AICRP- POTATO

Objectives

- Development/identification of improved potato varieties according to consumer's preference, user group and different target environments.
- Identification of appropriate agronomic practices and profitable potato based cropping systems for *tarai* and *bhavar* area of Uttarakhand.
- Monitoring of diseases/pests and other problems of potato in varied agro-climates and to develop appropriate measures for their control/management.
- Technology assessment and refinement.
- Development of linkages with State Departments of Agriculture/Horticulture, Krishi Vigyan Kendras and other developmental/extension agencies.

A. Crop Improvement:

Hybridization block were erected at VRC in 2007 as per technical guidance of CPRI, Shimla and breeding work on potato was started at Pantnagar.

1. Significatnt Achievements:

- Following technical steps were followed to develop superior hybrids in potato.
    1. Parental lines were selected on the basis of yield performance, tolerance to late blight and processing traits
    2. Tubers of selected parents were planted under extended photoperoid at Pantnagar.
    3. Crosses were made at Pantnagar and National Hybridization Garden at Kufri. F_1C_0 seeds were harvested.
    4. Seeds will be grown in next year to harvest F_1C_1 and likewise to harvest F_1C_2 generation.
- Total 157 parental lines of potato were generated in 5 years

Hybridization block and hybridization in potato at Vegetable Research Centre, Pantnagar

- At Pantnagar centre, 18 varieties are available for research and demonstration purposes.

Potato berry

True potato seed of F_1C_0

During the last 5 years contributed their role in release of 3 hybrids. 50 germplasm were collected from different parts of country including Uttarakhand.

2. Research Publications:

1. Singh, Dhirendra; Singh, JP and Tewari, Aradhana. (2011). Influence of photoperiod and flowering on tuber yield of potato cultivar Kufri Pukharaj in *tarai* regions of Uttarakhand. *Pantnagar Journal of Research,*9(2): 320-321.

2. Datta, S; Singh, Dhirendra; Singh, D.K. and Das, R. (2013). Evaluation of storage behavior of different Potato (*Solanum tuberosum* L.) germplasm at ambient condition. *Environment & Ecology*, 31 (3A): 1556-1559.

3. Lohani, Mani; Singh, Dhirendra and Singh, J.P.(2012). Genetic diversity assessment through principal component analysis in potato (*Solanum tuberosum* L.). *Vegetable Science*, 39(2): 201-209.

4. Marmu, Karuna; Thakur, TC; Kumar, Arun and Singh, Dhirendra.(2014). A study on the effect of deep and differential depths placement of fertilizers on potato crop response. International Journal of Agriculture innovations and research, 3(1): 231-239.

5. Datta, S; Das, R. and Singh, Dhirendra. (2014). Study of correlation among various characters of different Potato (*Solanum tuberosum* L.) germplasms. *Journal of crop and weed.*

6. Shubha K and Singh, D.(2015). Assessment of genetic diversity through principal component analysis in Potato (*Solanum tuberosum* L.) under*tarai* region of Uttarakhand. *Bioinfolet*., 12 (1B): 150-153.

7. Verma, Anamika and Singh, Dhirendra.(2015). Genetic variability, correlation and sequential path analysis of yield related traits in potato (*Solanum tuberosum* L.) genotypes. *International Journal of Basic and Applied Agricultural Research.*13 (3): 441-445.

8. Pandey, Ritu; Singh, JP; Singh, Dhirendra and Pandey, PK. (2016). Genetic variability, correlation and path coefficient analysis in F_1C_2population of potato genotypes. *Journal of Hill Agriculture*, 7(1): 75-79.

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attributing traits of Potato (*Solanum tuberosum* L.). *Res. Environ. Life Sci,*. 9(6): 771-774.

11. Singh, Dhirendra and Kumari, Shubha. (2016). Effect of day length and temperature on true potato seed (TPS) germination and seedling vigour. *Vegetable Science*, 43(1): 127-128.

