AICRP-NSP (CROPS) SEED TECHNOLOGY RESEARCH

Objectives

- Standardization of technology for disease Free Seed Production in soybean, rice and wheat crops.
- To find out effect of fungicides and insecticides on seed storability (wheat, soybean and hybrid rice).
- To standardized methods for detection of seed borne inoculums.
- Detection characterization and monitoring of seed-borne bacteria.
- Detection characterization and monitoring of seed borne viruses.
- Integrated management of important seed borne diseases.
- To establish seed certification standards for seed-borne diseases of significance.
- To work out effective seed treatment technology for management of seed-borne diseases of significance.
- To develop agronomic package of practices for seed production in field crops.
- To established role of growth regulators on seed set and seed yield of hybrid rice.
- Maintenance of viability of hybrids and their inbred lines during storage.
- Effect of storage conditions on enhancement of storage life of seed.
- To develop priming technology for enhanced planting value of seed under sub optimal condition in field crops.
- To establish planting ratio of hybrid seed production in sorghum.
- Assessment of RAPD and ISSR marker systems for establishing distinctiveness of forage sorghum varieties as additional descriptors for plant variety protection.
- Morphological characterization of forage sorghum [*Sorghum bicolor* (L.) Moench] varieties for DUS testing.
- To assess genetic variability in sorghum [*Sorghum bicolor* (L.) Moench] on the basis of SSR markers.
- To worked out synchronization of flowering of parental lines of hybrid seed production.

A. Seed production and certification

1. Significant Achievements:

- Wheat variety UP 2526 showed comparatively more yield if it is sown on FIRB as compare to normal showing in the field.
- In hybrid rice (i.e. Pant SankarDhan 3) better results for yield and its attributing traits were obtained under two treatments namely T2 (RDF + Basal Application of Zn under direct seed sowing) and T6 (RDF + Foliar application of Zn twice at one weak interval under transplanting).
- Traditional rice variety (i.e. Pant Dhan 18) gave more seed yield under T2 (Direct Sowing+ RDF + Basal Application of Zn) and T5 (Transplanting

+ RDF + Basal Application of Zn). Hence these two treatments aregood treatments to maximize the seed yield under direct sowing as well as transplanted conditions.

- The hybrid seeds of PSD-3 successfully produced in outside from the Pantnagar on farmer's field (at Ramnagar Road Kashipur), which increases income of farmers and also helps to reduce the transportation cost of hybrid seed.
- The hybrid seeds of PSD-3 were produced in the offseason but seed yield obtained was not up to the mark due to unfavorable environmental conditions and it was not economical. Thus, recommendations are given to the farmers to not produce the hybrid seed of rice during offseason in Uttarakhand.
- Early sowing is preferably more economical for seed production of Berseem as compare to late sowing condition.The 10 days Earlier cut regime over normal last cut produced more seed yield under almost all the treatments (viz., borax @ 100 ppm and Kno3 @ 2 % at reproductive stage just 10 days before last cut, Borax @ 100 ppm and Kno3 @ 2 % at the time of reproductive stage exactly at the time of normal last cut etc.).
- In Berseem crop, Spray application of chemicals viz., borax @ 100 ppm and Kno3 @ 2 % at reproductive stage just 10 days before last cut (T9 and T1 under early sowing condition and T13 and T5 under late sown environment) were found at par and significantly superior to produce the higher seed yield followed by chemical spray of Borax @ 100 ppm and Kno3 @ 2 % at the time of reproductive stage exactly at the time of normal last cut (T11 and T3).
- To mitigate the heat stress in wheat, The three treatments namely T1 i.e. spray with glycinebetaine 600 ppm followed by T5 i.e. α-tocopherol 150 ppm and T3 i.e. salicylic acid 400 ppmat vegetative, flowering and grain feeling stage were found significantly superior to increase the seed yield as well as storability then rest of the treatments.
- To increase seed yield and germination capacity in wheat crop, seed film coating polymere treatment i.e. Polymer (DISCO AG SP RED L-200) + Thiram + Quick Roots **/mycorrhiza was found superior followed Polymer (DISCO AG SP RED L-200) + Thiram + Genius Coat ** and. Polymer (DISCO AG SP RED L-200) + Thiram+Carboxine.

