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Annual Report

2073/74 (2016/17)

Government of Nepal

Nepal Agricultural Research Council

National Agricultural Research Institute

SEED SCIENCE & TECHNOLOGY DIVISION

Khumaltar, Lalitpur, Nepal

2017

Distinct Characters of Rice genotypes NR11011 with Purple Apiculous Colour

Distinct Character of Rice genotype NR 11011 with Anthocianin Colouration of nodes

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2017

Seed Science & Technology Division (SSTD)
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Office building of Seed Science and Technology Division, Khumaltar

FOREWORD

Seed Science and Technology Division (SSTD) is the central seed division of Nepal Agricultural Research Council (NARC) with aims to provide quality seeds and improving the agricultural production in the country through research, training and technical services especially on problem associated with quality seeds. It is working in collaboration and coordination with research groups, producers, distributing agencies, quality regulators, policy makers and seed users. SSTD has been involved in undertaking problem based research on seed quality in a variety of crop species (field crops, horticultural crops, and forage crops) in different aspect viz., seed production, seed morphology, seed physiology, post-harvest handlings, storage and molecular level for diversity analysis. It also provides the technical supports/ services in sustenance of national seed system using the quality seeds within and outside NARC. Seed Science and Technology Division (SSTD) is the pioneer seed institution of Nepal started with country's first seed testing laboratory in 1962 at Khumaltar, Lalitpur. It still imparts seed quality testing services to the different seed stakeholders.

National crop commodity program have developed and released large number of varieties and subsequently their source seed production is being carried out in different farm and station across the country. SSTD have developed descriptors of different pipeline crop varieties for their identification and maintenance. Different seed invigoration techniques, seed storage techniques etc. were studied during 2072/73 in this division.

I would like to express my sincere gratitude to the Executive Director, Dr. BN Mahato, and Directors, Crops and Horticulture Research, Dr. Y.P. Giri; Planning and Coordination, Dr. Aanand Kumar Gautam; Livestock and Fishery Research, Dr. Tek Bahadur Gurung and Administration, Shree AR Ansari for their guidance and continuous support to this division.

I am thankful to all staffs of SSTD for their untiring hard works and meticulous efforts in accomplishing the research and laboratory work on time. My special thanks goes to Ms. Sangita Kaduwal (S-1) and Gopal Bhandari (T-6) for compiling and presenting this report in this shape.

I am hopeful that the provided information on the activities and achievements on seed and related technologies would be informative and valuable for farmers, researchers and extension personnel. Any comments and suggestions to improve the forth coming publications will be highly appreciated.

Dr. Tara Bahadur Ghimire
Chief and Principal Scientist (S-5)
Seed Science & Technology Division, NARC, Khumaltar

ABBREVIATIONS & ACRONYMS

ABD	Agriculture Botany Division
AGD	Agronomy Division
AMSL	Above mean sea level
BS	Bikram Sambat
CBO	Community Based Organization
CBSP	Community Based Seed Production
CDD	Crop Development Directorate
Cm	Centimeter
CO_2	Carbon dioxide
CS	Certified seed
CSSTD	Central Seed Science & Technology Division
CV	Coefficient of Variation
DADO	District Agriculture Development Office
DAS	Days after sowing
DNA	Deoxyribose Nucleic Acid
DoA	Department of Agriculture
DUS	Distinctness, Uniformity and Stability
E	East
EC	Electrical Conductivity
FAO	Food and Agriculture Organization
FS	Foundation seed
FY	Fiscal Year
g gm	gram
GxE	Genotype x Environment
Ha	Hectare
HI	Harvest Index
HR	Human resource
HRD	Horticulture Research Division
Hrs	Hours
HYV	High Yielding Variety

IS	Improved seed
ISTA	International Seed Testing Association
Kg	Kilogram
KU	Kathmandu University
(L.)	Linnaeus
LSD	Least Significant Difference
m	meter
MAS	Molecular Assisted Selection
Max	Maximum
MC	Moisture content
mg	milligram
Min	Minimum
mm	millimeter
N	Nitrogen/North
Nacl	Sodium Chloride
NA	Not available
NARC	Nepal Agricultural Research Council
NARI	Nepal Agricultural Research Institute
NGO	Non-Government Organization
NMRP	National Maize Research Program
NRRP	National Rice Research Program
NWRP	National Wheat Research Program
No	Number
NR	Nepal Rice
NRs	Nepalese Rupees
NSB	National Seed Board
NSC	National Seed Company
PEG	Poly Ethylene Glycol
PICS	Purdue Improved Crop Storage
PMAMP	Prime Minister Agricultural Modernization Project
RARS	Regional Agricultural Research Station
RCBD	Randomized Complete Block Design
SASA	Scottish Agricultural Seed Association

SEAN	Seed Entrepreneurs Association of Nepal
SN	Serial Number
SQCC	Seed Quality Control Centre
SSR	Single Sequence Repeat
SSTD	Seed Science & Technology Division
t	ton
Temp	Temperature
TU	Tribhuwan University
UPOV	International Union for the Protection of New Varieties of Plants
USAID	United States Agency for International Development
VDCs	Village Development Committees
Viz;	Namely
WB	World bank
WK	Wheat Khumal
Wt	Weight
^0C	Degree Centigrade
@	At the rate of
&	and
%	Percent

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यो बीउ विज्ञान प्रविधि महाशाखाको आ.ब. २०७३/७४ को स्विकृत कार्यक्रम अनुसारको अनुसन्धान प्रतिफल हो । यस आ.ब. मा बीउको गुणस्तर तथा भण्डारको समस्यासँग सम्बन्धित नौ वटा अनुसन्धान परियोजनाहरु खुमलटारको आवहवामा खेत एवं प्रयोगशालामा संचालन गरिएको थियो । अनुसन्धानमा बीउ प्रविधिका विभिन्न पक्षहरु जस्तै बीउ उत्पादन, बीउ बालीको जातिय शुद्धता र बिबिधता, सुरक्षित भण्डारण परिक्षण तथा गुणस्तर प्रवर्धन सम्बन्धि विषयबस्तुमा केन्द्रीत थियो । अनुसन्धान गरिएका बालीहरुमा धान, मकै, गहुँ, जौ, मसुरो, जुट थिए । यि अध्ययनका मुख्य मुख्य नतिजाहरु निम्नानुसार रहेका छन् ।

- ६ वटा धानका १० वटा गहुँका तथा ८ वटा जौका पूर्व सिफारिश उत्कृष्ठ जातहरुको चारित्रिक विवरण तयार पारियो ।
- आठ वटा मसुरोको उपजातहरुको चारित्रिक विवरण तयार पारियो र उपजात कालो मसुरोको बीउको बाहिरी बोक्रो कालो रहेको र आई.एल.एल. ७७२३ मा बीउको बोक्रोमा कुनै धब्बा नरहेको र पातमा हरियोपन कम रहेको पाइयो ।
- जुटको उपजात ओ. ४ लाई सुपरग्रेन ब्यागमा भण्डारण गर्दा बीउको ओजस अन्य जातको भन्दा बढी पाइयो ।
- २० वटा एस.एस.आर. मार्कर मध्ये १३ वटा एस.एस.आर. मार्करले गहुको डि.एन.ए. लेवलमा विभिन्न ब्याण्ड तयार पारेको पाइयो ।
- ३० वटा एसएसआर मार्कर मध्ये १२ वटा एसएसआर मार्करले जुटको डिएनए लेवलमा विभिन्न ब्यान्ड तयार पारेको पाइयो ।
- जियोलाइट बीडको प्रयोगबाट हाईब्रीड गोलभेडा सृजनाको बीउको चिस्यान प्रतिशत २ महिनाको अवधिमा ९ प्रतिशतबाट ६ प्रतिशतमा झरेको पाइयो ।
- असुरो र नीमको पातको झोलमा गहुको बीउ भिजाएर छर्दा गहुको उमार राम्रो भएको पाइयो ।
- तरकारी बालीमा विशेष गरी शुरुको अवस्थामा चुस्ने कीराहरुको प्रकोप बढी भएको पाइयो ।
- नेपालको बीउ व्यवसायीहरुको बीउ प्रशोधन र भण्डारणको अनुगमनको नतिजा अनुसार ३० देखि ४० प्रतिशतसम्म सुधार गर्न सकिने स्थिति भेटियो ।
- बीउ विज्ञान प्रविधि महाशाखाबाट ४१३ वटा बीउका नमूनाहरुको परिक्षण सम्पन्न भयो ।

EXECUTIVE SUMMARY

This is the annual report of Seed Science & Technology Division (SSTD), NARC for the fiscal year 2073/74 (2016/17). There were seven research projects on seed science and technology on problems related to quality seeds and storage carried out in field as well as in the laboratory of SSTD, Khumaltar. The research areas focus were; seed production, genuineness of crop varieties and their morphology, seed storage and seed enhancement techniques. Crops under study were rice, maize, wheat, lentil, barley and jute. Followings were the key findings of these research studies:

- Descriptors of six pre-release varieties of rice , 10 genotypes of wheat and 8 genotypes of barley prepared based on agro-morphological characteristics.
- Descriptors of eight lentil genotypes prepared where black testa was noted in black lentil and seed testa mottling was absent in ILL-7723 with light foliage intensity.
- Out of 20 SSR markers, 13 SSR markers generated banding pattern in wheat genotypes.
- Out of 30 SSR markers, 12 SSR markers generated banding pattern in jute genotypes.
- With the use of Zeolite bead tomato hybrid seed moisture reduced from 9% to 6% within 2 month period.
- Asuro (*Adhatoda vasica*) and neem (*Azadirachta indica*) leaf extract were found promising in wheat seed priming.
- Jute genotype O-4 stored in super grain bag resulted higher vigour index among the studied genotypes
- Most of the sucking insects were found to be infested in the early stage of the vegetable crops that need to be manage in order to get proper plant/crop stand.
- Warehouse survey and monitoring revealed that about 30 to 40% improvement could be done in current status of warehouse or godown which ultimately improve the storability and quality of seed system.
- 413 seed samples were tested and reported to the clients.

1. WORKING CONTEXT

1.1 Basic and Applied Research in Seed Science & Technology

Seed technology is one of the central disciplines in agricultural science which is featured to lead the research and reviews on the problems relating to seed quality, seed physiology, seed production, seed health, harvest, processing, sampling, pre-and post-harvest management. Seed enhancement technology, variety identification, genetic purity evaluation, testing for genuineness of plant variety, development of seed quality assessment procedures, human resource development, and testing are therefore the research areas of the seed division. Seed Science and Technology Division (SSTD) is the leading division under National Agricultural Research Institute (NARI) of Nepal Agricultural Research Council (NARC) based in Khumaltar (1335m amsl; 85°10' E and 27°39' N). It embark on the research works on these disciplines and provides services ensuring the production and supply of quality seeds to farmers in a right place and time and helps in achieving a good harvest.

In the present context of depleting land and increasing population, we have to produce adequate food to address the hungry mouths. It is the established fact that use of quality seed maintains required plant population and uniform maturity leading to improving yield by 15-20 percent with correct use and application of other inputs. Basic and applied researches on sciences relating to seed quality, seed biology, seed management, seed quality enhancement, pre-harvest and post- harvest management, and seed distribution and support in activities related to seed policies and regulations are the areas dealt during the year as core research activities. The division is the principal division for seed in NARC. Consequently it works in collaboration with different institutions/ programs with seed component and involved in improving information about use and supply of quality seeds in the country. Major collaborative institutions are Seed Quality Control Centre (SQCC), Department of Agriculture (DoA), Directorate of Crop Development (CDD), National Seed Company (NSC), SEAN, CEAPRED, private seed companies, universities, seed cooperatives, CBSP groups and farmers.