12. Verma, Anamika and Singh, Dhirendra. (2016). Assessment of genetic diversity and association among agro- morphological characters in potato (*Solanum tuberosum* L.). *Indian Journal of Agricultural Research*, 50(4): 345-349.

13. Rajani, Singh;Singh, Dhirendra and Jeena, AS. (2017). Assessing genetic diversity of potato (*Solanum tuberosum*) genotypes grown in *tarai* region of Uttarakhand by using simple sequence repeat (SSR) technique. *Int. J. Curr. Microbiol. App. Sci*., 6(7): 4219-4230.

14. Rana, Renu and Singh, Dhirendra. (2018). Molecular markers play key role to evaluate and distinguish different cultivars of potato (*Solanum tuberosum* L.) on the basis of genetic diversity. *International Journal of Chemical Studies*, 6(2): 3073-3076

3. Thesis Research:

1. Sanjay Datta (2007) Genetic diversity for morphological, yield attributing and quality traits in Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

2. Kiran (2008) Assessment of genetic diversity in Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

3. Mani Lohani (2009) Study on biochemical and morphological variation and assessment of genetic diversity in potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

4. Kumari Shubha (2012) Morphological and biochemical characterization of potato (*Solanum tuberosum* L.) germplasm in tarai region of Uttarakhand M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

5. Renu Rana (2013) Genetic diversity revealed by morphological, biochemical and PCR based molecular markers in Potato (*Solanum tuberosum* L.) germplasm. Ph. D. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

6. Babita Upadaya (2013) Assessment of genetic diversity in Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

7. Pragati Saxena (2013) Effect of photoperiod on growth and quality traits in F_1C_4 generation of Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

8. Ravi Shankar ID No. (2014) Photoperoid effect on yield and attributing traits in Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

9. Anamika Verma (2015) Genetic diversity in Potato (*Solanum tuberosum* L.) Ph. D. submitted to GBPUAT under guidance of Dr. Dhirendra Singh.

10. Rajani Rawat (2015) Morphological, Biochemical and Molecular characterization in Potato Ph. D. submitted to GBPUAT under guidance of Dr. Dhirendra Singh

4. Future Thrusts:

- The post of potato breeder has been withdrawn.

B. Crop Production:

1. Significant Achievements:

Planting Time:

- In *tarai* region of Uttarakhand, best time of potato planting was October 15-30.

Size of seed and spacing:

- Seed size of 30g - 50g or 35-45 mm diameter tuber was found best for planting.
- Row to row and tuber to tuber spacing of 60 x 15 cm for manual and 60 x 20 cm for machine planting was found best.

Tuber Dormancy:

- Dipping of freshly harvested potato tuber is 1 ppm GA solution and then storage for 15 days in dark break the dormancy of tuber.

Nutritional Management:

- 100 kg nitrogen, 60 kg phosphorus and 60 kg potash is required in soils having organic carbon content more than 2%. 150 kg nitrogen, 120 kg phosphorus and 120 kg potash is recommended for the trial having organic carbon content less than 1.7 % phosphorus less than 30 kg and potash 200 kg/ha. 250-500 q/ha FYM is recommended for trial having low organic carbon content. Ten percent increase in yield was found with the application of 25 q/ha poultry manure.
- To overcome the micro nutrient deficiency foliar application of Agromin @ 1 kg/ha or tuber dipping in 0.05 % solution for 3 hour was recommended. Dipping of tuber in ZnSO4 solution @ 0.05% for three hours increased tuber yield.
- Higher yield and more number of medium size tuber was recorded with tuber dipping in GA @ 2 ppm for one hour.
- Spray of mistalal @ 2ppm on tuber and 4 ppm spray at 30 and 45 days after planting increased 10 % tuber yield.
- Kufri Pukhraj and Kufri Badshah varieties are recommended for early planting up to 20 days while Kufri Jawahar, Kufri Pukhraj and Kufri Badshah varieties are recommended for late planting up to 10 days than the date of 1st November in *tarai* region of Uttarakhand.
- 160:100:120kg/ha NPK was recommended for higher potato tuber yield under *tarai* region of Uttarakhand.
- At Pantnagar, Kufri Sadabahar and Kufri Surya both the varieties produced significantly high yields upto 150kg N/ha. The economic optimum dose of Kufri Sadabhar and Kufri Surya were 190.51 and 200.24 kg/ha respectively and is recommended for *tarai* region of Uttarakhand.
- Application of Zn @ 1.5 kg/ha for zinc as basal was recommended for *taai* conditions of Uttarakhand. Application of 80kg P_2O_5/ha for higher yield and net return with recommended dose of 160kg N/ha and 120 kg K_2O/ha is recommended for *tarai* region of Uttarakhand.

