbred lines through top crosses submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

54. V.K. Tiwari. 2003. Studies on heterosis, combining ability, inbreeding tolerance and phenotypic stability in intra- and inter-group single cross hybrids of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. I.S. Singh

55. Neha singhal. 2004. Line x Tester analysis in quality protein inbred lines of maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

56. A.A. Lone. 2005. Genetic studies on excess soil moisture tolerance in maize submitted for Ph. D. to GBPUAT under supervision of Dr. MZK Warsi.

57. V.K. Yadav. 2005. Distinctness, Uniformity and stability (DUS) testing of maize (*Zea mays* L.) inbred lines using morphological and molecular markers submitted for Ph. D. to GBPUAT under supervision of Dr. I.S. Singh.

58. S. Alamerew. 2007. Genetic studies on low nitrogen tolerance in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. MZK Warsi.

59. Preeti Massey. 2008. Studies on development of abiotic stress tolerant hybrids in maize submitted for P. D. to GBPUAT under supervision of Dr. MZK Warsi.

60. Pooja Devi. 2008. Morphological and molecular characterization of maize (*Zea mays* L.) inbred lines and their single cross hybrids submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

61. Seema Sat. 2008. Line x Tester analysis in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti

62. Seema Gaur. 2008. Heterosis, inbreeding depression, heritability and genetic advance for yield and its components in maize submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

63. Arvind Kumar. 2009. Studies on genetic components of variance under low nitrogen and drought conditions in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. MZK Warsi.

64. Priyanka Mishra.2009. Studies on quantitative and molecular diversity for carotenoids in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

65. Abhijeet Kumar. 2010. Molecular and morphological characterization of short duration inbred lines of maize (*Zea mays* L.)

66. Sandeep Sharma. 2010. Isolation and cloning of abiotic stress responsive transcription factor from maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

67. Sweta Dosad. 2010. Environmental influence on yield, kernel carotenoid and protein in indigenous maize (*Zea mays* L.) germplasm submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

68. Kamal Pandey. 2010. Combining ability and heterosis analysis for grain yield and its components in exotic inbred lines of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S. S. Verma.

69. Jitendra Bhaskar. 2010. Combining ability, heterosis, phenotypic stability for yield and other desirable characters in high quality protein maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

70. Nagma Kousar. 2011. Studies on genetic parameters in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

71. Chandana Behera. 2011. Studies on molecular diversity in short duration inbred lines of maize

submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

72. Pankaj Kumar. 2011. Studies on heterosis and combining ability under stress and non-stress conditions in short duration maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

73. Nandita Limbu. 2011. Studies on combining ability for morpho-physiological characters under excess water stress condition in maize submitted for Ph. D. to GBPUAT under supervision of Dr. N. K. Singh.

74. Meenakshi Uniyal. 2012. Line x Tester analysis for combining ability and heterosis in maize submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

75. P. Mishra. 2012. Studies on genetic components of variance and some other parameters in a high lysine maize (*Zea mays* L.) composite submitted for Ph. D. to GBPUAT under supervision of Dr. S.S. Verma.

76. Pooja Devi. 2012. Combining ability, heterosis and genotype x environment interaction in tropical maize (*Zea mays* L.) under heat stress and the optimal environment submitted for Ph. D. to GBPUAT under supervision of Dr. S.S. Verma.

77. S. Devi. 2012. Genetic analysis of grain yield and its attributes in varietal crosses of maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

78. G. Das. 2012. Estimation of combining ability and heterosis for grain yield and its component traits in maize (*Zea mays* L) submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

79. Pallavi Bhatt. 2014. Estimation of combining ability, heterosis and variability parameters in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

80. Rashmi Dhakoliya. 2014. Estimation of economic heterosis, correlation, path coefficient and genetic variability parameters in maize submitted for M. Sc. to GBPUAT under supervision of Dr. S.S. Verma.

81. P. S. Holiyachi. 2014. Estimation of combining ability, heterosis and variability for grain yield and other characters under two plant population density environments in maize submitted for Ph. D. to GBPUAT under supervision of Dr. S.S. Verma.

82. E. Lama Laxmi. 2014. Combining ability and heterosis analysis for yield and contributing traits under two plant densities and assessment of molecular diversity in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S.S. Verma.

83. M.P. Khandela. 2014. Estimation of standard heterosis, correlation, path coefficient and variability parameters in maize (*Zea mays* L. submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

84. Mahak Tufchi. 2014. Marker assisted conversion of normal maize into quality protein maize submitted for Ph. D. to GBPUAT under supervision of Dr. N. K. Singh.

85. Rashmi. 2014. Marker based genotyping of Lcy and CrtRB1 loci in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

86. Mrinal Shastry. 2015. Determining behavior of inbred lines of maize (*Zea mays* L.) over different environmental conditions submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

87. A.K. Chaturvedi. 2015. Estimation of two-way and three-way cross hybrids for grain yield and other characters in maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. D.C. Baskheti.

88. Manisha Negi. 2015. Genetic analysis and effect of seed quality on yield and its attributes in single cross hybrid of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. D.C. Baskheti.

89. Manjeet Kumar. 2015. Studies on molecular diversity of parental lines, combining ability, heterosis across the environments in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S.S. Verma.

90. Himanki Dabral. 2016. Effect of plant densities on genetic parameters related to yield associated traits and molecular diversity in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. D.C. Baskheti.

91. Abdul Kadir.2016. Genetic diversity analysis in teosinte derived lines of maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. N. K. Singh.

92. Anupam Barh. 2016. Determination of molecular diversity in parents and heterosis, combining ability and stability of derived test crosses in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. N. K. Singh.

93. Anurag Tripathi. 2017. Parental diversity, heterosis and gene action for yield and yield contributing traits in maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. S.S. Verma.

94. Jairam Amadabade. 2017. Determination of gene action and heterotic response across the environments for yield and yield contributing traits in short duration maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. N. K. Singh.

95. Amarjeet Kumar. 2019. Mapping drought tolerance using teosinte derived BC_1F_2 population of maize (*Zea mays* L.) submitted for Ph. D. to GBPUAT under supervision of Dr. N. K. Singh.

4. Future Thrusts:

1. Development high yielding medium maturity maize hybrids for plain areas whereas as early maturing hybrids for hilly areas of the Uttarakhand.
2. Focused approach on pre-breeding using wild relatives of maize for diversification of maize germplasm and also for domestication of wild adaptive alleles.
3. Development of potential inbred lines having biotic and abiotic stress tolerance.
4. Diversification and development of specialty corn parental lines for exploitation on hybrid breeding programme.
5. Development of seed production packages and seed production of promising hybrids.
6. Focused research on development of inbred lines and hybrids adapted to spring season.
7. Multi-institutional collaborative efforts involving ICAR institutes, CIMMYT and Universities for development of maize germplasm for management of Fall Army Worm.
8. Integration of markers in mapping and precise selection of desirable alleles.

B. Maize Agronomy

1. Significant Achievements:

1. During past > 50 years, large number of varieties and hybrids were evaluated under low, optimum and high nutrient management conditions and several varieties of maize have been released and adopted by farmers for cultivation.
2. Optimum plant population is 66 - 75 thousand plants/ha. Row to row spacing 60 cm with plant to plant spacing is 25 cm or row to row spacing 75 cm with plant to plant spacing is 20 cm.
3. Seed rate for composite varieties is 15-18 kg/ha and for hybrids 18-25 kg/ha.
4. An advanced sowing of late maturing hybrid, normal sowing of medium maturing hybrid and delayed sowing of early maturing hybrid may be adopted for higher grain yield and net return.
5. Sowing of maize can be advanced or delayed up to 10 days from normal date of sowing without significant reduction in yield.
6. Seed treatment with ZnO nano particles or TiO_2 nano particles at 0.01 % is helpful in improving seedling vigour.
7. Baby corn may be sown at spacing 45 × 20 cm.

8. Row spacing for no till maize is 45 cm with 90,000 plants/ha.

9. Optimum plant population for hybrid maize is 75 thousands/ha.

10. Maize seed may be treated with *Azotobacter* to improve yield.

11. For seed production of single cross hybrid maintain 4:1 female : male rows ratio.

12. A dose of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha is required. Zinc sulphate @ 20-25 kg/ ha should be used in zinc deficient areas.

13. Apply fertilizers 5 cm side to the seed and 3-5 cm below the seed.

14. Nitrogen applied in five splits at 20% basal, 25% at 4- leaf stage, 30% at 8- leaf stage, 20% at tassel emergence and remaining 5% at early grain filling stage produced higher yield and net returns.

15. Apply 180 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha for baby corn.

16. Hybrid maize responded to 200:75:75 kg N: P_2O_5:K_2O/ha.

17. Inbred lines responded to 200 kg N, 75 kg P_2O_5 and 75 kg K_2O /ha.

18. Lysine and tryptophan content in grain of quality protein maize (HQPM-1) remain unaffected by either organic or inorganic mode of nutrition.