2. Research Publications:

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3. Future Thrusts:

1. Strategic research on maintenance of genetic purity of high yielding varieties and the parental lines/ inbred line of hybrids especially in field crops.
2. Development of reliable and sustainable (lost cost) technologies to mitigate the effect of elevated temperature on seed set yield and quality in field crops.
3. Morphological as sell as molecular characterization for genuineness of the high yielding verities of field crops and development of genetic purity DNA kits specially for the varieties which are in seed chain.
4. Development and identification of chief and environment friendly seed polymer technology for better germ inability and seedling establishment under drought prone and rain fed areas of the country.
5. Redefining and standardization of isolation distance of various important crops to produce quality seed/ hybrids.
6. Dissemination of new technologies among the farmers through participatory and capacity building programe for doubling-up their income.

B. Seed Physiology, Storage and Testing:

1.Significant Achievements:

- Late planting of Urd UPU -30 by the end of August gave approx.28.6% higher yield than early planting under Tarai condition of Uttarakhand.
- Application of 150 kg N and 75 kg P_2O_5 /ha gave better performance in sunflower hybrid seed production than 120 kg N and 60 kg P_2O_5 /ha.

The effect of micronutrient and growth regulator on A line of sunflower hybrid (KBSH-1) at floret initiation was also tested. The maximum seed yield was recorded with spraying TIBA @ 75ppm or 1% Borex. The seed quality parameters i.e. per cent germination, seedling length and seed vigour was also higher than control.

- For higher seed yield the parents of single cross hybrid should be spaced at 45 cm row to row and fertilized with 150kg N and 60 Kg P_2O_5.Graded seed yield q/ha, per cent seed set and per cent recovery were significantly influenced by addition to the recommended NPK dose.
- Soybean, maize, rice hybrid seeds are poor storer. For maintain viability it should be dried up to 8-9 % moisture content and stored in poly lined cloth bag.
- Super grain bags were found to be safe packaging material for storing seeds of different crops at 8 % moisture level for one planting season and found to maintain seed quality above Minimum Seed Certification Standard with minimum insect/ pathogen incidence. Use of grain super bag is recommended for bulk storage of seed at commercial scale.
- Poly-lined gunny bag/poly-lined cloth bags were found better packaging material over conventional gunny bags for storing seeds of different varieties in field crops for one planting season at 8-9 % moisture content. It was found to maintain seed quality above IMSCS. Being cheaper, such bags are to be popularized among farmers in the country for storing seed material of field crops.
- The polymer coating in combination with pesticide (polymer coating @3ml/kg + vitavax 200 @2 g/ kg of seed) is beneficial for improving the initial quality as well as storability of soybean seed.
- Pre-sowing seed treatment of paddy seed (Pant Sugandga-2) with water for 18 hrs followed by shade drying at room temperature + seed treatment with thiram @2.5g/kg is beneficial for improving crop establishment and yield of rice.
- The polymer coating in combination with pesticide with or without colourant is beneficial in improving the initial quality as well as storability of soybean seed. The subsequent coating with polymer-fungicide-insecticide followed by vitavax 200 are most effective.
- Physical seed invigoration treatment with 100 Hz Pulsed Electromagnetic Field may be used to improve seed germination per cent and seeding vigour indices of revalidated green gram seed.
- Seed priming in wheat for soaking wheat seed in water for 14 hours (1:2::seed: water ratio) ratio followed by shade drying was found beneficial for improving crop establishment and yield under delayed and rainfed condition.
- In hybrid rice seed production highest seed set and seed yield was achieved by applying GA_3 @90-120 g/ha. However germination percent and seedling vigour of seed produced decreased with increasing dose of GA_3 as its residual effect. Application of GA3@ 90 g/ha+1 % boric acid at sprayed in parts of 40 % at first day and 60 % on subsequent day at 5 % panicle emergence was found most effective for maximizing hybrid rice seed production. Seed quality parameters in terms of per cent seed set ,per cent seed germination ,seedling length, seed vigour index and seed yield of F1 rice hybrid Pant Shankar Dhan -1 recorded highest ,when the crop was planted on 15th June in nursery.
- Further experiment on micro nutrient management on quality seed production on Pant Dhan 10 was planned to improve seed quality of rice through micronutrient application. Basal application of zinc at the rate of 25 kg /ha significantly increased seed yield over no zinc application.
- Application of FYM@20 t/ha and *Azospirillum* soil inoculation @5kg / ha followed by bio intensive crop protection measures like release of *Trichogramma*@1.5 lacs eggs/ha for the control of yellow stem borer and leaf folder was found most suitable in rice cv. Pusa Basmati-1
- Graded seed yield, per cent seed set and per cent

seed recovery in sunflower hybrid seed production were significantly influenced by the application of 0.5% micronutrient in addition to the recommended NPK dose.