Irrigation Management:

- 5 – 6 irrigations at an interval of 12-15 days gave higher tuber yield.
- First irrigation should be given light and 20-25 days after planting.

Inter cropping:

- Potato can be intercropped with wheat, radish and onion (for seed) with 3:1 ratio but higher income was obtained with potato, onion seed crop.
- Potato- Cowpea- Maize cropping sequence was found best for *tarai* region.

Weed Management:

- Application of Metribuzin @ 0.75 kg/ha either as pre- emergence or as post-emergence at 10% plant emergence can be recommended for effective weed control in potato for *tarai* region of Uttarakhand.

2. Research Publications:

1. Katiyar, H.; Singh, N.P. and Raghav, M.

(2000). Evaluation of potato (*Solanum tuberosum* L.) cultivars for processing and storage. *Progressive Horticulture*32(2): 167-171.

2. Singh, N.P.; Raghav,M. and Sengar, S.C. (2000). Growth behavior of early maturing hybrids of potato in *tarai* belt of Uttar Pradesh. *Annals of Plant and Soil Research*. 2(2): 270-272.
3. Singh, N.P. and Raghav, M. (2000). Response of potato to nitrogen and potassium fertilization under U.P.*tarai*condition. *J. Indian Potato Assoc*.27(182): 47- 48.
4. Raghav, M. and Singh, N.P. (2001). Production potential and profitability of potato based cropsequence in *tarai* belt of Uttaranchal. *J. Indian Potato Assoc*. 28(2&4):263-265.
5. Raghav, M. (2002). Comparative growth performance and yield of potato cultivars in mid-west plains of Uttar Pradesh. *J. Indian Potato Assoc*.29(2&4): 177-180.
6. Joshi, N and Raghav, M. (2002). Response of Zinc sulphate on growth, yield and quality of potato. *Potato Journal*.32 (3-4).
7. Raghav, M. and Singh, N.P. (2003). Difference among potato cultivars for their storability under room temperature. *Progressive Horticulture*.35(2): 196-198.
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10. Raghav, M. and Singh, N.P. (2004). Growth analysis of potato cultivars in autumn in *tarai* region of Uttaranchal. *Pantnagar Journal of Research*.2(2): 65-67.
11. Raghav, M. and Chandra, R. (2005).Effect of tuber soaking and bio-fertilizers on growth, yield and nutrientuptake by potato at two fertility levels. *Progressive Horticulture.* 37 (1): 157-162.
12. Singh, N.P., Raghav, M. and Kumar, V. (2005). Evaluation of potato for better yield under short day condition. *Progressive Horticulture.*37(2): 429-433
13. Joshi, N. and Raghav, M. (2006). Effect of zinc sulphate and their method of application on yield and quality attributes of potato cultivar Kufri Jawahar. *Progressive Horticulture.* 8(2): 248-251
14. Chauhan, Reshu and Raghav,M. (2007) Yield and quality of potato cultivar as affected by organic and inorganic source of nutrition. *Progressive Horticulture.* 39(1): 58-62
15. Raghav, M. and Singh, N.P. (2007).Effect of planting pattern, crop duration and fertilizer management on seed size tuber yield in potato. *Progressive Horticulture.* 39(2):175-177
16. Joshi, N. and Raghav, M. (2007).Growth and yield of potato as affected by zinc sulphate and their method of application. *Progressive Horticulture.* 39(2):189-193
17. Kamal, S.; Rajkumar.; Raghav, M.; Singh, Y.V. and Singh,N.P.(2007).Correlation and path analysis of yield determinants in potato (*Solanum tuberosum* L.) hybrids. *Pantnagar Journal of Research* 5(2):120-124
18. Gauhar S. and Raghav M. (2007) Effect of N and P levels with and without bio-fertilizers on N and P content, uptake and yield of potato cv. Kufri Jawahar. *Environment & Ecology* 25S (3A):788-791
19. Kamal, S.; Rajkumar and Raghav,M. (2007).Evaluation of potato (*Solanum tuberosum* L.) genotypes for quantitative traits. *Environment &Ecology*. 25S(3A): 916-920
20. Gauhar S. and Raghav, M. (2007) Potato growth and yield following nitrogen