19. The 50% of the inorganic fertilizers dose may be replaced by vermicompost in quality protein maize.

20. Application of 187.5 kg N, 75 kg P_2O_5 and 50 kg K_2O/ha is optimum for higher productivity of sweet corn.

21. Apply 200 kg N, 75 kg P_2O_5 and 75 kg K_2O /ha for seed production of single cross hybrid.

22. After 4 years of study, in maize-wheat–mungbean/ cowpea cropping system conventional tillage produced significantly highest maize equivalent yield but net return of the system remained at par among conventional tillage, zero tillage and permanent bed system. Crops fertilized with 100% RDF (120:60:40 kg N:P_2O_5:K_2O /ha in maize and 150:60:40 kg N-P_2O_5-K_2O /ha in wheat) being at par with SSNM (120:10:46 kg N:P_2O_5:K_2O /ha in maize and 110:15:64 kg N-P_2O_5-K_2O /ha in wheat) produced significantly more net return than farmer's practice (93:64:32 kg N:P_2O_5:K_2O/ha in maize and 116:64:32 kg N-P_2O_5-K_2O /ha in wheat).

23. Soil analysis after four year completion of maize-wheat–mungbean/cowpea cropping system revealed that organic carbon, available N and available P were significantly more in zero tillage than conventional tillage but remained at par with permanent bed system. Available K, soil pH and bulk density did not differ significantly due to different tillage treatments.

24. Full maturity hybrid maize (planted at geometry 67.5 cm x 15 cm ,98700 plants/ha and 67.5 cm x 20 cm ,74000 plants/ha) fertilized with STCR (212:106:87 kg N:P_2O_5:K_2O /ha) produced significantly highest grain yield and gross return but net return and B:C ratio did not differ significantly from RDF (120:60:40 kg N:P_2O_5:K_2O /ha) and SSNM (120:30:46 kg N:P_2O_5:K_2O /ha). Residual fertility effect was not noticed in succeeedding wheat crop.

25. Flowering stage is the most critical stage for irrigation. Drainage is must in maize. Water stagnation for is harmful. Early stage of crop is very sensitive to water stagnation.

26. Two to three hand weeding is sufficient.

27. Atrazine @ 0.75-1.00 kg a.i./ha or Alachlor @ 2.0 kg a.i./ha or Pendimethalin @ 1.0 kg a.i./ha should apply just after sowing or before germination of weeds.

28. In maize + legume intercropping system, apply Alachlor @ 2.0 kg a.i./ha just after sowing or before germination of weeds.

29. In no till maize 2 hand weeding at 20 and 40 days after sowing or application of paraquat @ 0.75 kg a.i./ha at 30 days after sowing is effective.

30. Application of Atrazine @ 1.0 kg *a.i.*/ha (Pre emergence) followed by 2,4-DEE @ 0.1 kg *a.i.*/ha (Post emergence) was found the most effective and was comparable to weed free condition. Herbicides atrazine, metribuzine, alachlor, glyphosate and 2, 4-DEE applied in preceding maize crop did not have their residual phyto-toxic effect on succeeding wheat crop

31. Post emergence herbicide Tembotrione @ 120 g a.i./ha can be used in maize 25 days after sowing for effective weed control witout residual toxic effect on succeding wheat crop.

32. Application of nano ZnO or nano TiO_2 either through seed treatment or foliar spray increased maize grain yield. Nano particles at concentration of 0.01 % were more effective to enhance growth and productivity. To fetch more net return seed treatment with TiO_2 at 0.01% concentration is a viable option.

33. Maize + legumes (soybean, groundnut and urdbean) intercropping system provides 40-50 % nitrogen requirement of maize. This beneficial effect is more pronounced under low fertility soil or low fertilizer application condition. This system also has good effect on succeeding wheat crop.

34. The rotation of maize with *rabi* pulses, lentil and chickpea saved 30 kg nitrogen/ha for maize and was economically profitable.

35. Maize + soybean- wheat, maize - maize + toria, Maize- mustard - mungbean, maize –toria - wheat and maize-potato-wheat are profitable cropping system.

36. Maintain 55-60 thousands plants of maize for intercropping with legumes.

37. Intercropping of two rows of groundnut in paired row maize (45/90 cm) is more profitable compared to intercropping of mungbean, urdbean, cowpea and soybean.

38. Paired row maize (45/90 cm) is advantageous for intercropping of urdbean in 2+2 row ratio as compared to intercropping of one row of urdbean between two rows of maize (67.5 cm apart). There is saving of 30 kg N/ha in maize with urdbean intercropping. Furrow placement of fertilizer gave the maximum maize grain equivalent yield and earned more net return than broadcast application.

39. In maize-wheat-mungbean cropping system, mungbean is not profitable due to poor seed setting.

40. The optimum plant population for *rabi* maize is 80 thousands/ha and row distance is 60 cm.

41. A dose of 150 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha is required for *rabi* maize.

42. Irrigate the *rabi* maize at IW/CPE ratio of 1.0 and maintain depth of irrigation 6.0 cm.

43. A 50% tassel removal in *rabi* maize is advantageous.

44. Application of nitrogen as 20% at basal, 20% prior to knee height, 40% at knee height and 20% at tasseling stage is ideal to get maximum productivity, nitrogen use efficiency and profit.

45. Mechanized earthing with band placement of urea by Pant Fertilizer Band placement cum Earthing machine is helpful for obtaining higher productivity and profitability of maize in *rabi* season.

46. Spring maize is not compatible in replacement manner either with sunflower or urdbean in spring season. Maize + urdbean (1+1) additive system had significantly higher production efficiency, more utilization of land and yield advantage.

47. Ridge planting technique with irrigation scheduling at 75 mm CPE with 6 cm depth is profitable for sweet corn in spring season.

48. In spring season Quality protein maize (QPM) may be grown at plant density of 83,333 plants/ha and with the application of 120:60:40 kg $N:P_2O_5:K_2O$ /ha.

49. A dose of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha along with 5 t FYM/ha is optimum for sweet corn in spring season.

50. In spring season, application of rice straw mulch

@ 5 t/ha after 2nd irrigation is effective in increasing productivity, net return and irrigation water use efficiency.

2. Research Publications:

1. M.S.Pal and Amit Bhatnagar (2009). Production potential and economics of winter maize (*Zea mays*) cultivars in *Tarai* belt of Uttarakhand. *Current Advances in Agricultural Sciences* 1(1): 14-16.
2. Veer Singh, Shri Ram, Amit Bhatnagar and Uma Shankar Savita (2011). Effect of tillage methods on soil properties and productivity of quality protein maize (*Zea mays*)- wheat (*Triticum aestivum*) system. *Indian Journal of Agronomy* 56(2):83-87.
3. A.S. Bisht, Amit Bhatnagar, M.S. Pal and Veer Singh (2012). Growth dynamics, productivity and economics of quality protein maize (*Zea mays* L.) under varying plant density and nutrient management practices. *Madras Agricultural Journal* 99(1-3):73-76.
4. M.S. Pal and Amit Bhatnagar (2012). Productivity and profitability of pop corn, composites and hybrid maize (*Zea mays*) under low nitrogen stress in Mollisols of Uttarakhand. *Madras Agricultural Journal* 99(4-6):259-262.
5. Amit Bhatnagar, Mahendra Singh Pal and Veer singh (2012). Productivity and profitability of maize based intercropping systems. *Madras Agricultural Journal* 99(7-9):530-532.
6. Harish Chandra Kuniyal, Veer Singh, Shri Ram and Amit Bhatnagar (2012).Nutrient management on soil health, nutrient uptake and yield of maize under temporary submerged condition in mollisols. *Madras Agricultural Journal* 99(7-9):548-552.
7. Veer Singh, Ajaya Srivastava, R.K.Singh and Amit Bhatnagar. (2013). Performance of different maturity group of maize (*Zea mays*) hybrids under temporary water logging condition in mollisols. *Indian Journal of Agricultural Sciences* 83(6):639-646.
8. A.S.Bisht, Amit Bhatnagar and Veer Singh. (2013). Influence of plant density and integrated nutrient management on N, P and K contents and uptake of quality protein maize *Madras Agricultural Journal* 100 (1-3): 110-112.
9. Amit Painyuli, M.S.Pal, Amit Bhatnagar and A.S.Bisht. (2013). Effect of planting techniques and irrigation scheduling on productivity and water use efficiency of sweet corn (*Zea mays saccharata*). *Indian Journal of Agronomy* 58(3):344-348.
10. Kusum Lala, Mahendra Singh Pal and Amit Bhatnagar (2013). Response of planting geometry and nitrogen on quality production of baby corn (*Zea mays* L.). New Agriculturist 24(2) : 141–146.
11. Amit Bhatnagar and M.S. Pal (2014). Evaluation of intercropping systems in spring maize with sunflower and urdbean in North Western plain of India. *SAARC Journal of Agriculture* 12 (1):26-32.
12. Amit Painyuli, M.S. Pal, Amit Bhatnagar and A.S. Bisht (2014).Effect of planting methods and irrigation schedules on growth, yield and nutrient content of sweet corn (*Zea mays saccharata*) in *Tarai* region of Uttarakhand. *International Journal of Basic and Applied Agricultural Research* 12 (3): 332-338.
13. Abhishek Jangir, Veer Singh, P.C. Srivastava, Shri Ram and Amit Bhatnagar (2015). Phosphorus and zinc uptake and protein, lysine and tryptophane contents in quality protein maize in relation to phosphorus and zinc fertilization in Mollisols. *Annals of Agricultural Research* New Series 36 (1):50-57.
14. Amol Babar, Amit Bhatnagar, Rajeew Kumar and Gurvinder Singh (2015) Effect of metal nano particles of zinc oxide (ZnO) and titanium dioxide (TiO_2) on germination and seedling vigour of maize (*Zea mays* L.). *Research Journal of Agricultural Sciences*. 6(3):610-612.
15. M.S. Pal and Amit Bhatnagar (2015). Effect of nitrogen scheduling on productivity, profitability and nitrogen use efficiency in maize (*Zea mays*