2. INTRODUCTION

2.1 Introduction and Background

Seed Science and Technology Division (SSTD) is the central division of seed re-established on 2068 BS, which works in close collaboration with the crop improvement and agricultural development programmes. The division undertakes the works and responsibility in two ways: (a) adaptive research on seed technology and (b) seed improvement through seed education, trainings, extensions and seed quality testing services.

Seed Science and Technology Division took its origin as first seed testing laboratory in 1962 under Agronomy Division and it moved to Agriculture Botany Division (ABD) in 1966 under the then Department of Agriculture (DoA). In due course of time, this division adapted different working modalities like Seed Technology and Improvement Program (STIP), Central Seed Science and Technology Division (CSSTD) and Seed Technology and Research. The division has been functioning effectively with fundamental role of bridging between research, extensions and end users of seed through seed monitoring, seed testing, seed technology research and planning and monitoring of source seed production. Seed Science and Technology Division as a central discipline for seed in NARC is therefore authorized to conduct seed research on practical problems and support in strengthening the national seed programs in use and distribution of quality seed. It, therefore, undertakes research on seed technology in a range of crop species on problems related to production, seed quality parameters, storage, physiology; provides seed quality testing services and monitors the quality of source seed produced in research farms and stations under NARC. The prime aim of the division in NARC is to assist the use and production of quality seed through research for agricultural development and work on seed in close association and coordination with different seed stakeholders under National seed system.

2.2 Goal

Promote and develop the national seed system through the use of quality seeds

2.3 Objectives

- To carry out the seed technology research on problems associated with quality seed on seed production, harvesting, post-harvest handlings and storage; seed morphology; seed physiology and seed quality testing
- To develop and standardize seed testing techniques through research support on seed certification system

- To make the seed producers, farmers, institutions and organizations aware of the value of use of quality seeds of improved crop varieties through training, education, quality testing services
- To provide venue of dissemination and exchange of information on seed, availability of source seed, seed related technologies among the seed stakeholders
- To work in close with the stakeholders of seed quality and central seed testing laboratory on regional and national problems on seed through quick researches as and when needed.

2.4 Strategies

During the initial days, the focus of SSTD was the development of procedures for testing the quality of seeds and providing quality testing service and quality information of seed lots to the farmers in the country. In due course with provided emphases, strengths and policies, HYVs of crops introduced, commodity research programs adopted and many international collaborative seed sector development projects implemented and strengthened the seed quality and research program. The program established the seed regulatory instruments to safeguard the use of quality seeds and helped the program in achieving the then agricultural goal.

SSTD's strategy in present context is to support the national seed program and improve the agricultural production through wide use of quality seeds and carry out the research related to seed quality, its production and application. Followings are the relative foci and research approaches (in *Current thrust areas for research*) of SSTD pursuing the above strategy:

- Strengthening national seed program in use of quality seeds
- Carrying out the adaptive research on seed quality and use
- Providing quality testing and information services on use of quality seeds
- Developing and promoting improved seed technologies
- Contributing in collaboration with national and international institutes/ stakeholders in use of quality seeds

2.5 Current thrust areas for research

Seed is a living entity. Its quality is affected by different factors at various stages during production, harvesting, processing and post-harvest handlings. Based on changes in planning of agricultural research and priority paid to research on problems demanded by time, space (location specific) and clients (users group), following areas for research

have been identified and undertakes the research activities associated with quality traits of seed and develop the appropriate technologies.

2.5.1 Seed production technology

Seed production follows a definite sequence of steps and needs constant surveillances and immediate actions when problems arise. Introduction of new varieties like hybrid, inbred, forage varieties; diverse cropping systems, cultivation of a range of crop species with different biology, changing environmental conditions, natural calamities and incidence of diseases/pests and their threats are the areas of research that may create problems in seed production. In such cases, sudden modifications in production technology need to be adopted to achieve the quality and quantity harvest. Besides, seed crop physiology, crop husbandry, the biology of seed maturation, role of minerals and micronutrients are the important aspects in seed production which require intensive research for harvest of quality seeds.

2.5.2 Seed testing technology and seed physiology

Seed testing determines the planting value of seed. Seed testing in general is carried following the methods standardized by International Seed Testing Association (ISTA). However, discrepancies in test results do occur in seed testing. In these circumstances, the division undertakes research and could develop the appropriate testing technology and assist the seed regulation programs with the quality testing techniques and supports in developing the seed and field standards.

2.5.3 Seed morphology and taxonomy

Genetic purity is one of the quality attributes of seed. It is maintained in seed crop by isolation, field inspection in standing crop and by physical purity and pre-and post-control plot tests in the laboratory. It is necessary to undertake the practical researches and develop the distinguishing and identifying characters of each named varieties to reduce and avoid the genetic contamination in field and seed. The division therefore undertakes the genuineness cultivar testing using the conventional field evaluation for agro-morphological characters, biochemical testing and also the molecular testing.

2.5.4 Seed post-harvest, handling and storage technology

Seed as an end product in seed production is a living material which deteriorates in storage and finally dies. It requires careful handling, safe processing and storage environment. Seed processing, drying, seed moisture level, seed treatment, seed storage containers, storage conditions and mechanism of seed dissemination have great effect on seed viability and longevity. The division has the facilities in carrying the research

on these areas and it has also an experience of working in collaboration with the national and international seed technology institutions.

2.5.5 Seed variety identification using DNA finger printing Technology

DNA finger printing and new advances in molecular techniques are the tools that its application in crop research (gene mapping, genotyping, MAS), conservation of biodiversity (duplication/redundancy in gene bank, core collection strategies, diversity analysis) and seed varietal identification has helped breeders, curators and seed analysts. With support of donor programs, a set of resources/facility on these modern techniques has been developed in the division. The division can use these facilities in developing the DNA finger printings of the crop varieties for release and registration process. SSR based DNA finger printing of rice genotypes (national listed varieties, landraces and wild types) is being achieved.

2.6 Infrastructure and facilities

The division has its own two floored office building in Khumaltar and equipped with the seed testing/research and molecular laboratories. It is equipped with the seed quality testing facilities and molecular marker testing at DNA level. It provides seed testing services of all kinds of agricultural, horticultural and forage crop species to farmers, seed producers, seed companies, researchers and provides analyses reports following the rules for testing seeds by ISTA, 2011 and guidelines and norms developed by national seed regulatory body under NSB. Analytical purity test, moisture test, germination test are the general testing services whereas accelerated ageing test of wheat, cold test of maize, tetrazolium test, biochemical test for varietal identification (phenol and potassium iodide-iodine tests) and pre and post field plot tests are the special tests provided by the division. The division has strengthened the molecular testing facilities for carrying out the genuineness test of the crop varieties using DNA molecular markers and these facilities are also used in studying the genetic diversity of agricultural crops specific to landrace diversity. These facilities are listed in annex 2.2.1 and 2.2.2.

The division also provides technical backstopping to SQCC in developing seed testing procedures, seed standards, field standards and minimum quality standards and assists in planning of source seed demand and supply. The division generates database on seed and seed related other matters and coordinate the NARC seed component among the seed stakeholders.

2.7 Organization structure and human resource

Following figure explains the organization structure of SSTD. It explains the working modality and human resources (HRs) strength that is adopted to help in achieving the objectives and strategies of the division. The division has in total 11 staffing including of scientific, technical and the administration, store and finance as HRs strength and details are given in annex 2.3.

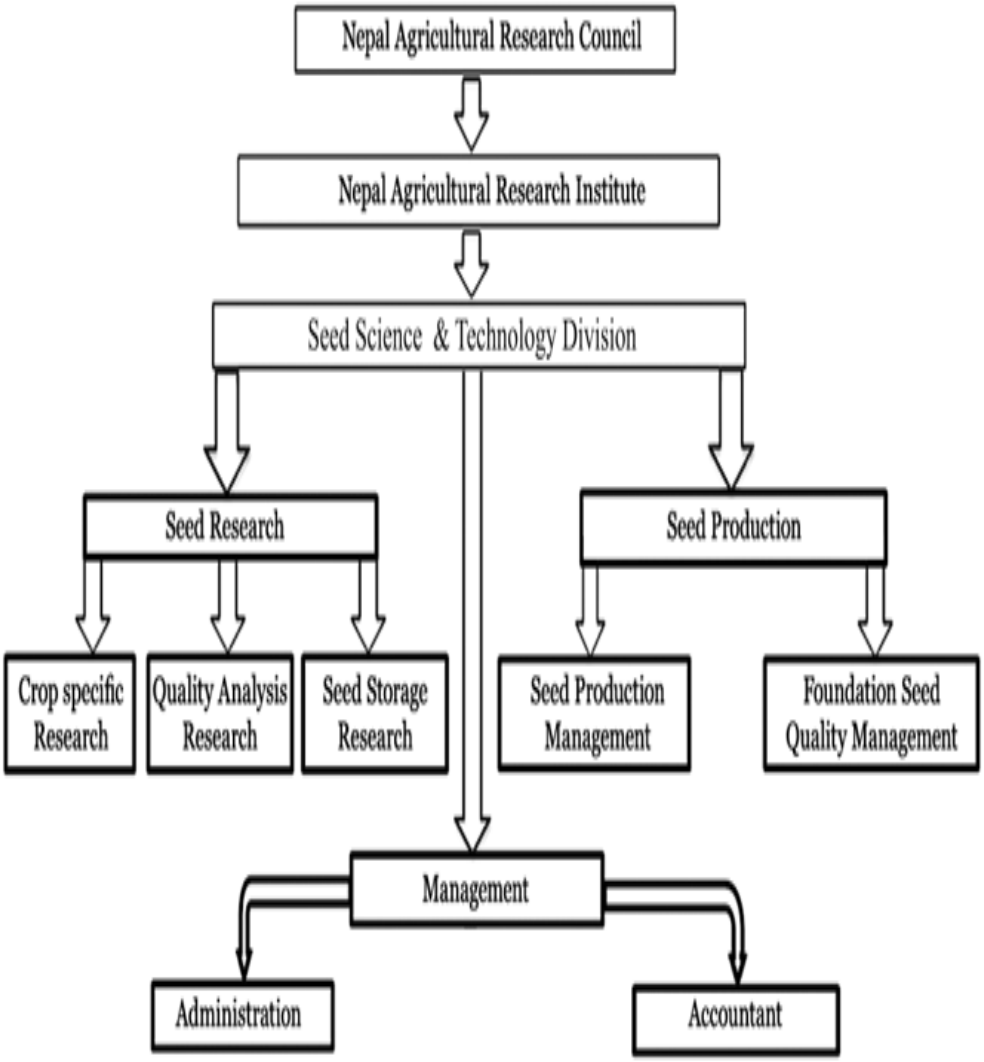


Figure 1. Organogram of SSTD

3. RESEARCH HIGHLIGHTS

3.1 Seed Production Technology

3.1.1 Monitoring of early damaging insect pest to carry out insecticidal seed treatment

Vegetable crops possess high level of pest infestation and likely to have high risk of pesticide application. Vegetables and salad crops are inevitable in every kitchen has high level of pesticides residues. They have been harvested, marketed and consumed just after spraying which fetches carcinogenic and teratogenic and other problems in human-beings. Compared to organophosphate and carbamate insecticides that we are using, neonicotinoids cause less toxicity in birds and mammals and seed treatment with neonicotinoids is immensely good for both seed and seedling insurance and less pesticide hazard (Tomizawa and Casida, 2005).

One of the cheap but magical technologies on pre-harvest early stage sap sucker and foliage insects is the seed treatment by insecticide. Among various insecticides neonicotinoids are regarded as better option as it has low mammalian toxicity, less resistance with high systematic potency. Neonicotinoid seed treatments (imidacloprid and thiamethoxam) are currently used in cowpeas; alternatives to seed treatments and the biological and economic benefits of imidacloprid and thiamethoxam seed treatments compared to other pest control options.