- Seed production of QPM maize hybrid Shaktiman-2 could be maximized even up to 45q/ha by sowing its parental lines at a row spacing of 75x15 in 2:4 planting ratio with application of 150:60:40 NPK kg/ha.

2. Research Publication:

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3. Thesis research:

1. NC Nainwal.2007. Effect of sowing dates on seed yield and quality parameters of ten wheat varieties

submitted for M.Sc. Agronomy to GBPUAT under supervision of Dr. Omvati Verma.

2. Shyamashree.2009. Effect of nitrogen levels and foliar application of urea on yield and quality of seed in late sown wheat crop submitted for M.Sc. Agronomy to GBPUAT under supervision of Dr. Omvati Verma.
3. Geeta Kaur.2010. Effect of seed rate and priming on performance of late sown wheat submitted for M.Sc. Agronomy to GBPUAT under supervision of Dr. Omvati Verma.
4. Neha Joshi.2013. Effect of seed enhancement treatment on seed quality and yield of wheat during storage and under late sown conditions submitted for M.Sc. Agronomy to GBPUAT under supervision of Dr. Omvati Verma.
5. Ritika Bhaskar.2018. Yield and seed quality of mungbean (Vigna radiate L wilczek) in response to foliar spray of nutrients and growth regulators submitted for M.Sc. Agronomy to GBPUAT under supervision of Dr. Omvati Verma.
6. Reena Verma.2019. Effect of seed priming and foliar Nutrition on yield and seed quality of timely and late sown wheat (*Triticum aestivum*.L) submitted for M.Sc. Agronomy to GBPUAT under supervision of Dr. Omvati Verma.

4. Awards/Honours

1. Shyamashree M.Sc. student awarded best thesis research entitled "Effect of nitrogen levels and foliar application of urea on yield and quality of seed in late sown wheat crop" Purnanand Adalkha award.
2. Vijay Laxmi, R.S. Verma and Omvati Verma awarded best research paper award entitled "Substratum and temperature requirement for germination of Satawar (*Asparagus racemosus*) seed" in ISST XIV National Seed Seminar held at ICAR-IARI, Depart of Agricuture, Cooperation & Farmers Welfare ,New Delhi w.e.f. Jan 28-30, 2017 organized by Indian Society of Seed Technology.
3. Reena, Verma, Omvati, Rashmi Sharma and Ritika Bhaskar awarded Best Poster Presentation award entitled "Germination and seedling vigour Activities of Wheat (Triticum aestivum L) seed as influenced by different seed invigoration treatments" in National Agronomy Congress 2018 organized by Department of Agronomy, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar w.e.f. February 20-22, 2018.Pp.489-491

5. Future Thrusts:

- Development of seed production technology for maximizing yield and quality seed under changing climate
- Standardization of stack height in soybean for maintaining germination and viability up to certification standard.
- Effect of seed enhancement treatments on physical, physiological and biochemical seedling vigour parameters
- Standardization of seed testing procedure in medicinal and aromatic plants

C. Seed Pathology:

1. Significant Achievements:

- Extensive studies have been carried out relating to the economically important seed-borne diseases and their pathogens in relation to the methods for their detection, mechanism of transmission from seed to plant and plant to seed; location of infection in seed; longevity of the pathogen in seed; and management of seed borne infection through seed treatment and integrated management of seed-borne diseases in seed crops.
- Embryo count method for detection of loose smut of wheat under laboratory condition has been developed for use by seed certification agencies. This has may helped to save the extra cost of fungicide application against loose smut of wheat contrary to blanket recommendation of seed treatment. Seed treatment is recommended only to those seed lots having loose smut infection above the certification limit of 0.5% in certified seeds and

0.1% in foundation seed in embryo count method. Seed lots showing 2.0% loose smut infection by embryo count method are advised not to be certified. The practice is being followed by UP Seeds and Tarai development Corporation for a long time and is still in practice in Uttaranchal Seeds and Tarai Development Corporation.