L.) under Tarai region of Uttarakhand. *International Journal of Basic and Applied Agricultural Research*. 13(1): 5-9.

16. Amit Bhatnagar, Gurvinder Singh and Veer Singh (2015). Performance of spring maize (*Zea mays*) in spatial association with sunflower (*Helianthus annuus*) and urdbean (*Vigna mungo*) in sub tropical North India. *Agricultural Research* 4(3):231-237.

17. Amit Bhatnagar, Gurvinder Singh and M.S. Pal (2015). Weed control potions for maize (*Zea mays* L.) and effects on succeeding wheat (*Triticum aestivum* L.) crop in *Tarai* region of Uttarakhand. *International Journal of Basic and Applied Agricultural Research*. 13(2): 245-249.

18. A.S. Bisht, Amit Bhatnagar, Anil Shukla and Veer Singh. 2015. Quantitative and qualitative implications of plant density and nitrogen management in quality protein maize (*Zea mays* L.). *Madras Agricultural Journal* 102 (4-6):151-154.

19. Gurvinder Singh, V.K. Joshi, Subash Chandra, Amit Bhatnagar and Anchal Dass. (2016). Spring maize (*Zea mays* L.) response to different crop establishment and soil moisture management practices in north-west plains of India. *Research on Cro*ps 17(2): 226-230.

20. Amit Bhatnagar, M.S. Pal and Gurvinder Singh.(2016). Influence of weed management on growth and productivity of maize (*Zea mays* L.) and residual effect on succeding wheat (*Triticum aestivum*) in sub tropical North India. *International Journal of Basic and Applied Agricultural Research*. 14(2): 152-157.

21. Amit Bhatnagar and Arun Kumar (2017). Fertilizer band placement-cum-earthing machine effects on growth, productivity and profitability of maize (*Zea mays*) under varying nitrogen levels. *Indian Journal of Agronomy*. 62(1):65-69.

22. Veer Singh, Anil Kumar Pant, Amit Bhatnagar and Manish Bhatt (2017). Evaluation of nutrient expert based fertilizer recommendation for growth, yield and nutrient uptake of maize hybrids and soil properties in maize- wheat cropping system in Mollisol. *International Journal of Current Microbiology and Applied Sciences*. 6(10): 3539- 3550.

3. Thesis Research:

1. G. G. Robinson. 1965. Response of three hybrids and one open pollinated variety of maize to different rates of nitrogen submitted for M.Sc. to GBPUAT

2. P. C. Gupta. 1965. Effect of four plant populations and five rates of nitrogen fertilization on the performance of hybrids maize (Ganga safed hybrid makka-2) submitted for M.Sc. to GBPUAT

3. R. P. S. Ahlawat. 1965. Effect of different methods of planting and various rates of nitrogen on Ganga hybrid makka-3 in Tarai conditions submitted for M.Sc. to GBPUAT

4. R. K. Pandey. 1966. Response of three hybrids and one open pollinated variety of maize to different rates of nitrogen submitted for M.Sc. to GBPUAT

5. K. N. Arora. 1967. Studies on the effect of levels and sources of nitrogen on hybrids maize (Ganga hybrid makka-3) submitted for M.Sc. to GBPUAT

6. N. P. Singh. 1967. Response of hybrids maize to nitrogen, phosphate and potash submitted for M.Sc. to GBPUAT

7. P. K. Awasthi. 1967. Evaluation of atrazine, simazine and EPTC herbicides in maize and their residual effect on subsequent crop submitted for M.Sc. to GBPUAT

8. Tajuddin. 1968. Study of the associated growth of maize and soybean submitted for M.Sc. to GBPUAT

9. Aschan Sukhtumrong. 1969. Weed control studies in maize submitted for M.Sc. to GBPUAT

10. Mangal Singh S. C. 1970. Irrigation requirement

of spring planted maize submitted for M.Sc. to GBPUAT

11. S. P. Garg. 1971. Studies on the effect of rates of nitrogen and phosphorus application on yield and quality of two maize hybrids submitted for M.Sc. To GBPUAT

12. P. N. Choudhary. 1971. Response of maize germplasms to different levels of nitrogen submitted for M.Sc. to GBPUAT

13. Mahesh Chandra Sharma. 1971. Effect of rates and times of nitrogen application on the performance of maize submitted for M.Sc. to GBPUAT under supervision of Dr. Bansari Lal

14. Chunmun Singh. 1971. Growth yield and nutrient accumulation pattern in maize as influenced by Phosphorous and zinc fertilization submitted for Ph.D. to GBPUAT

15. P. Rungchang. 1972. Effect of different rates on nitrogen and plant population on five germplasms of maize submitted for M.Sc. to GBPUAT under supervision of Dr. K. C. Sharma

16. U. Phoolkets. 1972. Effect of plant population and nitrogen rates on the performance of dwarf and tall germplasms of maize submitted for M.Sc. to GBPUAT under supervision of Dr. K. C. Sharma

17. R. P. S. Ahlawat. 1972. Studied on the foliar diagnosis on the nutrition status of maize plant submitted for Ph.D. to GBPUAT

18. Manohar Lal. 1972. Studies on the effect of direct and residual nitrogen application on the growth behaviour on yield of crops in maize- wheat-legume rotation submitted for Ph.D. to GBPUAT

19. D. Ramachandra. 1972. Effect of long term application of manure and fertilizers on physical and chemical properties of soil and performance of maize and wheat in fixed rotation submitted for Ph.D. to GBPUAT

20. G. R. Babu. 1973. Zinc-phosphorus interaction studies in maize submitted for M.Sc. to GBPUAT

21. H. K. Palvadi. 1973. Response f maize to water logged at different growth stages submitted for M.Sc. to GBPUAT

22. A. N. Arora. 1973. Studies on the response of maize and wheat to direct and residual nitrogen in maize-wheat legume submitted for M.Sc. to GBPUAT

23. A. K. Bandhopadyay. 1973. Studies on the response of maize and wheat to direct and residual nitrogen in maize-wheat legume rotation submitted for M.Sc. to GBPUAT

24. P. R. V. Subramonia. 1973. Nitrogen induced improvement in uptake and transport of Phosphorous by maize submitted for Ph.D. to GBPUAT

25. R. P. Singh. 1974. Defoliation studies in hybrid maize submitted for M.Sc. to GBPUAT

26. M. S. Raut. 1974. Relative performance of maize germplasms to flooding and nitrogen levels submitted for M.Sc. to GBPUAT

27. Gaurav Prabhat. 1975. A study of the differential response of maize to management nutrition submitted for M.Sc. to GBPUAT

28. V. P. Sharma. 1975. Studies on the effectiveness of slow release nitrogenous fertilizers and nitrification retarders in maize submitted for M.Sc. to GBPUAT

29. P. B. Sharma. 1976. Utility studies on controlled release of nitrogenous fertilizer and nitrification inhibitors in maize submitted for M.Sc. to GBPUAT

30. U. K. Patel. 1977. Evaluation of legume intercropping in conservation of fertilizer nitrogen in maize submitted for M.Sc. to GBPUAT

31. R. Dhanpal. 1980. Studies on the fluctuations of soil nitrogen and their impact on growth and yield of maize genotypes submitted for M.Sc. to GBPUAT

32. Vimal Kishor. 1981. Influence of source and sink size on grain yield of maize submitted for M.Sc. to GBPUAT

33. N. H. Yamvati. 1982. Callus induction and growth in maize and rice genotypes in relation to their plant growth and yield submitted for M.Sc. to GBPUAT