Thus, seed treatment with fungicides along with insecticides need to be accessed and its potency should be known. In order to assess the potency of these insecticides, a preliminary survey was needed to know the level of infestation and damage degree of various insects and crops so that we can use these experiment in the crop which we found infested mostly by the early damaging insect pests in Khumaltar condition.

On station and on farm survey of early damaging insect pests was conducted in various ecological regions from Tarai to hilly regions of Nepal. Seasonal monitoring were done in the insect forecasting station in Dulal Gaun, Kabrepalanchowk. Several observations were also carried out in farmers' field of potential vegetable growers. Various monitoring tools viz; sticky traps, pheromone traps, and visual observation etc. were used to check the prevalence of early damaging insect's pests of various vegetable. Vegetable crops below 50 days age were checked and the infestation rating and damage rating was done by the entomological expert from Entomology Division, Khumaltar, Lalitpur.

The monitoring results revealed that most of the sap sucking insects found to be infested in vegetable crop in early stage (Table 1).

Table 1. Common early damaging insect pests found in different vegetables in Nepal, 2073/74

SN	Insect pests-common name	Insect pest order	Insect type	Infestation rating %	Damage rating %	Crops found infested in early vegetative stage	Monitored Domain
1	Leaf Minor	Diptera	Mining	40	15	Potato	Kabre
2	Leaf Minor	Diptera	Mining	20	5	Pea	Kabre, Chitwan, Khumaltar
3	Flea beetle	Coleoptera	Chewing	30	5	Cabbage, Cauliflower, Broccoli, Okra, Brinjal	Kabre, Chitwan, Khumaltar
4	Whitefly	Homoptera	Sucking	60	20	Tomato under plastic house	Kabre, Chitwan, Khumaltar
5	Aphid	Homoptera	Sucking	30	15	Cowpea, Cole crops, Potato	Kabre, Chitwan, Khumaltar
6	Jassids	Homoptera	Sucking	20	5	Brinjal, Okra	Chitwan
7	White grub	Homoptera	Chewing	10	8	Potato	Kabre
8	Seed Maggot	Diptera	Sucking	20	10	Cowpea	Pokhara

White grubs were found only underground insect pest that incur almost 100% damage to the crop that it infest. Mostly beetles found less damaged pest as compared to other sucking pests like aphid, whitefly, jassids etc. More than 15% damage is regarded as the major damage in crop. So, leaf minor, whitefly and aphids in vegetables were found major insect pest of vegetables.

3.2 Seed Testing Technology and Seed Physiology

3.2.1. Seed vigor enhancing technology development in maize

Maize is the second most important crop after rice in terms of area and production in Nepal. Germination and rapid establishment of seedlings are the critical phases of plant life cycle and successful establishment of plant not only is related to rapid germination and homogeneity of seeds but also is the function of seed ability to rapid germination under stress conditions specially drought stress (Windor *et al*, 2007). Seed vigour enhancement treatments might be able to alleviate the negative effects of drought. The effects of priming treatments on germination of some seed crops has been studied, but relatively little information is available on the invigorating of maize seed under drought stress in Nepal.

The experiment was conducted in Khumaltar farm. Six different priming treatment viz., hydro priming (water priming), cow urine , vermin wash, salt solution, PEG , matrix priming and control seed were used. Maize variety Deuti was used in the experiment. Seeds were soaked in these solution/treatments for 18 hrs and shade dried before sowing. The experiment was conducted in randomized complete block design (RCBD) with three replications in 2 mx1.5 m plot. Crop geometry was 75 x 25 cm and one seeds per hill was sown. Fertilizers was applied @120:60:40 kg N: P_2O_5: K_2O/ha and two split application of nitrogen was done: first at knee height stage (30 DAS) and second at tasseling stage (60 DAS) in the form of urea. Sowing was done in 12th of Jestha, 2073. Weeding, earthing up etc. were performed as per the recommendation and need. Crop was raised on rainfed condition. Five plant were randomly selected and tagged with red thread to record the data. Harvesting was done when the plants had completely senesced with the expression of physiological maturation. Yield attributes , grain yield (ton/ha) and biomass yield (ton/ha) were recorded from net plot.

No significance difference in quantitative traits observed due to continuous rain after crop sowing (Table 2 and 3).

Table 2. Effect of different seed priming treatment on phenology of maize at Khumaltar condition, 2073/74

Treatments	**Days to 50% emergence**	**Early plant stand/plot**	**Plant height (cm)**	**Ear ht (cm)**	**Final plant stand/plot**	**Days to 50% tasseling**	**Days to 50% silking**	**Days to 50% maturity**
Hydro priming	8	11	348	163	11	63	66	108
Vermiwash	5	8	252	118	8	41	65	97
Salt solution	6	14	353	171	13	61	68	103
PEG solution	8	12	357	174	10	63	66	96
Matrix priming	7	13	352	169	13	43	68	61
Control	9	12	342	162	11	64	67	103

Table 3. Effect of different seed priming treatment on yield attributes and grain yield of maize at Khumaltar condition, 2073/74

Treatments	**No of cobs/plant**	**Cob diameter (cm)**	**Cob length(cm)**	**No of kernel row/cob**	**No. of kernels/row**	**No of cobs/plot**	**1000 grain wt (gm)**	**Biomass (tha^{-1})**	**Yield (tha^{-1})**
Hydro priming	2	49.69	20.4	13	37	20	403	86.87	5.49
Vermiwash	1	36.9	14.53	10	27	12	412	56.62	4.41
Salt solution	2	53.02	21.3	13	38	19	415	93.03	6.82
PEG solution	2	49.3	20.4	13	36	14	392	66.91	5.09
Matrix priming	1	49.03	21.73	12	38	15	418	97.71	4.82
Control	2	50.18	21.47	13	38	21	419	87.76	5.76

3.2.2. Effect of seed priming with botanical extracts on seed vigor and growth in wheat

Wheat is the third important cereal crop of Nepal after rice and maize both in area and production. However, average productivity of wheat is very low as compare to developed countries. As a major constraint limiting crop production worldwide, water deficit during germination stage results in a decline or even complete inhibition of seedling emergence and stand establishment. Under drought stress, seed germination and seedling establishment are inhibited due to the drop of water potential, which results in the decline in water uptake (Farooq *et al*., 2009).

It is necessary to alleviate the adverse effects of drought stress for achieving good crop yields. Among various strategies adopted to improve plant drought tolerance, seed priming is thought to be an easily applied, low-cost and effective approach. Seed priming not only improves the speed and uniformity of germination but also stimulates various biochemical changes in the seed, which are vital in breaking dormancy, the mobilisation or hydrolysis of seed reserves, enzyme activation, and the emergence of embryonic tissues (Catav *et al*., 2012).

The experiment was conducted on seed priming with botanical extracts in wheat at Khumaltar during 2073/74 in winter season. Chyakhura variety of wheat was used. Eleven different botanical extracts used in the experiment consisting of Gulmohar, Bitter gourd, Papaya, Dhaturo, Bhui Amala, Neem, Karbir, Asuro, Simali, Soizon leave extracts (1% all) and contol (hydro priming only). The field experiment was carried out in randomized complete block design (RCBD) with three replications. The plot size was of 2×1.5 $m^{\cdot}$ Sowing was carried out in 2nd week of November, 2016. Two seeds per hill was sown maintaining spacing of 25cm ×10cm. Seed rate was applied @120 kg/ha. The fertilizer was applied @120:60:40 Kg N,P_2O_5,K_2O ha^{-1}. Half of the recommended dose of nitrogen and whole P and K was applied as a basal dose and remaining nitrogen (urea) was divided in two splits: first half applied at tillering stage and remaining half at spike initiation stage. Irrigation was managed possibly as per the need till the grain filling stage. Weeding was done twice as per need. The data were taken from the net plot area excluding the boarder rows from each plot from five randomly tagged plants.

There was no significant difference in qualitative and quantitative traits among the different botanical extract treatments under study (Table 4). However taller plant height (104cm) was observed in papaya extract and shorter (90cm) in Asuro. Maximum tillering (17) was observed in hydropriming and minimum (12) in dhaturo and gulmohar treated seeds. Similary maximum head per m^2 (16) was observed in neem and hydro primed seeds. Longest spike (14.04cm) was observed in asuro treated seed and shortest (12.65cm) in gulmohar treated seed. Maximum number of grains per spike (77) was

observed in hydro primed seeds and maximum number of spikelets per spike (23) were observed in bitter gourd treated seeds. Early flowering (135 days) was recorded in karbir and simali extract and late most (137 days) in papaya, bhuiamala, neem and hydro primed seeds. Similarly early maturity (174 days) was observed in Karbir, asuro, soizon primed seed and late most (179 days) in bittergourd, papaya and dhaturo priming. 1000 grain weight was highest (55 gm) in hydro primed and soizon extract and lowest (51 gm) in bhuiamala and karbir. Maximum plant stand was observed in asuro extract followed by neem and soizon. Highest grain yield (6.11 tha^{-1}) was recorded in papaya followed by neem (6.90 tha^{-1}) and lowest in dhaturo treated seeds (2.25 tha^{-1}).

Table 4. Effect of seed priming with botanical extracts on yield and yield attributes of wheat at Khumaltar condition, 2073/74

Treatments	**Plant ht (cm)**	**No of tillers/ m^2**	**No of spike/ m^2**	**Spike length (cm)**	**No of grains/ spike**	**No of spikelets /spike**	**Days to 50% Heading**	**Days to 50% Maturity**	**1000 grain wt(gm)**	**Final pla stand/m^2**	**Biomass (tha^{-1})**	**Yield (tha^{-1})**
Gulmohar	92	12	10	12.65	65	21	134	176	52	34	5.31	3.01
Bittergourd	100	14	10	13.01	73	23	133	179	50	30	7.0	3.43
Papaya	104	16	15	13.17	72	21	134	179	52	38	10.3	6.11
Dhaturo	92	12	8	12.71	68	22	134	179	53	35	4.8	2.25
Bhui amala	93	15	11	12.92	62	21	134	178	56	32	5.52	3.07
Neem	104	15	16	13.46	76	22	133	178	51	42	10.99	6.9
Karbir	91	14	12	12.94	64	21	133	174	56	31	7.0	3.51
Asuro	89	14	13	14.04	70	22	133	174	53	44	11.09	4.61
Simali	100	13	11	12.99	63	21	133	175	52	39	8.61	4.93
Soizon	102	15	13	13.81	71	22	133	174	55	42	9.0	5.22
Control	105	17	16.4	13.54	77	22	133	175	55	40	12.21	5.84
Mean	98	14.42	12.33	13.2	69.18	21.55	133.33	2.46	53.21	37.09	8.34	4.44
P-value	0.16	0.35	0.12	0.62	0.4	0.46	0.87	0.77	0.5	0.69	0.38	0.4
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	7.31	16.27	27.15	6.54	12.19	3.97	1.09	2.45	6.73	27.58	50.35	55.22

3.3 Morphology and Taxonomy

3.3.1 Agro-morphological characteristics study of black lentil of Rasuwa region

Lentil is the main pulse crop in Nepal covering 62% area and 64% production of the total legume with a productivity of 1.11 (MOAD, 2014/15). Lentil is grown in terai, inner terai and mid hills of the country. The cultivation of lentil has been increasing because of its increasing preference for its internal consumption and potential for export market. Black masuro from Rasuwa is highly prestigious and needs to be registers for its commercial cultivation. The identity of genotype is established through characterization of a genotype by using a set of characteristics that are morphological, physiological or biochemical. PRVT set of lentil from GLRP was planted at Khumal farm and different morphological characteristics were recorded. Most of the qualitative traits of plants, leaf, grain varied among the genotypes (Table 5). Light Leaf colour was observed in ILL-7723 while remaining genotypes were medium green. Stem anthocyanin colour was present in all the genotypes except ILL-6467. Leaflet size ranged from small in black masuro, sagun; medium in RL-4, ILL-7164, ILL-8006, ILL-7723 and large in ILL-6467 and ILL-6819. Growth habit was erect in black masuro, ILL-6467, ILL-8006 and semi-erect in RL-4, ILL-6819, ILL-7164, ILL-7723 and Sagun. Testa colour of seed varied from brown in ILL-6467, ILL-6819, ILL-8006 to grey in RL-4, ILL-7164, ILL—7723, Sagun and black in black masuro. Testa mottling was absent in ILL-7723 and present in rest of the genotypes.