- An isolation distance of 150 metres has been recommended to be followed as certification standard for field for loose smut of wheat for quality seed production**.** Seed treatment either with rexil (@ 0.1%), or vitavax or bavistin (@ 0.2%) has been recommended for management of loose smut of wheat. Mistomatic method of seed treatment has been found most effective as compared to dry and slurry seed treatment. In wheat crops, seed treatment with bavistin + thiram (1: 1) @ 0.2% improved seed germination and seedling vigour during storage and reduced storage fungi in seed.
- Detection of paddy bunt and Karnal bunt of wheat by NaOH seed soak method has been worked out. The method has been found superior over visual examination in treated seeds. In paddy seed treatment with streptocycline and thiram (1: 1) @ 0.25 % followed by spraying with tilt @ 0.1% at boot leaf stage and at 50% penicle emergence reduces bunt infection. For management of Karnal bunt of wheat single spray of tilt @ 0.1% at early heading stage has been recommended.
- Developed techniques for the detection of important Seed-borne pathogens causing diseases such as Ascochyta blight of gram (*Ascochyta rabiei*), Alternaria blight of cauliflower (*Alternaria brassicae and A. brassicicola*), Phomopsis blight of brinjal (*Phomopsis vexans*), Anthrocose of chilli (*Colletotrichum capsici*) and soybean *(Colletotrichum truncatum)*, Charcoal rot of soybean (*Macrophomina phaseolina*) and sheath rot of paddy (*Sarocladium oryzae*); cob rot in maize; (*Fusarium moniliformae*); Alternaria blight of tomato (*Alternari solani)*; purple blotch of onion (*Altermaria porii*) ; bacterial blight of soybean (*Pseudomonas syringae* pv. *glycinea*); The panicle blight in paddy (*Burkholdaria sp.*); Bacterial canker in tomato(*Clavibacter michiganensis* subsp *michiganensis*)
- Location of Seed-borne infection of *Peronospora parasitica* has been worked out. The inoculum was found as oospores of the fungus, localized in seed coat. Seed treatment with apron 35 SD (0.2%) has been recommended in rape seed-mustard against downy mildew infection in seed.
- Oat meal agar medium has been found most suitable for detection of *Ascochyta rabiei* from chickpea seed. Histopathology of infected seeds revealed profuse inter and intracellular fungal mycelium in seed coat and cotyledons and pycnidia in seed coat, between seed coat and cotyledons. Seed transmission of the fungus from seed to seedling is non systemic in nature. Infected seedlings, showed characterstic pycnidia of the fungus on cotyledonary leaves first and primary leaves and the inoculun from such seedling served as the source of infection for the healthy plants/seedlings. The seed-borne inoculum reduced but not eliminated even after 8 months of storage at normal room temperature conditions. Seed treatment with bavistin + thiram (1: 1) @ 0.3% reduced Seed-borne inoculum of Ascochyta blight in chickpea.
- Deep freeze method has been found most suitable for detection of (*Alternaria brassicae and A. brassicicola*) in cauliflower seed. Pathogens have been found to be localized in the seed coat and in endosperm but not in embryo. The Seed-borne infection decreased with the increase in storage period. Collateral hosts also played an important role in disease dissemination. The mode of transmission of both the pathogens from seed to seedlings and to plant is non- systemic. Seed treatment with Rovral @0.25% or thiram or captan @ 2.5g/Kg as dry seed treatment significantly reduced seed infection and improved seed germination. An integrated management of the disease in seed crop of cauliflower may be achieved by seed treatment with rovral @ 2.5g/ Kg , transplanting at the spacing of 60x60cm^2, and spraying seed crop with indofil M-45 @ 0.2% at 20 days intervals after bolting or disease appearance.