34. M. M. Pandey. 1982. Effect of Zn reforced super phosphate on paddy and maize in the silt loam soils of Pantnagar submitted for M.Sc. to GBPUAT

35. Rishipal Singh. 1982. In-vitro and in-vivo studies on controlled release of N fertilizers and inhibitors in maize submitted for Ph.D. to GBPUAT

36. N. Bahadur. 1982. Nitrogen and plant population studies in pure and legume intercropping system of maize cultivation submitted for Ph.D. to GBPUAT

37. M. K. Kaushik. 1983. N and plant population studies in maize composition submitted for M.Sc. to GBPUAT

38. D. P. Singh. 1984. Efficiency of certain herbicides on weed control in maize and their toxicity estimation by bioassay submitted for M.Sc. to GBPUAT

39. Vimal K. Singh. 1984. Agronomic suitable of soybean cultivars for maize-soybean intercropping submitted for M.Sc. to GBPUAT under supervision of Dr. A. S. Chandel

40. R. C. Joshi. 1985. Effect of weed control measures and levels of nitrogen on maize and associated weeds submitted for M.Sc. to GBPUAT under supervision of

41. S. K. Tripathi. 1985. Studies on the direct effect of manuring in maize and residual effect on wheat submitted for Ph.D. to GBPUAT

42. Sahish Kumar. 1987. Management studies in maize-legume intercropping system submitted for M.Sc. to GBPUAT

43. Sandeep Garg. 1988. Effect of nitrogen levels and seed rates on yield and quality of fodder maize submitted for M.Sc. to GBPUAT under supervision of Dr. J. S. Khokhar

44. Hari Shankar Kushwaha. 1988. Flooding studies in maize culture submitted for M.Sc. to GBPUAT under supervision of Dr. R. P. Singh

45. Kranti K. Singh. 1988. Response of maize to nitrogen rates and tassel removal submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

46. Mahesh Kumar Kushik. 1988. Nitrogen economy in maize culture through legume submitted for Ph.D. to GBPUAT

47. Ahmed Fazeel. 1989. Effect of nitrogen rate and tassel removal on growth, and productivity of maize submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

48. Rajesh Singh. 1990. Effect of nitrogen and stage of harvest on growth, yield and quality of maize fodder submitted for M.Sc. to GBPUAT under supervision of Dr. Virendra Singh

49. Deonath Yadav. 1990. Growth and productivity of maize under different crop sequences and nitrogen rates submitted for Ph.D. to GBPUAT

50. S. I. Halikatti. 1990. Effect of mulch and intercropping grain legumes with maize on soil conservation and crop productivity submitted for Ph.D. to GBPUAT

51. S. P. Singh. 1990. Productivity and economics of maize based crop sequences and their effects on soil fertility in sandy soil of Western Uttar Pradesh submitted for Ph.D. to GBPUAT

52. Jojee Phillp. 1991. Effect of plant population and tassel removal on growth and productivity of maize submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

53. Prabal Kumar. 1991. Leaf removal studies in maize culture submitted for M.Sc. to GBPUAT under supervision of Dr. R. P. Singh

54. A. Bhattacharyya. 1991. Intercropping studies in maize at different nitrogen rates submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

55. D. K. Gupta. 1991. Response of maize to time of tassel removal at varying rates of fertilizer

nitrogen submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

56. Kapil Sahni. 1991. Effect of N levels and row spacing on the yield and quality of forage maize submitted for M.Sc. to GBPUAT under supervision of Dr. J. S. Khokar

57. P. K. Ghosh. 1992. Performance of maize under varying levels of nitrogen and preceding crop submitted for Ph.D. to GBPUAT

58. D. Chandra. 1993. Performance of maize varieties at varying plant densities submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

59. A.K. Bishnoi. 1993. Effect of flooding on maize sown at different dates submitted for M.Sc. to GBPUAT under supervision of Dr. R. P. Singh

60. Hari Shankar Kushwaha. 1994. Nitrogen requirement of soybean+maize and soybean+Sorghum inter-cropping system in Mollisols of Nainital submitted for Ph.D. to GBPUAT

61. Jitendra Kwatra. 1994. Performance of different maize-based cropping system submitted for Ph.D. to GBPUAT

62. Puneet Pachauri. 1995. Response of winter maize to irrigation schedule and tassel removal densities submitted for M.Sc. to GBPUAT under supervision of Dr. R. C. Gautam

63. Y. S. Shivay. 1995. Studies on nitrogen requirement of maize based intercropping system submitted for Ph.D. to GBPUAT

64. Arvind Kumar. 1996. Effect of nitrogen levels and row spacing on growth, yield and quality of fodder maize submitted for M.Sc. to GBPUAT under supervision of Dr. S. S. Verma

65. Saurbh Verma. 2000. Effect of herbicides on maize + cowpea for fodder and their associated weeds submitted for M.Sc. to GBPUAT under supervision of Dr. Ram Prasad

66. A. K. Dey. 2000. Response of soybean maize intercropping to phosphorous nutrition under Tarai condition submitted for M.Sc. to GBPUAT under supervision of Dr. S. C. Saxena

67. S. K. Sharma. 2001. Effect of rates and methods of atrazine application on growth and productivity of No-till maize submitted for M.Sc. to GBPUAT

68. Prakash Singh Shakhawat. 2001. Effect of row spacing and weed control methods on growth and productivity of maize (*Zea mays* L.) under tilled and untilled conditions submitted for Ph.D. to GBPUAT

69. Vijay Singh. 2003. Effect of intra row-spacing and nitrogen levels on yield of double cross maize hybrids submitted for M.Sc. to GBPUAT under supervision of Dr. S. K. Tripathi

70. Jagmohan Pandagare. 2003. Effect of row spacing, plant population and weed control method on no-till maize submitted for Ph.D. to GBPUAT

71. Chinmay K. Sharma. 2005. Effect of tillage, seed rate and weed control method on growth and productivity of maize (*Zea mays L.)* submitted for Ph.D. to GBPUAT

72. Kuldeep Kumar. 2006. Effect of nitrogen levels and seed rates on growth, yield and quality of fodder maize submitted for M.Sc. to GBPUAT under supervision of Dr. Y. P. Joshi

73. Amit Painyali. 2010. Effect of irrigation and planting techniques on productivity and economics of sweet corn (*zea mays*) submitted for M.Sc. To GBPUAT under supervision of Dr. M. S. Pal

74. Anand Singh Bisht. 2011. Effect of plant density and nutrient management on growth, yield and quality of quality protein maize submitted for M.Sc. To GBPUAT under supervision of Dr. Amit Bhatnagar

75. Kusum Lata. 2012. Effect of planting geometry and nitrogen on quality production of baby corn (*Zea mays* L.) submitted for M.Sc. To GBPUAT under supervision of Dr. M. S. Pal

76. Amol kantilal Babar. 2013. Studies of metal nano particles on growth and productivity of maize (*zea*

mays L.) submitted for M.Sc. To GBPUAT

77. Vinod Kumar Joshi. 2014. Studies on crop establishment and moisture management practices in spring maize (*Zea Mays* L.) submitted for M.Sc. To GBPUAT

78. Jayant Kumar Singh. 2014. Studies on integrated nutrient management in sweet corn (*Zea mays saccharata)* submitted for M.Sc. to GBPUAT under supervision of Dr. Amit Bhatnagar

79. Dilkhush Meena. 2014. Effect of planting geometry and nutrient management on quality production of baby corn (*Zea mays* L.) submitted for M.Sc. to GBPUAT

80. Deepak Pandey. 2015. Nitrogen management in maize based legume intercropping system submitted for M.Sc. to GBPUAT under supervision of Dr. Amit Bhatnagar

81. Meenakshi. 2015. Performance of maize (*zea mays* L.) and associated weeds under different herbicides schedule submitted for M.Sc. to GBPUAT under supervision of Dr. Naresh Malik

82. Garima Joshi. 2016. Integrated nutrient management in baby corn submitted for M.Sc. to GBPUAT under supervision of Dr. M. S. Pal

83. Yash Pal. 2016. Drip fertigation study in spring maize (*Zea mays* L.) submitted for M.Sc. to GBPUAT

84. Ajay K. Prabhaker. 2016. Influence of planting pattern and weed management on the performance of component crops in maize + urd bean intercropping system submitted for Ph.D. to GBPUAT under supervision of Dr. submitted for Ph.D. to GBPUAT under supervision of Dr. V. K. Singh

85. Amarendra Kumar. 2016. Effect of tillage and Nutrient management on productivity, profitability and resource use efficiency of maize-wheat cropping system submitted for Ph.D. to GBPUAT under supervision of Dr. submitted for Ph.D. to GBPUAT under supervision of Dr. M. S. Pal

86. Prithwiraj Dey. 2018. Weed management option for spring sweet corn (*Zea mays* L. *var. saccharata*) submitted for M.Sc. to GBPUAT under supervision of Dr. Tej Pratap

87. Shraddhanjali Dehury. 2018. Sowing dates and different mulching study in sweet corn (Zea *mays* L. *var. saccharata*) in spring season submitted for M.Sc. to GBPUAT under supervision of Dr. Amit Bhatnagar.