Plate 1. Testa mottling absent in ILL-7723

Plate 2. Black testa of black masuro

Table 5. Qualitative traits measured on agro-morphological characterization of lentil under, Khumaltar condition, 2073/74

Variety	Foliage: Intensity of green colour	Stem : Anthocyanin colouration	Leaf: Pubescence	Leaflet: size	Plant: growth habit	Flower: colour of standard	Pod: Anthocyanin colouration	Seed: Testa colour	Seed: Testa mottling	Cotyledon: colour
Black masuro	Medium	Present	Present	Small	Erect	Purple	Absent	Black	Present	Orange
RL-4	Medium	Present	Present	Medium	Semi-erect	Purple	Absent	Grey	Present	Orange
ILL-6467	Medium	Absent	Present	Large	Erect	Purple	Absent	Brown	Present	Orange
ILL-6819	Medium	Present	Present	Large	Semi-erect	Purple	Absent	Brown	Present	Orange
ILL-7164	Medium	Present	Present	Medium	Semi-erect	Purple	Absent	Grey	Present	Orange
ILL-8006	Medium	Present	Present	Medium	Erect	Purple	Absent	Brown	Present	Orange
ILL-7723	Light	Present	Present	Medium	Semi-erect	Purple	Absent	Grey	Absent	Orange
Sagun	Medium	Present	Present	Small	Semi-erect	Purple	Absent	Grey	Present	Orange

A significant variation was observed in most of the quantitative traits except for days to emergence, early plant stand and 1000 grain weight (Table 6). Tall plant height (26.20cm) was observed in ILL-6819 and shorter (17cm) in black masuro. Longest days to flowering (146 days) was taken by black masuro and ILL-7723 and shortest days to flowering (140 days) was taken by RL-4, ILL-6467, ILL-6819 and ILL-7164. Early maturity (146 days) was observed in black masuro which was at par with ILL-7723 (147 days) and late maturity in RL-4, ILL-6467, ILL-6819 and ILL-7164. Maximum number of pods/plant was in ILL-6819 and minimum in variety Sagun. Two seeds per pod was observed in all variety except ILL-7723. Yield performance was poor due to poor plant stand and wilting.

Table 6. Qualitative traits of lentil measured on agro-morphological characterization in lentil under, Khumaltar condition, 2073/74

Variety	Days to 50% emergence	Early plant stand/m^2	Plant ht (cm)	Days to 50% flowering	Days to 50% maturity	Final plant stand/m^2	No of pods/plant	Seeds/ pod	1000 grain yield (gm)
Black masuro	7	29	17d	146^{a}	146^{b}	22^{cd}	11cd	2^{a}	11.95
RL-4	7	26	23.1^{abc}	140^{c}	152^{a}	45^{b}	22abc	2^{a}	12.27
ILL-6467	7	26	22.23^{bc}	140^{c}	152^{a}	40^{b}	26ab	2^{a}	13.02
ILL-6819	7	23	26.2^{a}	140^{c}	152^{a}	70^{a}	34^{a}	2^{a}	13.21
ILL-7164	7	26	24.13^{ab}	140^{c}	152^{a}	36^{bc}	28^{ab}	2^{a}	13.91
ILL-8006	8	25	23.8^{ab}	142^{bc}	150^{ab}	39^{bc}	19^{bcd}	2^{a}	12.84
ILL-7723	8	25	19.9^{cd}	146^{a}	147^{b}	9^{d}	5^{d}	1^{b}	13.2
Sagun	7	28	24.03^{ab}	143^{b}	149^{ab}	35^{bc}	25^{abc}	2a	12.45
Mean	7.3	26.13	22.55	142.21	150.04	37.13	21.13	1.65	12.86
P-value	0.19	0.29	0.01	0	0.04	0	0.01	0.01	0.89
LSD (0.05)	-	-	3.89	2.98	4.18	17.71	13.85	0.22	-
CV(%)	8.91	6.06	9.86	1.2	1.6	27.25	37.44	7.6	13.59

3.3.2 Agro-morphological characteristics study of hill genotypes of rice (*Oryza sativa L.*)

Rice (*Oryza sativa L.*) is consumed by about 3 billion people and is the most common staple food of a large number of people on earth. It is one of the most important cereal crop of Nepal constituting an area of 1.42 million ha with a production of 4.78 million tons and productivity of 3.36 t/ha (MOAD, 2014/15). The uniqueness of a particular variety is to be established by the test called DUS. In Nepal, DUS testing is basic requirement to prepare descriptor for easy understanding of the traits and varietal identification characters by all concerned stakeholders. So attempt was made to characterize six promising rice genotypes (hill set) along with Khumal-4 as reference variety for distinguishing variability in morphological and agronomic traits among the genotypes. The major objective of this study is to develop descriptors of the promising varieties that help the seed producers, crop inspectors and respective commodity breeders in maintaining the genetically pure seed.

Six promising rice genotypes viz. NR11011, NR11105, NR11052, 08FAN10, NR10769 and Khumal-4 in 2073 developed by Agri-Botany Division, NARC along with Khumal-4 as reference variety were taken for agro-morphological characterization. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replication at Seed Science and Technology Division (SSTD), NARC Khumaltar, Lalitpur. Seedling was raised in dry nursery using 50 kg seed ha^{-1}. Seeding was done on 3^{nd} week of Jestha. Transplanting was done on 3^{rd} week of Ashar in 2073 B.S. in puddle field. Chemical fertilizer @ 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1} was used as a basal dose. Two split application of N was done. First half nitrogen was applied at tillering stage and remaining half at booting stage. Individual plot size maintained was 4m*1m with 20 cm*20 cm crop geometry. Data were recorded from the net plot area. Five plants from each net plot were randomly selected and tagged for data recording. Inter culture practices were carried out at different stages of crop as required. The qualitative, quantitative and biochemical traits were recorded according to UPOV guide lines. Additional traits were also studied viz., flag leaf length, flag leaf width, ligule length, culm number, no. of filled grains, no. of hulls, yield per spike, chlorophyll reading, date of booting, heading, flowering and maturity and biomass yield. Alkali digestion was carried out by putting 10 milled complete (unbroken) rice grains in a petri-dish with 1.5% solution of KOH and kept under room temperature of around 25 degree centigrade for about 24 hrs. Aroma was tested by adding 10 ml of 1.7% solution of KOH in 2 gram of decorticated grains where aroma was released within 10 minutes. Endosperm type was detected through three states of expression. Glutinous rice type was stained to reddish purple, non-glutinous to dark blue purple and intermediate type to reddish blue purple. Phenol reaction and intensity was determined by placing hulls from 10 grains

into a petri-dish of 5 cm diameter and adding 5 ml of 1.5% of phenol solution and placing it at room temperature for one day. The colouration of hulls represent the phenol reaction.

Significant variation was observed in qualitative traits (Table 7). Among six genotypes under study, NR11011 sheath colour was green with purple lines while that of remaining genotypes was green. Dark green leaves was present in 08 FAN10, light green in Khumal4 and rest genotypes had medium green leaves. Leaf sheath anthocyanin colouration was medium in NR11011 and absent in other genotypes. Purple auricle and collar coloration was present in NR11011 while other varieties lacked this trait. In NR11011 colored ligule was present and coloured ligule was absent in rest genotypes. Semi-erect flag leaf attitude was noticed at maturity in NR11011 and erect type in all other genotypes. Strong lodging resistance was observed in 08FAN10, moderately strong in Khumal-4, weak in NR11011 and intermediate in NR11105, NR11052 and NR10769. Culm angle was semi-erect in NR11011 and erect in all other genotypes. Strong anothocyanin pigmentation was present in NR11011 while other genotypes had no any coloration. At early stage purple coloured panicle awns was present in NR11011 and NR11052 and straw coloured in remaining genotypes. Awns in panicle was absent in remaining genotypes. Distribution of awn was observed till upper quarter of panicle in NR11011 and only in tips in NR11052. Strong pubescence in lemma was observed in 08FAN10 and NR10769, medium in NR11105 and NR11052, Khumal-4 and absent or very weak in NR11011. Lemma and Palea colour was white in NR11011 and straw coloured in all other genotypes. At late observation awn colour was gold in NR11011 and light gold in remaining genotypes under study. In NR11052 Type 3 type of secondary branching in panicle was present and Type 2 types of branching in rest of the genotypes. Threshability was easy in NR11011, 08FAN10, Khumal-4 and intermediate in rest three genotypes. Leaf senescence was late in NR1105, 08FAN10 and intermediate in NR11011, NR11052, NR10769 and Khumal-4. Purple glume and apiculous was present in NR11011 whereas brown coloured glume and straw colured apiculous in rest of the genotypes. Decorticated grain aroma was strong in 08FAN10, weak in NR11011, NR11052 and absent or very weak in NR1105, NR10769 and Khumal-4.

Table 7. Qualitative characteristics of promising rice genotypes in mid-hill, Khumaltar, 2015/16

Traits	**NR 11011**	**NR 11105**	**NR11052**	**08 FAN10**	**NR 10769**	**Khumal 4**
Coleoptile: Anothocyanin coloration	Absent	Absent	Absent	Absent	Absent	Absent
Basal Leaf Sheath: Sheath colour	Green with purple lines	Green	Green	Green	Green	Green
Leaf: Intensity of green colour	Medium	Medium	Medium	Dark	Medium	Light
Leaf: Anothocyanin colouration	Absent	Absent	Absent	Absent	Absent	Absent
Leaf: Distribution of anthocyanin colouration	Absent	Absent	Absent	Absent	Absent	Absent
Leaf sheath :anthocyanin coloration	Present	Absent	Absent	Absent	Absent	Absent
Leaf sheath: Intensity of anthocynain coloration	Medium	Absent	Absent	Absent	Absent	Absent
Leaf blade: Pubescence of surface	Medium	Medium	Medium	Strong	Medium	Weak
Leaf: Anthocyanin coloration of auricles	Present	Absent	Absent	Absent	Absent	Absent
Auricle colour	Purple	Pale green	Pale green	Pale green	Pale green	Pale green
Leaf: Anthocyanin coloration of collar	Present	Absent	Absent	Absent	Absent	Absent
Collar colour	Purple	Pale green	Pale green	Pale green	Pale green	Pale green
Leaf: shape of ligule	Cleft	Cleft	Cleft	Cleft	Cleft	Cleft
Leaf: color of ligule	Light purple	Colourless	Colourless	Colourless	Colourless	Colourless
Flag leaf angle	Erect	Erect	Erect	Erect	Erect	Erect
Flag leaf: attitude of blade (early observation)	Erect	Erect	Erect	Erect	Erect	Erect
Flag leaf: attitude of blade (late observation)	Semi-erect	Erect	Erect	Erect	Erect	Erect
Lodging resistance	Weak	Intermediate	Intermediate	Strong	Intermediate	Moderately strong
Culm: habit/angle	Semi-erect	Erect	Erect	Erect	Erect	Erect
Male sterility	Absent	Absent	Absent	Absent	Absent	Absent
Lemma: Anthocyanin coloration of keel (early observation)	Absent or very week	Absent or very week	Absent or very week	Absent or very week	Absent or very week	Absent or very week
Lemma: Anthocyanin coloratin of area below apex(early observation)	Absent or very week	Absent or very week	Absent or very week	Absent or very week	Absent or very week	Absent or very week