- Standard Blotter test could successfully be applied for detection of *Phomopsis vexans* in brinjal seed .The fungus is found to be seed-borne and seed transmissible and leads to pre-and post emergence damping off of seedlings. The histopathology of infected seed revealed profuse branched and septate mycelium aggregated in seed coat, endosperm and in the embryo region of the seed. The pycnidia of the fungus were also observed in seed coat, between seed coat and endosperm and in the endosperm tissue of the seed. Seed treatment either with triademefon or carbendazim or captan and subsequent spraying of copper oxychloride successfully controlled the disease in seed crop.
- Anthracnose an internally seed-borne disease in chilli crop is best controlled by seed treatment with thiram or captan and spraying the seed crop at the seed bed and fruiting stage with dithiocarbametes or difolatan or copper oxychloride (blitox and fytolan @ 0.2%). Standard blotter test is found most suitable for detection of Seed-borne infection. Seed-borne inoculum drastically reduced seed germination and led to seedling mortality.
- In rapeseed- mustard the seed-borne infection of *Alternaria brassicae* and *A. brassicicola* could be detected by washing test and Standard blotter test. Seed infection with both the fungi caused seed discolouration, decreased seed germination, seed size, seed viability and oil content in infected seeds. Both the fungi, however, got auto eliminated within 4 months when the seeds were stored in agroclimatic conditions where the room temperature goes beyond 30°C.
- Sheath rot (*Sarocladium oryzae)* and *Fusarium moniliformae* incidence was comparatively higher in hybrid parents (IR58025A and IR 58052B) as compared to conventional varieties. There has been more reduction in germination during storage in hybrid lines (IR58025A and IR 58052B) as compared to restorers (IR-66, and KMR-3) and conventional varieties. Paddy seed, stored at 12% moisture content in cloth bags, treated with thiram maintained maximum germinability, increased percentage of normal seedlings and reduced seed rot, during storage.
- Standard blotter test can successfully be applied for detection of *Macrophomina phaseolina* in Soybean. Histopathology of infected seeds revealed the presence of microsclerotia of the fungus in all the three layers of the seed as well as the sclerotia in the outer layer of the cotyledons. Pathogen is transmitted from seed to seedlings. Germinated seedlings, raised from infected seeds, showed reddish brown to gray lesions on the hypocotyls near crown. Infected radicles are covered with black microsclerotia. Seed treatment with topsin- M and thiram (1:1) (@4g/Kg) was found to be the best and significantly reduced Seed-borne infection and improved seed germination.
- Bacterium *Pseudomonas syringae* pv. *glycinea,* the cause of bacterial blight of soybean has been severe during 2012 in seed production plots at (Uttarakhand) region. An extensive study indicates that diseased seed are responsible for transmission of the pathogen. Such seeds were very poor in germination and caused seed rot which is evident by bacterial ooze on seeds surface.
- Soybean mosaic virus (SMV) is seed transmissible in soybean crop. In systemically infected soybean plants exhibited higher loss in respect of seed weight /plant, and number of pods/plant. Secondary infection of SMV in the field also resulted into significant reduction in yield. Early infected plants exhibited stunting rugosity and curling of leaves and sign of flower deformation and at times failure in seed setting. or in case they bear pods produce higher percentage of infected seeds as against the lower percentage of infected seed . Occasionally, infected plants may exhibit black mottled seeds. However , in Grow out test, of black mottled and non-mottled seeds indicate that virus is not necessarily carried only through black mottle seeds only and virus may be transmitted from non mottle seed may also.
- In soybean, seed treatment with Vitavax 200 @ 3g/kg and stored in polylined bags at 10.0% mc maintained prolonged storability until 12 months.
- *Colletotrichum truncatum,* the pathogen of anthracnose of soybean can successfully be

detected from seeds by Standard blotter test. The fungus is internally Seedborne and mycelium and acervuli, the fruiting bodies of the fungus, lies in seed coat and mycelium in cotyledon. Seedlings developed from infected seeds girdle the stem leading to the death of the seedlings. Such seedlings serve as source of dissemination of the pathogen in field. Seed treatment with thiram was found to be the best for management of Seedborne infection of *Colletotrichum trumcatum* in soybean crop.