4. Future Thrusts:

1. Possibilities of sweet corn and baby corn production in different seasons to improve economy of the farmers.
2. Enhancement of nutrient use efficiency in different types of corn.
3. Plant establishment methods for a better rhizosphere.
4. Combating deficit moisture stress in green cob crop during spring season.
5. Mitigating excess moisture stress in kharif season.

C. Maize Soil Science:

1. Significant Achievements:

Excess soil moisture in maize

During the past 40 years, more than thousand entries from coordinated trials were screened and characterized under excess soil moisture/water logging conditions at knee high stage. Under the condition of continuous seven days ponding of water, crop is found to be completely damaged within three days if the sky is clear however, there is no damage till 12 days if the sky is not clear or temperature is low. Early stage of crop is more prone to waterlogged than the later stage. However, knee high and tassel stages are more prone to the waterlogging as compared to other stages.

Under prolonged ponding of water, there was reduction of 40.7 and 39.0% nitrogen and potash in crop leaves, respectively, however phosphorus increased to 57.1% than normal condition. Yield was reduced to 42.1, 34.3, 28.4 and 16.6% in late, medium, early and extra early maturity, respectively,

under waterlogged condition than normal condition. It reveals that extra early maturity group is more prone to waterlogged condition.

Developed a maize variety "Pragati" in 2003 in association with maize breeders suitable for growing in waterlogged areas of Eastern U.P., Bihar, Jharkhand, Orissa and West Bengal.

Conservation agriculture

During three years, rexperiment, raised bed with or without residue conservation could substitute for conventional tillage method on Mollisols of *tarai* region in maize and soil fertility. However zero tillage and permanent bed system are equally effective to conventional tillage in maize-wheat system in long run. Overall, raised fresh beds had been observed superior in terms of yield deciding factors and yield over other tillage pratices. But zero tillage favours the saving of irrigation water followed by residue conservation. Zero tillage significantly increase the bulk density over the conventional tillage system under the continuous maize based cropping system. However, no significant effect was observed on pH and EC under various tillage systems.

Site Specific Nurient Management

In 3 years maize-wheat rotation, SSNM based on Nutrient Expert Software resulted 15.8% more grain yield over 100% RDF(120:60:40: N:P:K), while in succeeding wheat crop highest grain yield of wheat 42.02 q/ha was obtained at SSNM (N-130, P2O5 – 33, K2O -55 kg/ha) in HQPM-1 plot. Hybrids PMH-1 gave the highest grain yield (62.7 q/ha) with 120:55:55 N:P:K Kg/ha calculated based on Nutrient Expert Software over other hybrids.

Nutrient mangement based on leaf colour chart

In 2 years study on nutrient management based on leaf colour chart (LCC) of < 3.0 with 90 kg N resulted in equivalent yield and saved 30–60 kg N/ha to that of N applied at 120 and 150 kg at fixed time intervals. Usefulness of LCC threshold value of 5.0 during vegetative growth stage had been found optimal for obtaining higher grain yield and saving of N. The critical levels below which grain yield of maize and agronomic efficiency loss occurred owing to shortage of N seems to be 4.6 and 4.5 for vegetative stage and 4.9 and 4.8 for reproductive stage, respectively.

Organic maize production

Continuous application of recommended dose of N, P and K through chemical fertilizers along with farm yard manure 5 t ha^{-1} brought out a marked increase in productivity and nutrient uptake by maize and wheat as well as beneficial for the enhancing the soil organic carbon content and sequestration and maintaining soil health in maize-wheat rotation in mollisols hence may be the best option for higher crop yields. Intercropping of cowpea with maize crop is not suitable as it reduced the grain yield of maize however may be beneficial for succeeding wheat crop as it increased the grain yield of wheat by improving the soil organic carbon content in the soil. Incorporation of farm yard manure @ 5 t ha^{-1} along with half dose of recommended nutrients in maize crop accomplished grain yield at par with sole application of full dose of nutrients for both the crops hence may be more sustainable. Use of half dose of recommended nutrients, state practice (farm yard manure @ 5 t ha^{-1}) and control led to reduction in the crop yields and SOC sequestration rate.

Zn and P applications in maize

In conclusion, application of P up to 60 kg/ ha and Zn up to 10 kg/ha in general, increased the P and Zn uptake by maize, therefore, combination of P 60kg/ha and Zn 10 kg/ha appears to be the best for obtaining the higher maize productivity and maintaining the fertility. Phosphorus application at higher level (90 kg/ha) did harm the Zn status in soil as well as in plant in Zn deficient soil, however Zn @ 15kg/ha found to be beneficial and can be applied. Quality assessing parameters viz., protein, tryptophan and lysine contents were found to be increased significantly with increase in P and Zn levels.

2. Research Publications:

1. Singh, V., Pant, A. K., Bahtnagar, A. and M. Bhatt. 2017. Evaluation of Nutrient Expert Based Fertilizer Recommendation for Growth, Yield and Nutrient Uptake of Maize Hybrids and Soil

Properties in Maize- Wheat Cropping System in Mollisol. Int. J. Curr. Microbiol. App. Sci. 6(10): 3539-3550

2. Joshi, R., Singh, V., Ram, S. and A. Srivastava. 2016. Effect of soil compaction and fertilizer placement depth on growth, yield, nutrient uptake of maize (Zea mays L.) and soil properties in tarai soils of Uttarakhand. International Journal of Agriculture, Environment and Biotechnology 9(4): 1-7.

3. Singh, V., Bhatnagar, V. and A. P. Singh. 2016. Evaluation of leaf-colour chart for need-based nitrogen management in maize (Zea mays) grown under irrigated condition of Mollisols. Indian Journal of Agronomy 61 (1): 47-52.

4. Jangir, A., Singh, V., Srivastava, P.C., Ram, S. and A. Bhatnagar. 2015. Phosphorus and zinc uptake and protein, lysine and tryptophane contents in quality protein maize in relation to phosphorus and zinc fertilization in mollisol. Annals of Agriculture research 36(1): 1-8.

5. Bisht, A.S., Bhatnagar, A., Shukla, A. and Singh, V. 2015. Quantitative and qualitative implications of plant density and nitrogen management in quality protein maize (Zea mays L.). Madras Agricultural Journal 102(4-6):151-154.

6. Bhatnagar, A., Singh, G. and V. Singh. 2015. Performance of spring maize (Zea mays) in spatial association with sunflower (Helianthus annuus) and urdbean (Vigna mungo) in sub tropical North India. Agricultural Research 4(3): 231–237.

7. Singh, V., Srivastva, A., Singh, R.K. and A. Bhatnagar. 2013. Performance of difference maturity groups of maize (Zea may) hybrids under temporary waterlogging conditions in a mollisol. Indian Journal of Agricultural Sciences 83 (6): 639-646.

8. Bisht, A.S., Bhatnagar, A. and V. Singh. 2013. Influence of plant density and integrated nutrient management on N, P and K contents and uptake of Quality Protein Maize. Madras Agric. J. 100 (1-3): 110-112.

9. Bisht, A. S., Bhatnagar, A., Pal, M. S. and V. Singh. 2012. Growth dynamics, productivity and economics of Quality Protein Maize (Zea mays L.) under varying plant density and nutrient management practices. The Madras Agricultural Journal 99 (1-3): 73-76.

10. Kuniyal, H.S., Singh, V., Ram, S. and A. Bhatnagar. 2012. Nutrient Management on Soil Health, Nutrient Uptake and Yield of Maize under Temporary Submerged Condition in Mollisol. Madras Agric. J., 99 (7-9): 548-552.

11. Bhatnagar, A., Pal, M. S. and V. Singh. 2012. Productivity and Profitability of Maize Based Intercropping Systems. Madras Agricultural Journal 99 (7-9): 530-532.

12. Singh, V., Ram, S., Bhatnagar, A. and U.S. Savita. 2011. Effect of tillage methods on soil properties and productivity of quality protein maize (Zea mays) and wheat (Triticum aestivum), system. Indian Journal of Agronomy 56 (2): 83-87.

13. Singh, V., Srivastava, A., Singh, R.K. and U.S.Savita. 2011. Effect of tillage practices and residue management on soil quality and crop yield under maize (Zea mays) - based cropping system in Mollisol. Indian Journal of Agricultural Sciences 81 (11): 1019–25.