phosphorus application and inoculation with biofertilizers *Environment &Ecology* 25(4):785-787

21. Chauhan, R. and Raghav, M. (2007). Effect of farmyard manure and varying fertility levels on growth and yield of potato varieties. *Progressive Horticulture.*39(2):1-7

22. Raghav, M.; Kumar,T and Kamal, S.(2007). Effect of organic sources on growth, yield and quality of potato. *Progressive Horticulture.* 39(1):95-100

23. Raghav, M.; Kumar, N. and Kamal, S. (2008) Performance of potato based cropping system under organic mode during initial years of conversion in relation to nutrient management practices. *Progressive Horticulture.* 40(2):209-214

24. Dua V.K.; Jaiswal R.C., Khurana, S.C., Kumar Dhruv, Nandekar D.N., Raghav, Manoj; Rawal Sanjay; Sasani G.V., Trehan S.P., Trivedi S.K., Jatav M.K., Lal S.S., Thakur K.C., Pandey S.K. and Naik, P.S. (2008) Manipulation of agronomic practices for tuber-size distribution in potato (*Solanum tuberosum*) seed crop. *Indian Journal of Agronomy* 53(3):217-223

25. Gauhar S. and Raghav, M. (2008) Effect of integrated nutrient management on yield and quality of potato (*Solanum tuberosum* L.) *Pantnagar Journal of Research* 6(1):122-124

26. Raghav, M.; Kumar, T. and Kamal, Shashi. (2008). Effect of organic sources on growth, yield and quality of potato. *Annals of Horticulture* 1(1):67-70

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30. Raghav, M. and Kamal, Shashi. (2009).Effect of organic sources of nutrients on potato production in *Tarai* region of Uttarakhand. *Pantnagar Journal of Research* 7(1):69-72

31. Raghav, M. (2011) System productivity and nutrient status in soil with different organic nutrient management options in potato-cowpea-okra cropping system. *Pantnagar Journal of Research* 9(2): 249-252

32. Jatav,M.K.; Dua,V.K.; Kumar,M.; Khurana,S.C.; Bhatia,A.K.; Nandekar, D.N.; Manorama, K.; Trivedi,S.K.; Das, S.N.; Chettri, M.; Raghav,Manoj.; Verma, R.B.; Naik,P.S. and Verma, D. (2012) Contribution of nitrogen and phosphorus from combined application of *Azotobacter* and phosphobacteria in potato. *Vegetable Science* 39(2): 123-127

33. Bisht,P.: Raghav,M. and Singh,V.K. (2012) Effect of different irrigation schedules on the growth, yield and quality of drip irrigated potato. *Potato Journal* 39(2):202-204