- Seed-borne nature of urd bean leaf crinkle virus is established using conventional grow- on test and serological methods.
- In Chilli, seeds collected from anthracnose (*Colletrotrichum truncatum*) infected fruits, having an infected fruit area of 1-24 %, exhibited 15% seed infection and 55.0 % seed germination which is below certification standards (60.0%). Seed-borne inoculum of *Colletotrichum capsisi* drastically reduced seed germination and led to seedling mortality. The use of clean seed, with no infection of the fungus in seed, is recommended for seed production.
- Fungus, Alternaria *solani* , the cause of Early blight of tomato, is seed borne and seed transmissible. The transmission of the pathogen from seed to seedling is non systemic. The maximum recovery of the fungus from infected seed was on Standard blotter method. However, the fungus sporulated profusely on Potato Carrot Agar medium.
- Seed treatment with Thiram @ 0.2%, has been effective for management of seed borne infection. On the other hand, amid the eco-friendly seed treatment measures leaf extract of eucalyptus, bael, neem and bulb extract of garlic were effective for increasing seed germination and reducing seed rot. Seed treatment with combination of bio-control agents *T. harzianum* + *Ps. fluroscens* (1:1) (6g/ kg) has been an effective treatment to improve seedling vigour however was ineffective in management of seed-borne infection of *Alternaria solani*.
- For integrated management of Alternaria blight in seed crop of tomato seed treatment with thiram @ 0.2% and subsequent six prophylactic sprays of indofil M-45 or mancozeb @ 250ppm/ starting from the appearance of the disease at 10 day interval checks the disease in seed plots. Besides at farmers field, six prophylactic sprays of Mancozeb after 60 days of sowing and when planting was done early in July, 25th enhanced the yield.
- *Fusarium moniliformae,* (cob rot) a mycotoxin producing fungus in maize seed could successfully be isolated from infected seed using 2-4D method. Seed treated with flowable thiram @ 2.4ml/kg and stored in HDPE bags at 13.9% mc maintained germination above IMCS even after 10 months of storage and reduced the fungus and other associated mycoflora in storage.
- Fungus *Alernaria porri* , (purple blotch) in onion, could be detected from infected seeds using different incubation methods (standard blotter method, Agar Plate method and Deep freeze method) However, the maximum recovery of the fungus was in Deep freeze method.The fungus *Alernaria porri* , lies in the pericarp of the onion seed. The longevity of the fungus in infected seed is 12 months, under ambient storage conditions. Thrips infestation of seed crop enhances the purple blotch incidence.
- The panicle blight which has been reported for the first time from Pantnagar Centre in the year 2011-2012, is being observed as emerging disease in paddy.The causal agent has been identified as bacterium *Burkholdaria sp.* on the basis of morphological and biochemical test. Kings B medium has been most promising for detection of the bacterium. The bacterium could survive in the infected seed up to next cropping season. The flag leaf stage of the crop was found to be most susceptible stage for infection. The bacterium resembled with *Burkholdaria sp. in* magablast analysis.
- A survey conducted exhibited the presence of Bacterial canker in tomato disease in Kumaun region of Uttarakhand during 2015. The bacterium was identified as *Clavibacter michiganensis*

subsp *michiganensis (*Smith) Davis *(Cmm)* on the basis of morphological, physiological, biochemical, serological and molecular characterization. For the detection of the bacterium, the most promising media were Nutrient agar Glucose Yeast Medium (non selective medium) and Specific Clavibacter Medium (semiselective medium).

- Infected samples when collected from different locations in Uttarakhand and Himanchal Pradesh exhibited pathogenic variability in samples collected from different locations. For the molecular characterization the three most virulent isolates when screened by the primer specific for genus *Clavibacter* give an amplicon size of 1.45kb, while by the sub sp specific primer out of three isolates only two isolates that is *Cmm*10, *Cmm* 6 are identified as *Cmm* giving an amplicon of size 614bp. The antagonistic potential of bioagent PBAT-1 gave maximum inhibition (89.5%) of the bacterium. *Cmm* has been found sensitive to Streptomycin sulphate with maximum zone of inhibition (2.33cm). However, defense inducers benzothiodiazole followed by salicyclic acid exhibited significant disease reduction as compared to control.

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3. Thesis Research:

1. Sanjay Kumar. 1991. Studies on seed-borne nature of *Phomopsis vexans,* the cause of fruit rot of brinjal (*Solanum melongena* L.) submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
2. Alok Kumar. 1994. Studies on seed-borne nature

of *Alternaria brassicae* & its effect on seed quality in rapeseed mustard (*Brassica* sp.) submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.