3. Thesis Research:

1. Poonam Gangola. 2016. Soil test crop response studies in french bean (*Phaseolus vulgaris* L.) – maize (Zea mays L.) cropping sequence submitted for Ph.D. to GBPUAT under supervision of Dr. Poonam Gautam

2. Rakesh Joshi. 2015. Effect of soil compaction and fertilizer placement on growth, yield and nutrient uptake by hybrid maize (*Zea mays* L.) submitted for M. Sc. to GBPUAT under supervision of Dr. Veer Singh

3. Abhishek Kumar. 2013. Effect of P and Zn interactions on growth, yield, nutrient uptake and quality of maize (HQPM-1) grown in mollisol submitted for M. Sc. to GBPUAT under

supervision of Dr. Veer Singh

4. Harish Chandra Kuniyal. 2011. Performance of maize with INM under temporary excess soil moisture condition submitted for M. Sc. to GBPUAT under supervision of Dr. Veer Singh

5. Megha Joshi. 2010. Effect of Zinc and phosphorus levels on dry matter yield, uptake and utilization of ^{65}Zn, B_7 maize in mollisol submitted for M. Sc. to GBPUAT under supervision of Dr. Shri Ram

6. Ashutosh Singh. 2010. Effect of INM in pigeon pea based intercropping system on soil properties, growth and yield of pigeon pea, black gram, maize on mollisols of the Tarai region submitted for Ph.D. to GBPUAT under supervision of Dr. H.S.Mishra

7. Chhaya Joshi. 2010. Estimation of critical limit of B in soil and maize crop submitted for M. Sc. to GBPUAT under supervision of Dr. P.C. Srivastava

8. Divya Joshi. 2008. Effect of INM on soil properties and performance of maize crop in Tarai soil submitted for M. Sc.. to GBPUAT under supervision of Dr. H.N. Singh

9. Silpi Gupta. 2005. Evaluation of Azotobactor strains for nitrogen fixation survival, soil fertility, plant growth and nutrient uptake by maize submitted for M. Sc. to GBPUAT under supervision of Dr. H.P. Singh

10. Sandeep Upadhayay. 2005. Studies on integrated nutrient management (INM) in maize submitted for M. Sc. to GBPUAT under supervision of Dr. H.N. Singh

11. Vinod Kumar. 2002. Studies on integrated plant nutrient supply system for maize intercropping with urd under maize-wheat cropping system in Tarai region of Uttaranchal submitted for M. Sc. to GBPUAT under supervision of Dr. Narendra Kumar

12. A. K. Tyagi. 1998. Relationship between plant N, P and K and waterlogging tolerance of some maize genotype submitted for M. Sc. to GBPUAT under supervision of Dr. Sobran Singh

13. Jitendra Singh. 1998. Studies on relationship between micronutrient content and flooding tolerance of maize (Zea mays L.) submitted for M. Sc. to GBPUAT under supervision of Dr. R. S. Sachan

14. Debashish Mandal. 1994. Forms of sulphur in tarai and bhabhar and sulphur content and yield of wheat and maize under different doses of fertilizer submitted for M. Sc. to GBPUAT under supervision of Dr. Room Singh

15. B. P. Singh. 1990. Effect of water logging on nutrient uptake and growth of maize germplasm submitted for M. Sc. to GBPUAT under supervision of Dr. T.R. Rathore

16. Tahir Ali. 1987. Effect of phosphorus fertilization on adsorption and diffusion of zinc in a Mollisol and its uptake by maize submitted for M. Sc. to GBPUAT under supervision of Dr. T.A. Singh

17. Bahadur Lal. 1986. Evaluation of partial acidulated phosphate rock for maize and residual effect on wheat submitted for M. Sc. to GBPUAT under supervision of Dr. A. K. Agnihotri

18. K. P. Sharma. 1985. Effect of flooding at different stages of development on the growth and praline content of maize verities submitted for M. Sc. to GBPUAT under supervision of Dr. T.R. Rathore

19. Satya Dev. 1985. Effect of soil and water table conditions on water stress, growth and yield of summer maize submitted for M. Sc. to GBPUAT under supervision of Dr. R. P. Tripathi

20. Rajeev Singh. 1985. Effect of calcium peroxide on seedling emergence of maize under varying soil moisture regimes submitted for M. Sc. to GBPUAT under supervision of Dr. T. R. Rathore

21. J. R. Murthy. 1980. Productivity of two mollisols of tarai for maize under different management system submitted for M. Sc. to GBPUAT under supervision of Dr. A. K. Sharma

22. M. Singh. 1979. Effect of plant population, N level, excess soil moisture and temperature on growth of maize submitted for M. Sc. to GBPUAT under supervision of Dr. T.A. Singh

23. B. S. Mehara.1979. Effect of carbonates and boron availability to maize and its fixation in soil submitted for M. Sc. to GBPUAT under supervision of Dr. M. S. Gangwar

24. Dilip Kumar. 1977. Studies on zinc retention in cultivated and forest soils of tarai and its effect on zinc uptake by maize submitted for M. Sc. to GBPUAT under supervision of Dr. M. S. Gangwar

25. R. S. Mehta. 1973. Nutrient uptake pattern in maize submitted for M. Sc. to GBPUAT under supervision of Dr. T.A. Singh

26. Kishor Kumar. 1972. Evaluation of wheat and maize germplasm for salinity tolerance submitted for M. Sc. to GBPUAT under supervision of Dr. T.A. Singh

27. M.V.S murthy. 1972. Soil moisture extracting pattern in maize crop submitted for M. Sc. to GBPUAT under supervision of Dr. B. P. Ghildyal

28. V. K. Bhatnagar. 1965. Effect of soil compaction and fertility levels on soil properties and performance of hybrid maize submitted for Ph.D. to GBPUAT under supervision of Dr. S. C. Modgal

29. R. B. Singh. 1969. Studies on the irrigation requirement of spring maize submitted for M.Sc. to GBPUAT under supervision of Dr. Maharaj Singh

4. Future Thrusts:

1. Development and refinements of site specific nutrient management practices for new high yielding varieties of maize.
2. Enhancement of nutrient use efficiency in different types of corn under normal and waterlogged condition in *tarai* region.
3. Development of effective soil management practices in maize through resource conservation technique for combating moisture stress
4. Evaluation and enhancement of soil quality and health under maize based cropping system.
5. Evaluation of biofertilizers in maize under maize-wheat rotation

D. Maize Pathology:

1. Significant achievements:

1.1 Screening of germplasm

Resistant Lines were identified against Bacterial Stalk Rot, Banded Leaf and Sheath Blight and Brown Strip Downy Mildew.

1.2 Disease Management

General

1. If farmer wishes to use their own seed then seeds should be treated with Tiram or Captan (2 gm/kg) before sowing.
2. Neem cake soil application provided maximum germination and suppressed the seed & seedling rots.
3. Sowing at the end of June may avoid effect of different diseases.

Management of Bacterial Stalk Rot

1. Developed artificial inoculation technique for field screening of maize germplasm against bacterial stalk rot
2. Worked out epidemiology of the stalk rot of maize under *tarai* condition of Uttar Pradesh
3. For management of Bacterial stalk rot of maize soil application of bleaching powder @ 25 kg/ha at the time of flowering followed by second application after 10 – 12 days.
4. For the management of bacterial stalk rot application of bleaching powder (3%) @ 16.5 kg/ha through irrigation water at the time of disease appearance or at flowering is recommended.

Management of Downy mildew

1. Worked out epidemiology of Brown stripe downy mildew of maize under *tarai* condition of Uttar Pradesh

Table 2: Moderately Resistant Lines against Banded Leaf and Sheath Blight in AVT

Year	No. of entries	Late Maturity	Medium Maturity	Early and Extra Early	Pop Corn	Sweet Corn	Baby Corn	QPM
2010	245	Nil	HKM31, HM8	Early Maturity: R2006-1	Nil	Nil	Nil	HQPM-2, JHQPM-304,JHQPM-250, HQPM-7
2011	606	M9977, A7501, NMH958, X8B562, HM10(C), EHQ-16 DMH7705,	BH4100, X35A17, KDMH176, BIO-688, JH31292, KDMH017	Nil	Nil	Nil	Nil	MHQPM-09-8
2012	548	GK3103, MCH45, A7501, BIO-562, PMH1(C) Nil	BIO-688, KDMH176, KNMH 401061, NMH1242	Early Maturity: JH31485, K21, CMH10-525 Early	Nil	Nil	Nil	HQPM-1 (Filler), HQPM-2(Filler), MHQPM-09-8, HQPM-1 (Filler), HQPM01 (Filler), HQPM-5 (Filler), HQPM-1(C), NSCH12, HQPM1(F), PMH4(F) Nil
2013	500	NR31834, CP999	RASI3033, PRO383	Maturity: FH-3626, EHL162508, KNMH 4010141 Early	Nil	Nil	Nil	BAUQMH-17
2014	615	VNR-4325, DAS-MH-106,	EHL3412	Maturity: EH2214EE Maturity: PMH3-F, HM10-F EE Maturity:	Nil	Nil	Nil	IIMQPMH 1507, PMSQ5, AQH4 (EDV),
2015	606	JH 13282, JH12010, PM14101L, DKC9159 (IN8570), CMH 10-555, CMH 11-618, Gold 1166, HT 51412607, ADV 0990296, ADV 1190384, JH 13270, DKC 9151 (IN8902),	BH4120 84, HT 51412607, HTMH 5402, BIO 9637-C	KDN1263SC* (First Year), FH 3605, FH 3626, Bio 9720, AH 1317	HPC 1, DMRHP 1401, IMHP 1535	ADVSW-2, FSCH 41, ADVSW-1, WOSC-, Priya-C	IMHB1539, IMHB 1537, DMRH 1305, IMHB 1531, IMHB 1532, GAYMH-1, IMH 1525, BAUM-3, HKH 425, ASKBH1, AH5021	BAUQMH-18, BQPMH 141 (EDV-DHM117), IIMRQPMH 1501, IIMRQPMH 1503, IIMRQPMH 1506, LQPMH 215, VEHQ15-1, DHM117-C,