Traits	NR 11011	NR 11105	NR11052	08 FAN10	NR 10769	Khumal 4
Lemma: Anthocyanin coloration of apex(early observation)	Absent or very week	Absent or very week	Absent or very week	Absent or very week	Absent or very week	Absent or very week
Spikelet: color of stigma	White	White	White	White	White	White
Stem: Anthocyanin coloration of nodes	Present	Absent	Absent	Absent	Absent	Absent
Stem: Intensity of anthocyanin coloration of nodes	Strong	Absent	Absent	Absent	Absent	Absent
Stem: Anthocyanin coloration of internodes	Absent	Absent	Absent	Absent	Absent	Absent
Internode colour	Light gold	Light gold	Light gold	Light gold	Light gold	Light gold
Panicle: awns	Present	Absent	Present	Absent	Absent	Absent
Panicle: colour of awns (early observation)	Purple	Light gold	Light gold	Light gold	Light gold	Light gold
Panicle: Distribution of awns	Upper quarter only	Absent	Tips only	Absent	Absent	Absent
Spikelet: Pubescence of lemma	Absent or very weak	Medium	Medium	Strong	Strong	Medium
Spiklet: Color of tip of lemma	White	Yellowish	Yellowish	Yellowish	Yellowish	Yellowish
Lemma and Palea colour	White	Straw	Straw	Straw	Straw	Straw
Panicle: Colour of awns (late observation)	Gold	Light gold	Light gold	Light gold	Light gold	Light gold
Panicle: Attitude in relation to stem	Slightly drooping	Slightly drooping	Slightly drooping	Slightly drooping	Slightly drooping	Slightly drooping
Panicle: Presence of secondary branching	Present	Present	Present	Present	Present	Present
Lemma and Palea pubescence	Short hairs	Short hairs	Short hairs	Short hairs	Short hairs	Short hairs
Panicle: Type of secondary branching	Type 2	Type 2	Type 3	Type 2	Type 2	Type 2
Threshability	Easy	Intermediate	Intermediate	Easy	Intermediate	Easy
Panicle: Attitude of branches	Semi-erect	Semi-erect	Semi-erect	Semi-erect	Semi-erect	Semi-erect
Shattering	Very low	Very low	Very low	Very low	Very low	Very low
Panicle: Exsertion	Well exerted	Well exerted	Well exerted	Well exerted	Well exerted	Moderately well exerted
Leaf: Time of senescence	Intermediate	Late	Intermediate	Late	Intermediate	Intermediate
Lemma: Colour	Light gold	Light gold	Light gold	Light gold	Light gold	Light gold
Sterile lemma colour	Straw	Straw	Straw	Straw	Straw	Straw
Lemma orientation	Gold	Gold	Gold	Gold	Gold furrows	Gold

Traits	NR 11011	NR 11105	NR11052	08 FAN10	NR 10769	Khumal 4
	furrows	furrows	furrows	furrows		furrows
Lemma: Anthocyanin colouration of keel (late observation)	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak
Lemma: Anthocyanin colouration of area below apex (late observation)	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak
Lemma: Anthocyanin colouration of apex(late observation)	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak	Absent or very weak
Glume: colour	Purple	Brown	Brown	Brown	Brown	Brown
Apiculous colour	Purple	Straw	Straw	Straw	Straw	Straw
Decorticated grain aroma	Weak	Absent or very weak	Weak	Strong	Absent or very weak	Absent or very weak
Intensity of phenol reaction	No reaction	No reaction	No reaction	No reaction	No reaction	No reaction
Lemma: Phenol reaction	Absent	Absent	Absent	Absent	Absent	Absent
Alkali digestion	Not digested	Not digested	Not digested	Not digested	Not digested	Not digested
Endosperm type	No stain	No stain	No stain	No stain	No stain	No stain
Coleoptile: Anthocyanin coloration	Absent	Absent	Absent	Absent	Absent	Absent

Plate 3. Pigmented auricle and ligule in NR 11011 **Plate 4.** NR11011-Semi-erect culm habit

A significant variation was observed for most of the quantitative traits (Table 8 & 9) except leaf width below the flag leaf, flag leaf width, exertion length, glume length. Longest flag leaf length was of NR11052 and shortest of Khumal-4. Ligule length was longest in Khumal-4 and shortest in 08FAN10. Tallest plant height (173cm) was recorded in NR1101 and shortest (159cm) in 08FAN10. Longest panicle length (28.73cm) was of NR10769 and shortest (22.77cm) in NR11105. Grain L/W ration was

maximum (4.16) of 08FAN10 and minimum in NR11052(3.23) which was at par with NR-11011(3.20).

Table 8. Variation in growth and leaves characteristics of rice genotypes evaluated under Khumaltar condition, 2073/74

Genotypes	Leaf length (below the flag leaf) (cm)	Leaf width(Below the flag leaf) (cm)	Flag leaf length (cm)	Flag leaf width (cm)	Ligule length (cm)	Culm length (cm)	Plant height (cm)
NR 11011	57.91^{a}	1.37^{ab}	40.17^{ab}	1.81	2.17^{ab}	148.07^{a}	173.33^{a}
NR 11105	47.95^{bc}	1.17^{c}	33.72^{bc}	1.59	1.69^{c}	136.33^{c}	159.10^{c}
NR11052	52.96^{ab}	1.32^{abc}	44.68^{a}	1.73	2.21^{a}	144.07^{ab}	171.03^{ab}
08 FAN10	40.70^{c}	1.41^{a}	30.53^{bc}	1.72	1.44^{c}	91.87^{d}	159.10^{c}
NR 10769	53.37^{ab}	1.22^{bc}	40.37^{ab}	1.65	1.75^{bc}	139.53^{bc}	168.27^{b}
Khumal 4	58.57^{a}	1.14^{c}	37.18^{abc}	1.61	2.29^{a}	144.00^{ab}	171.13^{ab}
Mean	51.91	1.27	37.78	1.69	1.93	133.98	159.92
P-value	0	0.04	0	0.13	0.01	0	0
LSD(0.05)	7.52	0.18	7.93	-	0.44	5.04	4.3
CV(%)	7.96	7.82	11.54	5.81	12.6	3	1.48

Table 9. Variation in grains characteristics of rice genotypes evaluated under Khumaltar condition, 2073/74

Genotypes	Decorticated grain length (cm)	Decorticated grain width (mm)	Decorticated grain depth (mm)	Glume length (mm)	Grain length (mm)	Grain width (mm)	Grain L/W
NR 11011	6.14^{cd}	2.46^{a}	1.81^{b}	2.47	8.78^{bc}	2.75^{a}	3.20^{e}
NR 11105	6.32^{c}	2.33^{bc}	1.79^{b}	2.48	8.70^{c}	2.57^{b}	3.39^{d}
NR11052	6.06^{cd}	2.35^{b}	1.77^{b}	2.49	8.41^{c}	2.61^{b}	3.23^{e}
08 FAN10	7.31^{a}	2.19^{de}	1.94^{a}	2.71	9.63^{a}	2.32^{c}	4.16^{a}
NR 10769	6.81^{b}	2.24^{cd}	1.77^{b}	2.37	9.13^{b}	2.39^{c}	3.82^{b}
Khumal 4	5.81d	2.10^{e}	1.65^{c}	2.33	8.50^{c}	2.35^{c}	3.62^{c}
Mean	6.41	2.28	1.78	2.47	8.86	2.5	3.57
P-value	0	0	0.01	0.14	0	0	0
LSD(0.05)	0.34	0.09	0.11	-	0.4	0.13	0.15
CV(%)	2.92	2.26	3.48	6.33	2.52	2.9	2.36

No significant difference was observed in no. of hulls, 1000 grain weight, biomass yield and harvest index (Table 10). Highest number of effective tillers (12) was observed in NR11105 which was at par with Khumal-4 (11) and lowest (9) in NR11011 and 08FAN10. Maximum filled grain was observed in NR11052 (194) which was at par with NR11011 (189), NR11101 (162) and Khumal-4 (192) and minimum (106) in 08FAN10. Likewise in phenological traits early heading (69 days) was observed in 08FAN10 which was at par with Khumal-4 and late heading (82 days) in NR11011 which was also at par with NR11052 (78 days). Similarly, early flowering (71 days) was observed in 08

FAN10 late most flowering (85 DAS) in NR11011 and NR11052. Shortest days to maturity was taken by 08FAN10 (116 days) which was also at par with NR10769 (118 days) and NR11105 (120 days) and late most maturity was noted in NR11011 (132 days). No significance difference in biomass and grain yield and harvest index was observed however maximum yield (5.64 t ha^{-1}) was obtained in NR11105 and NR11052 and minimum (3.6 tha^{-1}) in 08FAN10. Among the studied genotypes, highest (0.4) harvest index was of NR11052 and 08FAN and lowest (0.31) in NR10769.

Table 10. Yield and yield attributes of rice in agro-morphological characterization under Khumaltar condition, 2073/7

Genotypes	Culm diameter (cm)	Culm number/ hill	Filled grain/ panicle	No of hulls/ panicle	1000 grain weight (gm)	Days to 50% heading	Biomass (tha^{-1})	Yield (tha^{-1})	Harvest index (HI)
NR 11011	5.59^{a}	9^{b}	189^{a}	27	25.86	82^{a}	8.4	5.04	0.38
NR 11105	5.09^{bc}	12^{a}	162^{a}	32	22.59	72^{bc}	7.13	5.64	0.39
NR11052	5.54^{ab}	10^{ab}	194^{a}	42	23.57	78^{a}	10.83	5.64	0.4
08 FAN10	4.93^{c}	9^{b}	106^{b}	30	22.38	69^{c}	5.43	3.6	0.4
NR 10769	5.22^{abc}	10^{ab}	151^{ab}	29	22.21	70^{bc}	9.9	4.5	0.31
Khumal 4	5.13^{bc}	11^{a}	192^{a}	33	22.5	69^{c}	6.73	4.18	0.39
Mean	5.25	10.42	165.83	31.9	23.85	73.94	8.07	4.58	0.38
P-value	0.05	0.03	0.03	0.73	0.83	0	0.07	0.1	0.22
LSD(0.05)	0.46	1.78	54.08	-	-	3.82	-	-	-
CV(%)	4.84	9.48	18.15	38.07	15.5	2.84	26.03	16.57	12.66

3.3.3. Agro-morphological characteristics study of wheat genotypes

Wheat is third major food crop of Nepal next to rice and maize that contributes significant role in the agricultural system of Nepal. Agro-morphological characterization of crop varieties as a series of works has been carried and the descriptors of the pipeline varieties of wheat made available to support in variety registration/released process.

An agro-morphological characterization experiment was conducted consisting of ten promising genotypes of wheat in field condition at Khumaltar during 2073/74 in winter season. Ten promising lines were WK-1712, WK-2225, Chyakhura, WK-2123, WK-2278, WK-2286, WK-2370, WK-2414 and WK-2422. One popular check variety WK-1204 was also included in the study. The study was carried out in randomized complete block design (RCBD) with three replications. The plot size was of 4×1 m. Seed rate was applied @120 kg ha^{-1}. The fertilizer was applied @80:40:40 Kg $N_2O_5K_2O$ ha^{-1}. Half of the recommended dose of N was applied as a basal dose and whole P_2O_5 and K_2O was applied as a basal dose remaining half of N was divided in two split first half was applied at tillering stage and remaining half at booting stage. Irrigation was managed possibly as per the need till the grain filling stage. The data were taken from the net plot area excluding the boarder rows from each plot from five randomly tagged plants.