3. Arvinder Kaur.1996. Loose smut of wheat (*Ustilago segatum*): Evidence for Seed-to- Plant transmission and Integrated Disease Management submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
4. Arun Kumar Chaurasia.1998. Storage conditions: Effect on viability vigour & seed health status in hybrid rice submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
5. Rajbir Singh.2000. Studies on seed transmission of *Sarocladium oryzae* and *Fusarium moniliforme* in hybrid rice, and their management through seed treatment submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
6. Vinod Arya.2003. Studies on seedborne nature of charcoal rot of soybean (*Macrophomina phasealina* (Tassi) Gold), its transmission and management through seed treatment submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
7. Neelam Singh Baliyan.2003. Studies on seedborne nature of *Colletotrichum truncatum* (Schu.) andrus and W.D. Moore, the cause of *Anthracnose* of Soybean (*Glyine max* (L.) Merrill) and its management submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
8. Shilpi Chawla.2005. Studies on toxicological and residual effect of dyes on seed treatment in field crops. (wheat and paddy) submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
9. Priyanka Mehta.2011. Screenings of chemicals, botanicals and bioagents against Fusarium oxysporum the cause of Seed rot of Soybean submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
10. Nitika gupta.2011. Bacterial Blight of Soybean: Detection, Transmission and Management of Seed-borne Infection submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
11. Pankaj Kumar.2013. Post harvest storage of wheat (*Triticum astivum*): management of seed quality, longevity and seed health submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
12. Abhishek Gowda H.R.2018. Detection and Management of *Burkholderia glumae* (Kuritaand Tabei) , the cause of panicle blight in Paddy (*Oryzae sativa* L.) submitted for M.Sc. (Ag.) Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
13. Lakshman Prasad.2001. Detection, transmission and longevity of infection of *Alternaria brassicae, Alternaria brassicicola* and disease management in cauliflower seed crop submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
14. Himanshu Negi.2005. Seedborne nature of urdbean leaf crinkle virus, its transmission and management through seed treatment submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
15. Khilendra Singh.2007. *Colletotrichum capsici* (syd.) Butter and isby the cause of anthracnose of chilli: the role of seed borne infection on seed quality parameters and management of disease submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
16. Rashmi Sorari.2007. Detection, transmission and eco -friendly management of early blight of Tomato (*Lysopeersicon esculentum* Mill), caused by *Alternaria solani* (Ell. And Mart) submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
17. Vikaram Singh.2010. Detection of Soybean mosaic virus using PCR based techniques and the losses and management of the disease submitted for Ph.D. Plant Pathology to GBPUAT under

supervision of Dr. K. Vishunavat.

18. Amit Kumar.2010. Morphological and molecular diversity of Sorghum genotypes against grain mould submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
19. Priyanka Mehta.2011. Detection of *Ustilago segatum* var. *tritici* in infected seed by PCR based assay and its management by natural products and biological control agents submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
20. Chandra Prabha Bhandari.2012. Fusarium Ear Rot of Maize*:* Impact on seed health, seed storability & seed production and successive management under field condition submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
21. Kumud Uprati.2013. Post harvest seed storage in maize (zea mays l.): impact on seed quality, longevity and seed health submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
22. Deepa Nainwal.2014. Studies on seed borne aspects of *Alternaria porri* (Ellis) Cifferi, the causal agent of purple blotch of onion, its molecular characterization and disease management submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
23. Deepali Singh.2015. Isolation, Identification and longevity of *Burkholderia glumae* (Kurita and Tabei) urakami *et. al.,* in Paddy *(Oryza sativa* L.) seed , the cause of bacterial panicle blight and the disease management under field conditions submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
24. Ajay Puri.2016. Effect of storage conditions, treatments, and threshing methods on seed quality parameters in Soybean [*Glycine max* (L.) Merrill] submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
25. Meenakshi Dwivedi.2018. Induction of mutation in *Trichoderma* strains for enhancing biocontrol potential and compatibility with fungicides submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.
26. Ruchi Tripathi.2018. Exploration of different methods for detection of clavibacter michiganse pv michiganensis, the cause of bacterial wilt and canker of tomato and its management submitted for Ph.D. Plant Pathology to GBPUAT under supervision of Dr. K. Vishunavat.

4. Future Thrusts:

- Standardizing the Seed Production Technologies for new hybrids through electrophoresis, Biochemical Tests and DNA Finger Printing.
- For long term storage of germplasm, cryopreservation technique need be standardized.
- Attention is needed to workout disease free seed production areas for diseases of economic importance.
- A systematic approach to work out tolerance limits for important seed borne diseases to maintain seed quality and seed health.
- To work out bio-pesticides for management of important seed borne diseases and insect-pests of significance to discourage the indiscriminate use of chemicals for disease management.
- Characterization and monitoring of seed borne viruses in legumes.
- Advanced quick and sensitive molecular techniques are to be standardized for seed health testing and detection of seed borne pathogens of significance keeping in view the SPS issues in the light of the GATT, WTO.
- Under organic seed production, Botanicals and other plant products are to be worked out for management of important seed borne diseases of significance to discourage the indiscriminate use of chemicals for disease management.