		NMH-1247, Super-1177, KMH-3981, GK3118, 115-08-01, DMRH1308, DKC9133, DKC9141 (IM8539), IM8556, CP999, X35D601, Siri-4527, PMH-3-C PM15103L, DKC9164 (IP9002), PM15104L, DKC9163		Early Maturity: JH31785			AH5021, AH7043, IMHB1525, IMHB1538, IMHB1531, GAYMH1, IMHB1532 Nil	HQPM 4-C, HQPM 7-C IIMRQPMH1501, IIMRQPMH1609, IIMRQPMH1607,
2016	538	(IP8703), SYN516753, CMH12-688, DKC9151 (IN8902), ADV0990296	BL107, JH13348, BL106, JH13347		IHPC1201, IHPC1203, SJPC1	ASKH4, ASKH6, Madhula, MITHAS		IIMRQPMH1602
		Mod. Resistant-NS8001, JH13023, JH 15080,		Early Maturity:- FH3765,			Nil	VEQH-16-1, IIMRQPMH1712, IIMEQPMH1602,
2017	647	IMH1527 Nil	Resistant IMH 1603 Mod. Resistant JKMH1414, DMRH141, 9DKC9179, LMH616, CMH08-292 Nil	DKC7074 (Mod. Resistant) Nil	Nil	Nil		OQPMH-14191 Nil
2018	442				Nil	BSCH 416078, DSCH320, Misthi		

2. For the management of Brown stripe downy mildew 4 – 6 foliar spraying of mancozeb (0.3%), Captan (0.2%) at 7 to 10 days interval**.**

3. Three foliar spraying of Zinc Sulphate + Lime (0.5% + 0.25%) and Copper sulphate (0.1%) at 7 days interval was found effective in managing Brown strip downy mildew of maize.

4. For the management of brown stripe downy mildew seed treatment with Metalaxyl 35% WS @ 7 gm/kg seed followed by foliar spraying of mancozeb 75% WP or Metalaxyl 8% + Mancozeb 64% WP @ 2 – 2.5 kg/ha was found effective.

Table 2: Moderately Resistant Lines against Banded Leaf and Sheath Blight in AVT

Year	No. of entries	Late Maturity	Medium Maturity	Early and Extra Early	Pop Corn	Sweet Corn	Baby Corn	QPM
2010	245	Nil	- Nil	Nil	Nil	Nil	Nil	Nil
2011	606	Nil	JH31292	Nil	Nil	Nil	Nil	EHQ-16, VEHQ-3019, HQPM-1(C), HQPM-7(C)
2012	548	Nil	JH31292	Nil	Nil	Nil	Nil	Nil
2013	500	CMH09-464	Nil	Nil	Nil	Nil	Nil	Nil
2014	615	Nil	Nil	EE Maturity: HM10-F	Nil	Nil	Nil	MMHQPM-6-12-13
2015	606	Resistant lines- JH13282, PM14101L, CMH12-663, 115-08-01, CP999, X35 D601	Nil	Nil	Nil	ASKH1, FSCH 41, ASKH4	MBC-11-15, IMHB 1537	VEHQ14-1, HQPM 4-C
2016	538	Nil	Nil	Nil	Nil	Nil	Nil	IIMRQPMH1609
2017	647	Nil	Nil	Nil	Nil	Nil	Nil	Nil
2018	442	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 3: Resistant Lines against Brown Stripe Downy Mildew in AVT

Year	No. of entries	Late Maturity	Medium Maturity	Early and Extra Early	Pop Corn	Sweet Corn	Baby Corn	QPM
2013	500	JH 31601, P 3596(X 35B396), NMH 1265, CMH 09-464, MCH 46	JH 31470, EH 1974, HM 8(C)	Early: FH 3626, EH 2223, Bio 6008, REH2011-2, FH 3605, CMH 10-484, AH 1206, K 21, DAS-MH 501, EHL 162508 Extra Early: DH 262, FH 3558	Nil	Nil	Nil	EHQ 63, VEHQ 11-1, MMHQPM-6-12-13, HQPM 5©, BISCO, MADHU, MADHURI, HM 4©,

Management of Banded Leaf and Sheath Blight

1. Loss assessment studies conducted for 3 years showed that BLSB may cause yield loss up to 33 percent under tarai conditions.
2. Chopped green paddy stem with 10% sucrose and peptone was found the best substrate for mass production of *Rhizoctonia solani* for artificial inoculation under field conditions
3. For the management of Banded leaf and sheath blight drainage of water, weed control and removal of infected leaf at second interculture operation was found effective in minimizing the disease.
4. For chemical management of banded leaf and sheath blight two foliar spraying of Propiconazole 25 EC/ Dinfenconazole 25 EC @ 0.1% at 10-15 days interval was found effective.
5. Among newer compounds Pencycuran 250 SC @ 0.1% or Azoxystrobin 250 Sc @ 0.05% was found effective for the management of BLSB.
6. For biological management of Bacterial Leaf & Sheath Blight, soil application of *Trichoderma harzianum* impregnated FYM @ 100kg/ha and seed dressing with the same @ 2.5g/ka seed gave the highest disease control and yield.

Post Flowering Stalk Rot

1. For management of Post flowering of stalk rot seed treatment with Benlate (2 gm/kg seed), drainage of water at the time of flowering and irrigation in case of moisture stress was found effective in minimizing the disease incidence. In hot and dry weather harvesting should be preponed by 8 – 10 days.

Foliar Diseases

1. For the management of Maydis leaf blight two spraying of mancozeb 75WP or Zineb 75WP @ 2 – 2.5 kg/ha at 10 to 15 days interval is recommended.
2. For management of foliar diseases like brown strip downy mildew, leaf blight and rust 3 – 4 spraying of mancozeb @ 2kg /ha at 10 to 12 days interval was found effective.

2. Research Publications:

1. Sharma, Geeta and Saxena, S.C. (2000) Association of *Trichoderma* sp. in causing cob rot of maize. *Advances in Plant Sciences*, Vol. 13 (II),595-598.
2. Sharma, Geeta and Saxena, S.C. (2000) Integrated Management of Banded Leaf and Sheath Blight of Maize (*Zea mays* L.) caused by *Rhizoctonia solani* (Kuhn). *Advances in Plant Sciences,* Vol. 15 (1), 107-114.
3. Sharma, Geeta and Saxena, S.C. (2001). Severity of Banded leaf and sheath blight of maize caused by *Rhizoctonia solani*, in presence of *Trichoderma* sp. *Annals of Plant Protection*. Vol.-9, No. 144-145.
4. Singh Alok Kumar, Sharma, Geeta and Saxena, S.C. (2002). Evaluation of Maize Germplasms against Banded Leaf and Sheath Blight Disease. *Indian Phytopathology*, Vol. 55(3), 281.
5. Singh, Dinesh, Verma, V.S., Jamwal, J.S. and Tewari. A.K. (2004). Management of leaf blight of maize caused by *Helminthosporium turcicum* through disease resistance. *Journal of Research SKUAST- J.* 3: 146-151.
6. Nasir, A., Singh, V.K., Singh, A., and Singh, Y. 2012. Field evaluation of maize germplasm for resistance against maydis leaf blight pathogen. *Maize Journal* 1: 85-87.
7. Bisht, Sunaina, Kumar, P., Srinivasanraghavan, A. and Purohit, Jyotika 2013. In vitro management of *curvularia* leaf spot of maize using botanicals, essential oils and bio-control agents. The Bioscan 8(3): 731-733.
8. Sunaina Bisht; Pradeep Kumar; Srinivasanraghavan,a and Jyotika Purohit.2013.*In Vitro* management of Curvularia leaf spot of maize using botanicals, essential oils and biocontrol agents. The *Bioscan8*(3):731-733.
9. Bhandari Chandra Prabha and Vishunavat K.