34. Jatav,M.K.;Dua,V.K.; Kumar, M.; Trehan, S.P.; Singh,S.K.; Khurana,S.C.; Bhatia,A.K.; Nandekar, D.N.; Manorama, K.; Patel, C.K.; Trivedi,S.K.; Das, S.N.; Chettri, M.; Raghav,M.; Jha, G.; Saikia,M.; Naik,P.S. and Verma, D. (2013) Soil test based phosphorus

recommendation for potato. *Vegetable Science* 40(1): 17-22

35. Verma, M.K. and Raghav, M. (2014) Effect of calcium on growth, yield, quality and storage ofpotato (*Solanum tuberosum* L.) *I J Basic & Applied Agri. Res.*12 (2):231-234

36. Chandra,G. Kumar, Udit and Raghav,M. (2014) Physiological and biochemical impact of nitrogen on potato tuber. *Progressive Research* 9(3&4): 570-573

37. Chandra, G.; Raghav,M. and Kumar, U.(2015) Performance of potato varieties with varying nitrogen levels for yield and yield contributing traits of tuber. *Annals of Plant and Soil Research*17(3):15-18

38. Kumar, U.; Raghav,M. and Chandra, G. (2015) Production potential of potato cv Kufri Sadabhar as influenced by mode of nitrogen application. *Annals of Plant and Soil Research*17(5):96-98

39. Narollia, R.; Raghav, M.; Singh, V.K.and Kumar, N. (2015) Growth and yield response of potato to irrigation levels and mulching methods. *I J Basic & Applied Agri. Res.* 13(1):38-41

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41. Chandra, G.; Raghav,M.; Kumar, U. and Kumar, P. (2017). Effect of nitrogen levels on yield, nitrogen uptake and efficiency of potato varieties under *tarai* region of Uttarakhand. *The Bioscan* 12(1): 515-519

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44. Sati, K.; Raghav,M.; Singh, C.P.; Singh, V.K. and Shukla, A. (2017) Effect of zinc sulphate application on growth and yield of potato. *Research on crops* 10 (8):685-687

45. Sati, K. and Raghav,M. (2017) Effect of commercial formulation of mycorrhiza on growth and yield of potato (*Solanum tuberosum* L.) cv. Kufri Jawahar. *Research Journal of Agricultural Science* 8(1): 181-183

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47. Lavlesh; Raghav, M.; Sati, U.C. and Sati, K. (2017) Evaluating the manual and chemical methods for weed control in potato (*Solanum tuberosum* L.)under tarai conditions of Uttarakhand. *The Bioscan* 12(1): 683-686

48. Sati, U. C.; Raghav, M.; Sati. K. and Lavesh (2017) Effect of different levels and methods of potash application on growth and marketable tuber yield of potato. *Research Journal of Agricultural Science* 8(3): 700-704

49. Pandey, P; Raghav, M.; Singh, D.K.; Singh, V.K.; Raverkar, K.P. and Jeena, A.S. (2017) Grading of potato tubers as influenced by nitrogen scheduling. *International Journal of Chemical Studies* 5(4): 567-570

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potato tubers (*Solanum tuberosum* L.) *The Bioscan* 12(3): 1703-1708

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3. Thesis Research:

1. Swalin Gauhar (2002) Effect of Bio-fertilizers on growth and yield of Potato (*Solanumtuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
2. Neelima Joshi (2004) To Study the effect of zinc sulphate on growth, yield and quality characters of Potato (*Solanum tuberosum* L.) cv. Kufri Jawahar M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
3. Reshu Chauhan (2004) Effect of FYM and doses of NPK on growth yield and quality characters of Potato cultivars M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
4. Swalin Gauhar (2007) Effect of integrated nutrient management on growth and quality of Potato (*Solanum tuberosum* L.) Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav
5. Raju Lal (2011) Effect of calcium sulphate on growth, yield and quality of Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
6. Sanjay Kumar Meena (2012) Effect of date of planting and varieties on growth and yield of Potato M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
7. Rajeev Kumar Narolia (2013) Response of Potato (*Solanum tuberosum* L.) To Irrigation and Mulching Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav
8. Mukesh Kumar Verma (2013) Effect of calcium on growth, yield and storage of Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
9. Umesh Chandra Sati (2014) Potash management in Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
10. Anil Chander (2014) Effect of Planting dates on growth, yield quality of Potato (*Solanum tuberosum* L.) Varieties Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav
11. Girish Chandra (2015) Performance of Potato varieties under varying nitrogen levels for yield, quality and storability traits seed tuber Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav
12. Udit Kumar (2015) Nitrogen Management in Potato Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav
13. Kailash Sati (2016) Effect of zinc sulphate application on growth, yield and quality of Potato (*Solanum tuberosum* L.) Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav
14. Lavlesh (2016) Effect of manual and chemical methods of weed management on Potato (*Solanum tuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav
15. Pooja Pandey (2017) Effect of nitrogen

scheduling on growth, yield and quality of Potato (*Solanum tuberosum* L.) Ph. D. submitted to GBPUAT under guidance of Dr. M. Raghav

16. Prakash Kanwar (2018) Response of Potato (*Solanum tuberosum* L.) to zinc application M.Sc. submitted to GBPUAT under guidance of Dr. M. Raghav

4. Future Thrusts:

- More efforts should be devoted to promote organic farming which is not only ecologically viable but also environmentally safe
- Need to develop water efficient system and input use system which must be adopted by all the farmers, producers, workers, researcher etc.
- Need to focus on potato cropping system

C. Crop Protection:

a. Potato Entomology:

1. Significant Achievements:

- At Pantnagar aphids (*Myzus persicae*) appears in potato crop in first week of December but its appearance could be delayed up to January second week by insecticidal application. However cutting of foliage is necessary at this time for disease free production of potato seed. Thus, it is recommended that potato seed should be sown on 15th October and be harvested on 10th January (90 days) to minimize the infestation by aphids and getting healthy seeds.
- Phorate 10 G@10 kg/hectare at the time of earthing-up (last week of November) followed by spray of Monocrotophos 0.036% or Dimetoate 0.03% or Oxydemeton-methyl 0.025% was found effective against aphids. Deltamethrin was also effective against insect pests.

Major Insect Pests of Potato:

1- Insect Pests damaging potato tuber:

- Cut worm (*Agrotis ipsilon*): Larvae of this insect damage the potato tuber. Per cent damage was 0.5 per cent. No damage was observed other plant parts.
- Potato tuber moth (Pthoromyia *opercullella*): No damage of this pest was reported at Pantnagar area but in Uttarakhand hills the damage was observed up to 40 per cent in potato seed godown in Dhari block of Nainital District. Damage of this pest was also reported in Almora and Garud region of the hilly areas. No infestation was observed above 1900 msl elevation. Further investigation is required for detailed study of this pest.

2. Insect pests damaging leaves:

- Epilachna beetle (*Epilachna vigintioctopunctata*):This pest damage early (September) and late (November/ December) sown crops. Damage has been observed in hilly areas.
- Bihar hairy caterpillar (*Diacrysia oblique*): Damage of this pest was occasionally recorded on leaves but the extent of damage was high.
- Tobacco caterpillar (*Spodoptera litura*): The extent of damage was low but sometimes it damages the tuber in storage.
- Plusia Caterpillar(*Plusia oricalsia*): Some extent of damage was reported by this green caterpillar occasionally. The above insects are not associated with significant yield loss in potato crop.

2. Sucking insects:

- Jassids (*Amaraska bigutula bigutula*): This is polyphagous pest infesting early sowing crop by sucking the sap from lower leaves resulted in significant yield loss.
- Aphids (*Myzus persicae* or *Aphis*

gossypii): Two species i.e. *Myzus persicae* and *Aphis gossypii*have been reported in Pantnagar area. Viral disease like yellow mosaic and leaf curl are transmitted by this aphid.