A significant variation was observed for most of the qualitative traits (Table 11 and 12). Coloeptile anthocyanin colouration was absent or very weak in WK-1712, WK-2370, medium in WK-2225, WK-2286, WK-2414 and strongly present in remaining genotypes. Plant growth habit was of prostrate type in WK-2225, Chyakhura, WK-2286 and semi-prostrate in rest of the genotypes. Foliage colour varied from green in WK-2225, Chyakhura, WK-2370, WK-2414, WK-2422 to dark green in WK-1712, WK-2123, WK-2278, WK-2286 and WK-1204. Auricle colouration of flag leaf also varied from absent or very weak in WK-2225, WK-2370 to strong in Chyakhura to very strong in WK-2278 and medium rest genotypes under study. Flag leaf hair on auricle was strongly present in WK-2225, Chyakhura, WK-2278, WK-2286, WK-2370, WK-2414, WK-1204 medium in WK-2123, WK-2422 and absent in WK-1712. Plants with recurved flag leaves were very high in WK-2422, WK-2370, high in Chyakhura,WK-2414, medium in WK-1712,WK-2286,WK-1204 absent or very low in WK-2225, WK-2278 and low in WK-2123.Sheath glaucosity was strongly present in all the genotypes except WK-2225. Similarly ear glaucosity very strongly present in awnless genotype WK-1712, strongly present in Chyakhura, WK-2123, WK-2278,WK-2286, WK-2370, WK-2414, WK-2422, WK-1204 and medium in WK-2225. Glaucosity of culm was very strongly present in all the studied genotypes except WK-2225 where medium glaucosity was present. Straw pith in cross section was thin in WK-1712 and WK-2370 and medium in remaining genotypes. Long tip scur was present in WK-2123, WK-2278, WK-2286, WK-1204 and short tip in remaining genotypes. Short awn tip was observed in WK-1712, medium in WK-2278 and long in remaining genotypes. WK-1712 was awnless, medium spreading attitude of awn was observed in WK-2225, WK-2370, fully spreading types attitude of awn was seen in rest of the genotypes. Anther colour also differed among genotypes. It was purple coloured in WK-2225, WK-2278 and white in WK-1712, Chyakhura, WK-2123, WK-2278, WK-2286, WK-2370,WK-2414, WK-2422 and WK-1204. Erect flag leaf was noted in WK-1712, WK-2278, WK-2422, droopy in Chykhura and semi-erect in rest genotypes. Spike attitude at the time of maturity was bent in WK-1712, WK-2225,WK-2123, WK-2370, WK-2414, WK-2422, crooked in Chykhura and straight in WK-2278,WK-2286 and WK-1204

Plate 5. WK-1712 awnless with very strong waxiness

Plate 6. Chyakhura with droopy flag leaf attitude

Table 11. Different qualitative characteristics of promising wheat genotypes measured in agromorphological characterization at Khumaltar condition, 2073/074.

Genotype	Coleoptile anthocyanin colouration	Plant growth habit	Foliage colour	Flag leaf anthocyanin colouration of auricles	Flag leaf hair on auricle	Frequency of plant with recurved flag leaf	Glaucosity of sheath	Waxiness of sheath	Ear glaucosity	Culm glaucosity	Straw pith in cross section
WK-1712	Absent or very weak	Semi-prostrate	Dark green	Medium	Absent	Medium	Very strong	Very strong	Very strong	Very strong	Thin
WK-2225	Medium	Prostrate	Green	Absent or very weak	Strong	Absent or very low	Strong	Strong	Medium	Medium	Medium
Chyakhura	Strong	Prostrate	Green	Strong	Strong	High	Very strong	Very strong	Strong	Very strong	Medium
WK-2123	Strong	Semi-prostrate	Dark green	Medium	Medium	Low	Very strong	Very strong	Strong	Very strong	Medium
WK-2278	Strong	Semi-erect	Dark green	Very strong	Strong	Absent or very low	Very strong	Very strong	Strong	Very strong	Medium
WK-2286	Medium	Prostrate	Dark green	Medium	Strong	Medium	Very strong	Very strong	Strong	Very strong	Medium
WK-2370	Absent or very weak	Semi-prostrate	Green	Absent or very weak	Strong	Very high	Very strong	Very strong	Strong	Very strong	Thin
WK-2414	Medium	Semi-prostrate	Green	Medium	Strong	High	Very strong	Very strong	Strong	Very strong	Medium
WK-2422	Strong	Semi-erect	Green	Medium	Medium	Very high	Very strong	Very strong	Strong	Very strong	Medium
WK-1204	Strong	Semi-prostrate	Dark green	Medium	Strong	Medium	Very strong	Very strong	Strong	Very strong	Medium

Table 12. Different qualitative characteristics of promising wheat genotypes measured in agromorphological characterization at Khumaltar condition, 2073/074.

Genotype	Ear shape in profile	Awns or scurs presence	Scurs	Awn at tip of ear	Awn colour	Awn attitude	Anther flower colour	Flag leaf attitude	Disease incidence	Ear colour	Spike attitude at the time of maturity
WK-1712	Tapering	Scurs	Short tip	-	Awnless	Awnless	White	Erect		Coloured	Bent
WK-2225	Tapering	Both present	Short tip	Long	Light brown	Medium	Purple	Semi-erect		Coloured	Bent
Chyakhura	Tapering	Both present	Short tip	Long	Light brown	Spreading	White	Droopy	Loose smut	Coloured	Crooked
WK-2123	Tapering	Both present	Long tip	Long	Light brown	Spreading	White	Semi-erect		Coloured	Bent
WK-2278	Tapering	Awns present	Long tip	Medium	Light brown	Spreading	Purple	Erect		Coloured	Straight
WK-2286	Tapering	Both present	Long tip	Long	Light brown	Spreading	White	Semi-erect	Yellow rust	Coloured	Straight
WK-2370	Parallel sided	Both present	Short tip	Long	Light brown	Medium	White	Semi-erect		Coloured	Bent
WK-2414	Tapering	Both present	Short tip	Long	Light brown	Spreading	White	Semi-erect	Yellow rust	Coloured	Bent
WK-2422	Tapering	Both present	Short tip	Long	Light brown	Spreading	White	Erect		Coloured	Bent
WK-1204	Parallel sided	Both present	Long tip	Long	Light brown	Spreading	White	Semi-erect		Coloured	Straight

A significant variation was observed for most of the quantitative traits except for flag leaf length, culm no, maturity, sterility% and biomass yield (Table 13 and 14). Taller plant height (131cm) was observed in WK-2225 and shorter in WK-2123 (87 cm). Longest flag leaf length (22.05 cm) was observed in Chyakhura and broadest (1.85 cm) in WK-1712 whereas it was shortest (15.03 cm) in WK-2286. Early heading (124 days) was in WK-2422 and late (142 days) in WK-2370. Similarly, early booting (109 days) was in WK-1712 and late (114 days) in WK-2286 and WK-2370. Shortest days to flowering (132 days) was taken by WK-2422 and longest days (147 days) was taken by WK-2370. Peduncle length ranged from 21.63cm (WK-2278) to 10.20 cm in (WK-2123). Longest spike length was observed in Chyakhura (12.24 cm) with maximum no of grains (70) whereas least grain number (44) were observed in WK-2414. Thousand grain weight was maximum (55.23 gm) in WK-2422 and minimum (43.30 gm) in WK-2278. Highest grain yield (4.19 t ha^{-1}) was recorded in WK-2286 and lowest in Chyakhura (2.12 t ha^{-1}).

Table 13. Different quantitative characteristics of promising wheat genotypes at Khumaltar, 2073/074

Variety	Plant ht (cm)	Flag leaf length (cm)	Flag leaf width (cm)	Culm no/hill	Days to 50% heading	Days to 50% booting	Days to 50% maturity
WK-1712	108.13^{b}	15.82	1.85^{a}	12	126^{cd}	109^{e}	170^{ab}
WK-2225	131.33^{a}	15.69	1.55^{bc}	14	131^{bcd}	110^{cde}	173^{ab}
Chyakhura	94.20^{cd}	18.34	1.77^{ab}	14	130^{bcd}	112^{abc}	177^{a}
WK-2123	86.80^{d}	17.35	1.79^{ab}	15	132^{bc}	110^{bcde}	177^{a}
WK-2278	127.00^{a}	16.47	1.43^{c}	12	130^{bcd}	109^{de}	174^{ab}
WK-2286	95.93^{cd}	15.03	1.76^{ab}	13	134^{bc}	114^{a}	176^{ab}
WK-2370	99.67^{bc}	22.05	1.79^{ab}	12	142^{a}	114^{a}	166^{b}
WK-2414	101.87^{bc}	17.02	1.43^{c}	13	136^{ab}	112^{abcd}	176^{ab}
WK-2422	92.73^{cd}	15.74	1.71^{ab}	13	124^{d}	110^{bcde}	171^{ab}
WK-1204	93.87^{cd}	17.57	1.75^{ab}	14	136^{ab}	113^{ab}	171^{ab}
Mean	103.13	17.11	1.68	14.5	132.07	111.1	178^{a}
P-value	0	0.13	0.03	0.7	0.01	0	0.35
LSD(0.05)	11.97	-	0.28	-	8.22	2.71	-
CV(%)	6.76	15.1	9.62	14.5	3.63	1.42	3.49

Table 14. Different quantitative characteristics of promising wheat genotypes at Khumaltar, 2073/074

Variety	Peduncle length (cm)	Spike length (cm)	Sterility%	No of grains/spike	1000 grain wt (gm)	Biomass (tha^{-1})
WK-1712	13.77^{bc}	10.17^{e}	5.57	47^{cd}	53.99^{ab}	5.47^{ab}
WK-2225	17.33^{ab}	12.40^{abc}	6.22	48^{bcd}	46.56^{cd}e	5.80^{ab}
Chyakhura	16.23^{abc}	12.94^{a}	4.94	70^{a}	47.71^{bcde}	3.23^{c}
WK-2123	10.20^{c}	11.57^{bcd}	6.59	57^{bcd}	44.16^{de}	5.40^{ab}
WK-2278	21.63^{a}	10.59^{de}	6.95	48^{bcd}	43.30^{e}	6.07^{a}
WK-2286	12.23^{bc}	11.29^{cde}	9.42	50^{bcd}	52.19^{ab}c	5.90^{a}
WK-2370	14.13^{bc}	12.55^{ab}	9.22	57^{bcd}	46.09^{cde}	5.19^{ab}
WK-2414	17.60^{ab}	11.67^{bcd}	7.69	44^{d}	49.26^{abcde}	5.16^{ab}
WK-2422	15.57abc	10.98^{de}	6.18	45^{cd}	55.23^{a}	4.00^{bc}
WK-1204	11.47bc	11.21^{cde}	8.34	60^{ab}	50.68^{abcd}	5.71^{ab}
Mean	15.02	11.54	7.11	52.29	48.92	5.19
P-value	0.04	0	0.71	0	0.02	0.1
LSD(0.05)	6.87	1.25	-	12.86	6.91	-
CV(%)	26.69	6.33	44.63	14.33	48.92	21.31

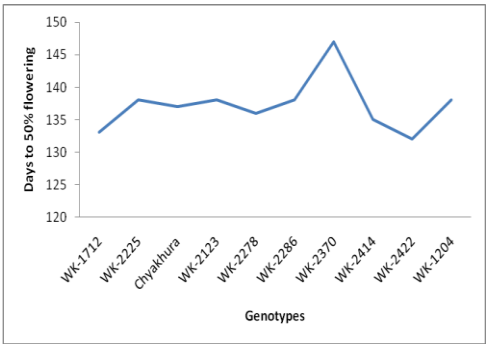


Figure 2. Yield of wheat evaluated in DUS test

3.3.4. Agro-morphological characteristics study of barley genotypes

Barley (*Hordeum vulgare L.*) is one of the old and an important winter cereal crop for the people living in high mountain areas of Nepal. It covers an area of 28053 ha with a productivity of 1.33 tha^{-1} (MOAD, 2014/15). Barley is cultivated in a wide range of environments in Nepal (Baniya et al., 1997). Barley is the second cereal crop to rice in Jumla. Although, the acreage of barley in Nepal is limited, it is very important crop in remote and food deficit areas. Many local landraces perform well in Mustang and Rasuwa and their seed production and maintenance technology is delivered to local community. These landraces needs to be registered for commercial seed production.