(2014) Seed health testing methods for detection of seed-borne *Fusarium verticilloides* in maize seeds. Indian Journal of Plant Protection. 42 (4) : 470-473

10. Sunaina Bisht; Rekha Balodi and Pradeep Kumar.2015 Optimisation of Growth Parameters of *Bipolaris maydis* (Nisikado and Shoemaker) causing Southern Leaf Blight of Corn(Zea mays).Trends in Biosciences 8(12):3135-3142

11. Sunaina Bisht; Rekha Balodi; Abhijeet Ghatak and Pradeep Kumar.2016. Determination of susceptible growth stage and efficacy of fungicidal management of Curvularia leaf spot of maize caused by *Curvularia lunata* (Wakker) Boedijn. Medica 61:1-5.

3. Thesis Research

a. M.Sc. Ag. Thesis

1. Saxena, S.C., 1971. Studies on the foliar application of fungicides on the in cidence of Brown stripe Downy Mildew of Maize.

2. Raju, C.A., 1973. Studies on some aspects of *Cephalosporium* and *Fusarium* stalk rots of maize.

3. Sood, G.K., 1974. Brown stripe downy mildew of maize: Evaluation of germplasm and chemical control.

4. Nath, K. 1976. Control of sugarcane downy mildew of maize and persistence of effective fungicide in treated seedlings.

5. Kodali, Buchaiah 1977. Studies on banded sclerotial disease of maize.

6. Gangopadhyay, S., 1977. Biochemical changes in maize leaf sheath in relation to resistance against banded sclerotial disease (*Rhizoctonia solani* Kuhn.

7. Baruah, P., 1979. Studies on some aspects of banded sclerotial disease of maize caused by *Rhizoctonia solani* f. sp. sasakii.

8. Bhargawa, S., 1980. Chemical control of sugarcane downy mildew of maize with particular emphasis on metalaxyl.

9. Kumar, P., 1980. Variation in maize isolates of *Drechslera maydis* Subr. and Jain.

10. Reddy, C.L., 1985. Management of aflatoxins in maize.

11. Tripathi S.M., 1990. Some cultural, physiological and biochemical characteristics of soft rot of maize, sorghum and potato.

12. Pandey, M.K., 1992. Studies on the Banded leaf and sheath blight of maize.

13. Pant, Rajeev 1994. Studies on some factors affecting severity of Brown stripe downy mildew of maize.

14. Sharma Geeta, 1996. Studies on integrated management of banded leaf and sheath blight of maize (*Zea mays* L.) caused by *Rhizoctonia solani* (Kuhn).

15. Sankea Singh, 2000. Integrated mgt of banded leaf and sheath blight of maize.

16. Singh, S. 2000. Integrated management of Banded leaf and sheath blight (*Rhizoctonia solani* Kuhn) of maize (*Zea mays* L.).

17. Prajapati, C.R. 2001. Estimation of thiram on treated seeds of maize.

18. Joshi, Arti 2003. Integrated Disease Management of maize (*Zea mays*, L.) in Tarai region of Uttaranchal.

19. Rijal, T.R. 2003. Integrated Management of Banded leaf and sheath blight of Maize (*Zea mays* L.) caused by *Rhizoctonia solani* (Kuhn).

20. Goswami, Sarita 2008. Studies an management of banded leaf and sheath (*Rhizoctonia solani kuhn*) of maize (*Zea mays* L.).

21. Nasir, Abdul 2008. Studies on some aspects of Maydis leaf blight of maize caused by *Bipolaris maydis*.

22. Bisht, Sunaina 2011. Studies on leaf spot of maize caused by caused by Curvularia lunata (Wakker) Boedijn.

23. Sharma, B.C. 2012. Management of banded leaf and sheath blight of maize using bio-control agents and chemicals.

24. Bhatt, Bhagyashree 2018. Studies on growth inhibition of *Exserohilum turcicum* (Pass) Leonard and Suggs, the causal organism of northern leaf blight of maize.

25. Bhatt, Divya 2018. Cultural characteristics and growth evaluation of *Curvularia lunara* (Wakker) boed., the causal organism of leaf spot of maize.

b. Ph. D. Thesis

1. Misra, R.S., 1977. Aflatoxin contamination of some agricultural commodities in Tarai and biochemical effects of Aflatoxin B_1 on maize seeds.

2. Chaube, H.S., 1978. Effect of chemical seed treatments on rhizosphere microflora of maize and wheat.

3. Saxena, S.C., 1982. Epidemiology and control of Erwinia stalk rot of maize.

4. Dwivedi, R.R., 1985. Studies on *Acremomlum strictum, Cephalosporium maydis* and *Fusarium moniliforme* causing stalk rots of maize.

5. Mukhtar, J., 1988. Etiology and management of premature drying of maize wilt emphasis on Maize Path. *F. moniliforme* and nematode complex in disease development.

6. Manoj Kumar, 1995. Investigations on Seed discolouration in Maize.

7. Mr. A.K. Singh, 1998. Studies on *Rhizoctonia solani* Kohn Incitant of Banded leaf and sheath blight of *maize* (Zea mays H.) with special reference to variability and Integrated Management.

8. Nupur Agarwal, 1999. Role of some nutrients, organic acids, growth agro meteorological factors on the studies of brown stripe downy mildew of maize.

9. Bhagwan Singh, 2005. Morphological and molecular variation in maize (*Zea mays* L.) with special reference to banded leaf and sheath blight.

10. Vinod Mehra, 2006. Banded leaf and sheath blight of maize.

11. Pradeep kumar, 2007. Banded Leaf and sheath blight of Maize: Option for integrated management fo the disease.

12. Chandra Prabha Bhandari, 2012. Fusarium Ear Rot of Maize: Impact on seed health, seed storability & Seed Production and successive management under field condition.

13. Bimla Kumari, 2012. Studies on the management of banded leaf and sheath blight of maize caused by *Rhizoctonia solani* f. sp. *sasakii* (Kühn.) Exner.

14. Kumud Upreti, 2013. Post harvest seed storage in Maize impact on seed quality longevity and seed health.

15. Sunaina Bisht, 2015. Southern Leaf blight of maize (*Bipolaris maydis*): Disease epidemiology & management strategies.

4. Future Thrusts:

1. Preparation of disease distribution map of Uttarakhand and identification of emerging problem of the state through survey and surveillance.

2. Development of sick plot for screening of germplasm against BLSB abd BSR.

3. Developing low input eco-friendly diseases management approaches for resource poor farmers.

4. Development of IPM practices for organic maize production.

5. Studies on diseases of winter/spring maize.

6. Development of disease forecasting model for major diseases of maize.

7. Study of root microbiome of maize growing in varying agro climatic conditions.

8. Studies on interaction of biotic and abiotic stresses on maize

E. Maize Entomology:

1. Significant Achievements:

1. **Survey:** In kharif 14, rabi 29 and spraying 23 insect pests were recorded. Maize stem borer in kharif season army worm in rabi season and shoot fly in spring season identified as major pest.

2. **Screening of Resistant Germplasm**

a.	Stem borer	:	CM500
b.	Shoot fly	:	CM200, CM201, D765 and Synthetic PS29 × Kisan
c.	Army Worm	:	D768 × D787, Kanchan, Taseen, D861, D822 & Naveen was found moderately resistant
d.	Corn Maggot	:	Tarun, Ganga-5 less prone
e.	Multiple resistance	:	M-15
f.	Cytotriga	:	D741, Suwan resistant
g.	Multiple pest resistance	:	PR7921 (Stem borer, Shootfly, Grain moth, Rice Moth, Rice wcevil)

3. **Management :**

a. Stem Borer:

i. To break the life-cycle of stem borer Maize stem should be chopped before January and stored.

ii. Stubbles should be removed from the field

iii. Seed rate should be increased and optimum plant population be maintained by thining

iv. In standing crop apply Carbofuran 3G@7.5 Kg/ha in whorls.

v. Spray Deltamethrin or Cypermethrin @ 100ml/ha

vi. Spraying of mixture of Neem and Karanj oil was found effective.

vii. Developed artificial diet for rearing of stem borer of maize

b. Shoot Fly:

i. In areas where incidence is low problem can be managed by increasing the seed rate.

ii. Sowing of spring maize should be done in last week of January.

iii. Apply Thimate 10G@15K/ha in furrows at the time of planting or

iv. Spray Methosystox @ 0.025% (400 – 600 l/ha)

v. Remove wild sorghum from the surrounding the field.

c. Army Worm:

i. Spray Fenvelrate@100 ml/ha or apply Carbofuran 3G in whorles.

d. Thrips and Aphids:

i. Spray Methosystox @ 0.025% (500 – 800 l/ha)

e. General

i. Planting of one row of urd bean after every two row of maize was found effective in minimizing the insect infestation.

ii. Storage of maize seed with cow dung as in moisture proof bag was found effective in reducing the infestation of storage pests and improved the seed germination