B. Potato Pathology:

1. Significant Achievements:

- **Gene complex and mating type**: The occurrence of 1,2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 gene complex races for *Phytophthora infestans* were reported. For the first time, A2 mating type was reported during the crop season 2013-14.
- **Forecasting model**: Late blight forecasting model developed specifies that if 7 day moving average relative humidity e" 85% prevails for e"85 hrs and 7day moving average congenial temp. (7.2 to 26.6°C) for e"135 hrs, blight would appear within 14 days. (2013)
- **Late blight management :**

a. Prophylactic spray with Mancozeb @0.2% followed by second spray of (Fenamidone + Mancozeb) @0.3% after seven days and a third spray with Mancozeb @ 0.2% after seven days of the second spray is recommended for the control of late blight in *tarai* region of Uttarakhand.

b. Prophylactic spray (just at the time of canopy closure, when leaves of adjacent rows come close) with Mancozeb @ 0.2% followed by Cymoxanil + Mancozeb @ 0.3% or Dimethnomorph @0.3% after one week and one more spray with Mancozeb @ 0.2% after another week should be adopted for late blight management.

- **Metalaxyl resistance**: The Metalaxyl sprayed plots (K. Bahar, K. Badshah, K. Sutlej, K. Jawahar) had ***P infestans*** exhibited Met-resistance up to 200 ppm.
- **Black scruf:**

a. Tuber treatments with Boric Acid @ 3% or Monceren @ 0.2% were highly effective in controlling black scurf. Bio-agents evaluated, alone or in combination, were not effective in controlling black scurf; however good yields were harvested.

b. In station trials tuber treatment with cow urine (50% dilution, 15 min) was found promising in managing black scurf.

PNT/05-06-93 and PNT/07-01-04 potato genotypes showing field resistance to late blight

c. Tuber dip treatment with Penflufen @0.062% and 0.083% for 10 minutes before planting was found at par with Boric acid @3% as no black scurf incidence was observed in these treatments.

d. The disease in treatments *Trichoderma viride* @ 1kg/ 10 L at planting (51.24%), *Bacillus subtilis* @ 0.25% (44.23%) and Cow urine + Cow dung @ 50% (42.15%) at par with control.

e. Highest tuber yield harvested from Tuber dip treatment with Penflufen @0.083% for 10 minutes before planting.

- **Stem necrosis:** Recently stem necrosis (Groundnut bud necrosis virus) has been recorded at Pantnagar. The disease was first observed during 2009–10 and further studies have confirmed the disease and the pathogen involved. The occurrence is erratic and patchy, especially in late sown crop.

- **White stem rot:**White stem rot was recorded (20%) in K. Sadabahar during 2012-13.

2. Research Publications:

Research papers

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4. Singh, R.P. and Pundhir V.S. 2004. Uptake, Translocation and Persistence of Metalaxyl in Potato. *Journal of Mycology and Plant Pathology*, Vol. 34, No. 1, 93 – 95.
5. Khan M. R.; Pundhir V. S. and Anil Kumar 2004. ELISA, a sensitive method, for diagnosis of *Ralstonia solanacearum* (Smith) Yabuuchi *et al.Journal of Indian Potato Association*.
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8. V.S. Pundhir, Shailbala and V.K. Singh. (2006). Eco-friendly innovative approaches in the management of late blight of potato. National Symposium and 28th Annual Meet of Indian Society of Mycology and Plant Pathology from 9th -11th November, 2006. pp 131-132.
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12. Shailbala and V.S. Pundhir. (2008). Efficacy of fungicides and bio-agents against late blight severity, infection rate and tuber yield of potato. *J. Pl. Dis. Sci*. 3(1): 4-8.
13. Shailbala and V.S. Pundhir. (2008). Integration of host resistance and fungicides for management of late blight of potato. *Potato J*. 35(1-2): 97-99.
14. Shailbala, V.K. Singh and S.K. Sharma. (2009). Field efficacy of kocide 3000 46.1 % DF (copper hydroxide) against late blight of potato caused by *Phytophthorainfestans* (Mont.) de Bary. *Pestology*. 33(7): 38-41.
15. V.K.Singh, Shailbala and V.S.Pundhir. (2013). Forecasting models for potato late blight management- A review. *Agricultural Reviews*. 34(2): 87-96.
16. Shailbala and A. Kumar. (2017). Eco-friendly management of late blight of potato - A review. *J. Applied and Natural Sci*. 9(2): 821-835.