Therefore, an agro-morphological characterization experiment was conducted in field condition at Khumaltar during 2073/74 in winter season consisting of eight promising genotypes viz., NB-1003-37/1034, Xveola-45, NB-1003-37/903, Xveola-38, Local uwa, Local jau, Marpha uwa and Marpha Jau. One popular check variety Solu uwa was also included in the study. The study was carried out in randomized complete block design (RCBD) with three replication. The plot size was of 1.8×5m. Seed were soaked in water for 19 hr before sowing. Sowing was carried out on 5 th November, 2016. Two seeds per hill was sown maintaining a space of 30cm ×10cm. The fertilizer was applied @30:20:10 Kg $NP_2O_5K_2O$ ha^{-1} all as a basal dose. Seed rate was applied @100 kg/ha. Irrigation was applied possibly as per need at the regular interval till the grain filling stage. Weeding was done twice as per need. The data were taken from the net plot area excluding the boarder rows from each plot from five randomly tagged plants.

Qualitative traits varied among the studied genotypes (Table 15). Growth habit was erect in NB-1003-37/1034, Xveola-38, Local jau and semi-prostrate in remaining genotypes. Stem pigmentation was present in all the genotypes except NB-1003-37/903. Flag leaf attitude varied from erect in NB-1003-37/1034, Solu uwa, Local uwa, Local jau to semi-erect in NB-1003-37/903, Xveola-38 and drooping in Xveola-45 , Marpha Jau. Spike colour was dark green in Local uwa, pale green in Local jau and green in remaining genotypes. Spike attitude was semi-erect in Local jau, Marpha Jau and erect in remaining genotypes. Smooth awns were observed in Xveola-45, NB-1003-37/903, Xveola-38, Local jau and rough awns in NB-1003-37/1034, Solu awa, Local uwa and Marpha Jau. Spike density was dense in Xveola-45, Solu uwa, Local jau and intermediate in rest of the genotypes. White grain colour was noted in NB-1003-37/1034, Xveola-38 and yellow in remaining genotypes. Grain shape varied from oval in Xveola-38 to oblong in rest of the genotypes under study. Narrow grain crease width was observed in NB-1003-37/903, Solu uwa, Local uwa, Marpha Jau and intermediate in NB-1003-37/1034, Xveola-45, Xveola-38 and Local jau. Poor crop stand was seen in Marpha jau.

Plate 7. Pale green spike colour of Local jau

Plate 8. Drooping flag leaf attitude of Xveol-45

Table 15. Different qualitative parameters of barley measured in agro-morphological characterization at Khumaltar condition, 2073/74

Traits	**NB-1003-37/1034**	**Xveola-45**	**NB-1003-37/903**	**Xveola-38**	**Solu uwa**	**Local uwa**	**Local jau**	**Marpha Jau**
Growth habit	Erect	Semi-prostrate	Semi-prostrate	Erect	Semi-prostrate	Semi-prostrate	Erect	Semi-prostrate
Stem pigmentation	Present	Present	Absent	Present	Present	Present	Present	Present
Auricle pigmentation	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Upper node pigmentation	Present	Present	Present	Present	Present	Present	Present	Present
Flag leaf attitude	Erect	Drooping	Semi-erect	Semi-erect	Erect	Erect	Erect	Drooping
Flag leaf waxiness	Present	Present	Present	Present	Present	Present	Present	Present
Spike type	Six row	Six-row	Six row	Six row	Six row	Six row	Six row	Six row
Spike waxiness	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Spike colour	Green	Green	Green	Green	Green	Dark green	Pale green	Green
Spike attitude	Erect	Erect	Erect	Erect	Erect	Erect	Semi-erect	Semi-erect
Awn roughness	Rough	Smooth	Smooth	Smooth	Rough	Rough	Smooth	Rough
Awn tip pigmentation	Present	Present	Present	Present	Present	Present	Absent	Present
Spike basal sterility	Present	Present	Present	Present	Present	Present	Present	Present
Lemma pigmentation	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Awns present	Present	Present	Present	Present	Present	Present	Present	Present
Spike density	Intermediate	Dense	Intermediate	Intermediate	Dense	Intermediate	Dense	Intermediate
Grain hullness	Covered	Covered	Covered	Covered	Covered	Covered	Covered	Covered
Grain colour	White	Yellow	Yellow	White	Yellow	Yellow	Yellow	Yellow
Grain shape	Oblong	Oblong	Oblong	Oval	Oblong	Oblonh	Oval	Oval
Grain surface	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Rachilla hairs	Rudimentary	Rudimentary	Rudimentary	Rudimentary	Rudimentary	Rudimnetary	Rudimentary	Rudimentary
Grain crease width	Intermediate	Intermediate	Narrow	Intermediate	Narrow	Narrow	Intermediate	Narrow
Awn type	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Type	6 row haulled	6 row hauled	6 row hauled	6 row hauled	6 row haulled	6 row haulled	6 row haulled	6 row hauled
Appearance	Good	Good	Good	Good	Good	Good	Good	Poor

A significant difference was observed in all the quantitative traits under study (Table 16 and 17). Tallest plant height (108cm) was recorded in Local jau which was at par with Xveola-38 (105cm), Xveola-45 (105cm) and shortest in genotype Marpha Jau (78cm). Maximum tiillering was observed in Marpha Jau (34) and in rest of the genotypes tillering was observed at par with each other. Peduncle length ranged from 16.93 cm in NB-1003-37/903 which was at par with Xveola-38 to 6.87 cm in Marpha Jau. Longest flag leaf length was of Xveola-38. Awn length also varied from 9.67 cm in Xveola-38 to 3.76 cm in Local jau. Longest flag leaf length (16.71 cm) was in Xveola-38 and shortest (10.11cm) in Marpha Jau where as broadest flag leaf (1.75 cm) in Marpha Jau and

narrow (1.28cm) in Xveola-45. Spikes per square meter was maximum (20) in Xveola-38 and minimum(14) in Local jau which was at par with local uwa and NB-1003-37/903. Spike length (8.97cm) was longest in Xveola-45 and shortest in Local jau (6.39cm). Shortest days to heading (114 days) was taken by Solu uwa and Local uwa and longest days to heading was taken by Local jau (121 days). Similarly early flowering (113 days) was observed in Xveola-38 and late flowering (131 days) in Local jau and Marpha Jau. Early maturity was in Solu uwa (151 days) which was at par with Local uwa (152 days) and late maturity (163 days) was observed in Xveola-38. Highest grain yield (3.8 tha^{-1}) was recorded in Xveola 45 and lowest yield (2.62 tha^{-1}) was recorded in Solu uwa.

Table 16. Different quantitative traits of barley measured in agro-morphological characterization at Khumaltar condition, 2073/74

Variety	No of tiller/m^2	Peduncle length (cm)	Flag leaf length (cm)	Flag leaf breadth (cm)	No of spike/m^2	Spike length (cm)	Awn length (cm)
NB-1003-37/1034	18^{b}	11.47^{c}	12.27^{bc}	1.46^{a}	18^{ab}	8.35^{abc}	7.03^{d}
Xveola-45	20^{b}	18.87^{a}	12.86^{abc}	1.28^{a}	19^{ab}	8.97^{a}	7.63^{cd}
NB-1003-37/903	15^{b}	16.93^{ab}	14.65^{ab}	1.49^{a}	14^{b}	8.81^{ab}	8.25^{bc}
Xveola-38	22^{b}	16.53^{ab}	16.71^{a}	1.41^{a}	20^{ab}	7.95^{bc}	9.67^{a}
Solu uwa	19^{b}	15.33^{b}	13.58^{abc}	1.49^{a}	17^{ab}	7.90^{bc}	7.89^{cd}
Local uwa	16^{b}	16.33^{b}	14.35^{ab}	1.53^{a}	15^{b}	8.32^{abc}	8.73^{abc}
Local jau	15^{b}	12.73^{c}	12.79^{abc}	1.53^{a}	14^{b}	6.39^{d}	3.76^{e}
Marpha Jau	34^{a}	6.87^{d}	10.11^{c}	1.75^{a}	25^{a}	7.85^{c}	9.32^{ab}
Mean	17.49	12.79	11.92	1.33	15.76	7.17	6.93
P-value	0	0	0	0	0.01	0	0
LSD(0.05)	11.37	2.44	4.1	0.52	9.85	0.92	1.12
CV(%)	37.55	11.04	19.88	22.57	36.11	7.43	9.38

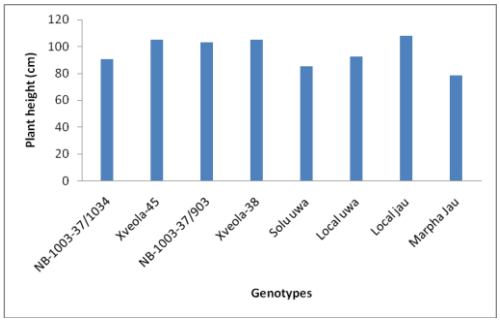


Fig 3. Plant height of barley evaluated in DUS test

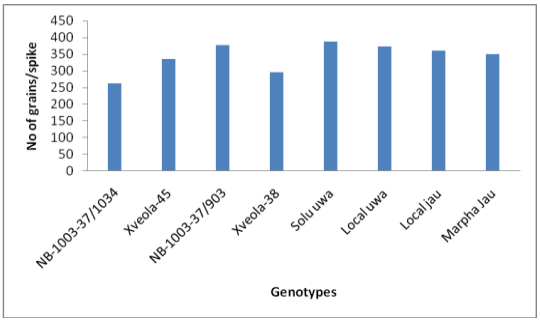


Fig 4. No of grains/spike of barley evaluated in DUS test

Table 17. Different quantitative traits of barley measured in agro-morphological characterization at Khumaltar condition, 2073/74

Variety	Days to 50% maturity	Seed length (mm)	1000 grain wt (gm)	Sterility%	Biomass (tha^{-1})	Grain yield (tha^{-1})
NB-1003-37/1034	159[a]	6.19[d]	36.97[b]	10.89[ab]	6.17	2.88[a]
Xveola-45	161[a]	6.58[cd]	49.28[a]	13.82[a]	4.93	3.80[a]
NB-1003-37/903	159[a]	7.2[ab]	47.84[a]	8.53[bc]	7.44	3.79[a]
Xveola-38	163[a]	7.34[a]	51.75[a]	8.73[bc]	6.46	3.79[a]
Solu uwa	151[b]	6.83[bc]	34.71[b]	6.48[bcd]	4.9	2.62[a]
Local uwa	152[b]	6.95[abc]	36.49[b]	4.64[cde]	4.49	3.03[a]
Local jau	158[a]	7.04[ab]	50.91[a]	6.57[bcd]	5.56	3.66[a]
Marpha Jau	160[a]	7.34[a]	49.72[a]	2.35de	5.5	0.82[b]
Mean	141	6.16	39.74	6.89	5.3	2.71
P-value	0	0	0	0	0.87	0
LSD(0.05)	5.5	0.42	7.1	4.98	6.51	1.25
CV(%)	2.26	3.96	10.33	41.73	71.04	26.61

3.4 Seed Post Harvest Handling and Storage Technology

3.4.1 Seed quality assessment of various jute seed collected from Eastern regions of Nepal

Jute is one of the important commercial/cash crops cultivated in few eastern terai districts. Jute is mainly cultivated for fibre purpose thus it has been found that little attention is given to its seed production. The seed crop remains almost uncared for a long period. The seed crop is affected by diseases and insects and produces poor quality seed which is of low germination and vigour. The various physiological attributes either drought, environmental stress, or even due to prolonged dormancy jute seed viability deterirate fast. Thus various seed storage techniques evaluated for the safe storage of seed.