• Book Chapters

1. V. K. Singh, **Shailbala** and **V.S.Pundhir**. (2012-2013).Potato late blight forecasting models–An effective tool for disease management. In: Eco-friendly innovative approaches in plant disease management (Eds by V.K. Singh, Y. Singh and A. Singh). International Book Distributers, Dehradun. pp 101-112.

3. **Shailbala** and V.K.Singh. (2015). Potato diseases and their eco-friendly management. In: Innovative approaches in plant disease management - crop diseases and their management (Eds by K.P.Singh, C.R.Prajapati and A.K.Gupta). Lambert

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- **Booklet**

1. Diseases and Pests of Potato - Diagnostics and Management by **Shailbala**, V.K.Singh and **V.S. Pundhir**. (June 2012). Department of Plant Pathology, College of Agriculture. G.B.P.U.A.&T., Pantnagar , University Press. 44 pp.

2. Aloo ki Phasal Ksureksha by **Shailbala**, V. K. Singh and **V. S. Pundhir**. (September 2012). Department of Plant Pathology. College of Agriculture. G.B.P.U.A.&T., Pantnagar , University Press. 36 pp.

- **Laboratory Manual**

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3. Thesis Research:

1. Pandey, S. (2000). Management of Black scurf of Potato. Ph.D. submitted to GBPUAT under guidance of Dr. V.S.Pundhir.
2. Shanmugam, V. (2001). Epidemiology and management of late blight of potato. M.Sc. submitted to GBPUAT under guidance of Dr. V.S. Pundhir.
3. Pradeepa, N.H.L. 2003. Biological control of black scruf of potato. M.Sc. submitted to GBPUAT under guidance of Dr. V.S. Pundhir.
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5. Shailbala. (2005).Studies on Epidemiology and management of late blight of potato caused by *Phytophthora infestans* (Mont.) de Bary. Ph.D. submitted to GBPUAT under guidance of Dr. V.S.Pundhir.
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7. Chilwal, V. (2009). Management of black scruf of potato. M.Sc. submitted to GBPUAT under guidance of Dr. V.S. Pundhir.
8. Rajashekara. (2010). Studies on Stem Necrosis of potato (*Solanumtuberosum* L.) M.Sc. submitted to GBPUAT under guidance of Dr. V.S. Pundhir.
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10. Joshi, V. (2012). Late blight of potato under tarai region. Ph.D. submitted to GBPUAT under guidance of Dr. V.S.Pundhir.
11. Ansar, M. (2012). Stem necrosis of potato. Ph.D. submitted to GBPUAT under guidance of Dr. V.S.Pundhir.
12. Gunwant, K. (2012). Management of black scruf of potato. M.Sc. submitted to GBPUAT under guidance of Dr. V.S. Pundhir.

4. Future Thrusts:

- Though INDO BLIGHT CAST warning system against late blight of potato have been developed for this region but this is the need to validate and popularized INDO BLIGHT CAST model at farmers field
- Requiring towards the non-chemical management approaches for management of diseases and pests of potato
- Need more focus on viral diseases of potato. Evenstem necrosis is also a problem so and develop such effective integrated disease management strategies
- Golden nematode is new emerging problem so need to develop survey map of this region