Five genotypes KEN- BL-130, JRO-524, O-4, KEN-DS-058 and KEN-DS-66 were stored in different hermetic bags viz., super grain bag, PICS bag and muslin cloth for 12 months at Jute Research Program Itahari and seed quality tested following ISTA rules at SSTD lab. Their initial and final quality parameters were measured. There was significant difference among the different treatment in quality parameters under study. Among the different treatment genotype JRO-524 stored in PICS bag had maximum germination percentage and muslin cloth had poor germination. Longest seedling length

was observed in genotype O-4 stored in super grain bag with highest vigour index. Vigour index was lowest in muslin cloth stored seeds. Maximum thousand grain weight was recorded in KEN-DS-058 stored in muslin cloth and lowest in JRO-524 stored in super grain bag. Highest moisture percentage was recorded in KEN-DS-058 packed in muslin cloth and minimum moisture percent was in O-4 stored in PICS bag (Table 18).

Table 18. Seed quality attributes of different genotypes of jute stored in different pachakaging materials

Treatments	Germination (%)	Seedling length(cm)	Vigour index	1000 grain wt (gm)	Moisture(%)
V1S1	88	6.23	549	2.03	11
V1S2	91	6.43	589	2.05	11
V1S3	0	0	0	2.05	11
V2S1	91	6.03	548	1.88	11
V2S2	94	5.1	479	1.92	10
V2S3	0	0	0	1.91	11
V3S1	93	7.6	704	2.02	10
V3S2	92	5.63	516	1.89	10
V3S3	0	0	0	1.97	11
V4S1	89	6.27	557	1.97	11
V4S2	90	5.93	534	2.06	11
V4S3	0	0	0	2.08	13
V5S1	92	7.53	695	2.05	12
V5S2	87	7	609	2.03	10
V5S3	0	0	0	2.00	11
Mean	61	4.58	386	1.99	11
P-value	<.001	<.001	<.001	<0.001	0.05
LSD(0.05)	7	0.7	83	0.04	1
CV(%)	6.8	9.2	12.9	1.3	7.7

Note: V1= KEN-BL-130, V2=JRO-524, V3= O-4,V4=KEN-DS-058, V5=KEN-DS-66
S1=Super grain bag, S2= PICS, S3=Muslin cloth

3.4.2 Monitoring on seed storage condition of seed producing farms of NARC, Seed Company, and farmers groups

Seed is the fundamental input of agriculture whose vitality is directly related to the proper crop stand and succeeding crop yield. The contribution of quality seed alone is estimated to be 15- 20% to total crop production. When seed has good physical, physiological, health and genetic qualities, farmers have greater prospects of producing a good crop. High quality seed is a major factor in obtaining a good crop stand and rapid plant development even under adverse conditions although other factors such as rainfall,

agronomic practices, soil fertility, and pest control are also crucial. About 95% of research investments have focused on increasing productivity and only 5% directed towards reducing losses contrary to that, investment on generation of technologies in reducing losses is more lucrative than technologies on increasing production and productivity. Proper Seed post-harvest technology thus is highly worthwhile than the seed production because wherever produced seed can be used for centuries not only for production but also as genetic resource and further crop improvement. The quality parameters of seed largely affected by the post-harvest and storage conditions. Thus the immense establishment of an eco-friendly, socially acceptable and economically viable storage and post-harvest technology is the research need of the country. To develop appropriate post-harvest technology, one should be familiar with the existing situation of the seed system. So, this survey and warehouse auditing mainly intended for finding pros and cons of existing seed postharvest handling system and workout where improvement can be made.

A survey was conducted in order to make qualitative assessment through random and purposive sampled of 20 seed production and storage farms. Both questionnaires and seed sample survey were carried out to assess the actual condition of the governmental farms, seed producing groups, seed companies and other seed entrepreneurs. A seed warehouse auditing checklist of Mid America Crop Life Association (MACA, 2012) was somewhat modified in Nepalese condition and monitoring was done by the special technical personnel after orientation. Warehouse of stations from NARC, Seed Company and seed farms of farmers groups were randomly sampled and monitored by the checklist. Although seed production is highly technical occupation but the manpower involvement in seed production was relatively low. Only 2% technical people are involved in seed production. Moreover the technical persons in many farms were found not familiar with actual seed production technology and plant breeding background.It was found that more than 95% wheat seeds are harvested through combine harvester while rice and maize are harvested manually but threshed mechanically. High level of physical, physiological and genetic deterioration of seed was found in this stage. Fragmented seed production of several varieties in a small area was another cause that incur varietal mixture in seed lot. In Nepal, solar seed dryer and cabinet seed dryer were found tested for small scale but no any commercial use of artificial seed dryer was found to be used. Only sun drying was used as single option for seed drying. Seeds produced in rainy season and regions with high humidity like RARS, Lumle, it was found difficult to lower the moisture percentage of seed which ultimately limit for the longevity of the seed. So, in these context, proper research need and development of artificial seed dryer was found crucial to enhance the seed quality.

The survey revealed all seed producers equipped with the mechanical seed processing machine. Lack of skilled mechanics for timely repairing and maintenance and high cost of spare parts were recorded as major problem in mechanization which was also seen in processing machines. Many public farms had couples of harvesting and processing machines in impairment condition. So it would be better to hire a trained manpower for repairmen of agricultural machineries. Regarding the value addition in seed and promoting the seed system isolated from the grain, a different mechanism should be developed. Seed treatment, seed coloring and seed coating are the some instances that can improve the seed quality and seed health. But in Nepalese context among major cereal crops, wheat was found to be treated with Vitavex by 84% and maize with Bavistine by 55%. Rice seeds were rarely (4%) found treated with fungicide (Table 19). One reason behind rice seed is not treated is due to surplus seeds which could be sold for food if it is not sold.

Table 19: Seed treatment and value addition status of major crops in NARC, Seed Company, and farmers groups

Major crop	Seed Treatment	Seed Coloring	Seed Coating
Rice	4% (Bavistine)	No	No
Wheat	84% (Vitavex)	No	No
Maize	55% (Bavistine)	No	No

Seed storage system was found unsatisfactory. Almost all seeds were stored in open storage condition for one season only. The open storage was found almost similar to the granary and milling industry where only physical damage considered to be protected. A little vegetable seeds from private company were found to be using sealed container storage in aluminum packet and vacuum packing that can be used for at least two season while there is only one private seed company, CG Seeds and Fertilizers Pvt. Ltd. Kushaha, Sunsari, Nepal found to be using conditioned seed storage through controlled temperature and humidity.

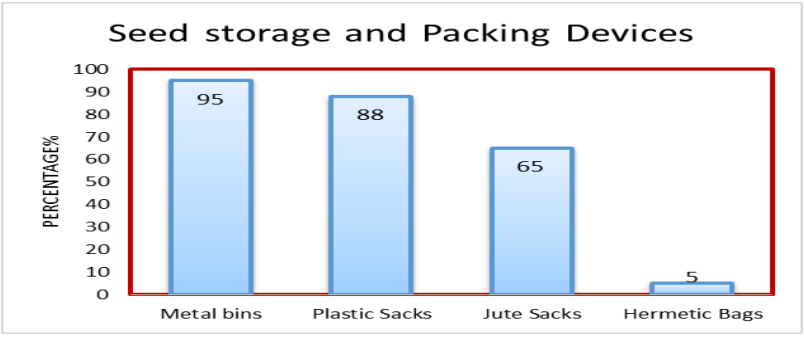


Figure 5. Seed storage and packing devices used in seed warehouse of NARC, Seed Company, and farmers groups

In farm level, almost all farms (95%) found to be using metal bins for storage of source seed except some seed producing farmer group. About 88% farms were using plastic sacks for packaging and storing their seeds while 65% are using jute sack. This is because of the price of jute sack is being expensive than plastic sack. Hermetic bags has been used largely for subsidizing farmers for seed storage but the seed producing farms were not using this technology substantially (Fig 5).

Moreover, problem of selling of spurious seed to the small farmers by showing large seed sack was another problem reported by various farmers. To address this seed packing in smaller labeled packet consisting of 2kg to 5kg should be developed.

Major pests in seed storage was recorded as insects, rodents, fungi etc. in the conventional open seed storage system, the insect problem comes first followed by rodents then fungus. Mite problem was found high in wheat seed in Nepal Seed Company (NSC), Itahari.

Table 20. Monitoring on warehouse performance of seed producing farms of NARC, Seed Company, and farmers groups in Nepal, 2073/74 (Score : 1-100)

SN	Stations/Company	Industrial hygiene	Construction and building Maintenance	Product Segregation	Lighting	Safety and Training	Storage Security	Storage Security System	Fire Protection	General Safety	Total
	Score➔	**26**	**18**	**4**	**6**	**8**	**6**	**10**	**8**	**14**	**100**
1	RARS, Tarahara	17	16	4	2	4	4	3	4	6	**60**
2	Jute Research Program, Sunsari	15	14	2	2	0	4	3	4	6	**50**
3	Nepal Seed Company, Itahari	17	16	4	2	2	5	5	5	8	**64**
4	CG Seeds and Fertilizers Pvt. Ltd. Kushaha, Sunsari,	21	18	4	2	4	5	5	5	10	**74**
5	NRRP, Hardinath	17	16	4	2	4	4	3	4	8	**62**
6	ARS, Belachapi	17	16	4	2	2	5	5	5	10	**66**
7	Oilseed Research Program, Sarlahi	16	16	4	2	2	5	5	5	10	**65**
8	RARS, Parwanipur	16	16	4	2	2	5	5	5	10	**65**
9	Sugarcane Research Program, Jitpur	14	16	4	2	2	2	5	5	10	**60**
10	National Maize Research Program, Rampur	14	16	4	2	2	4	5	5	10	**62**
11	National Wheat Research Program, Bhairahawa	18	16	4	2	2	4	5	5	10	**66**
12	RARS, Nepaljung	14	14	4	2	2	4	5	5	10	**60**
13	ARS, Surkhet	14	14	4	2	2	4	5	5	10	**60**
14	Grain Legume Research Program, Nepaljung	14	14	4	2	2	4	5	5	10	**60**
15	Unnat bej Bridhi Krishak Samuha	18	16	4	2	4	5	5	5	10	**69**
16	Kalika Seed	12	14	4	2	2	2	5	5	8	**54**

SN	Stations/Company	Industrial hygiene	Construction and building Maintenance	Product Segregation	Lighting	Safety and Training	Storage Security	Storage Security System	Fire Protection	General Safety	Total
	Company, Bhairahawa										
17	HRS, Maleptan	12	14	2	2	2	2	5	4	8	**51**
18	RARS, Lumle	18	14	4	2	4	2	5	4	10	**63**
19	Unique seed company Pvt.Ltd.	19	14	4	2	4	5	5	5	10	**68**
20	Agronomy Division, Khumaltar	18	14	4	2	4	5	5	5	10	**67**

From the auditing of sampled 20 public and private seed companies, the warehouse performance was found poor. The seed storage and grain storage warehouses are found more or less similar which denotes seed stakeholders are not aware of seed viability and vigor and only found giving emphasis on quantitative losses that incurred by rodents and other pests. The highest mark was recorded in CG Seeds and Fertilizers Pvt. Ltd. Kushaha, Sunsari which is equipped with all processing plants along with conditioned storage. Mostly warehouse performance of public farms were found poor as compared to private farms. A suitable farmers' friendly Seed post-harvest protocol should be developed to enhance the quality aspects and minimizing vigor and viability losses in seed. Furthermore, before starting the seed business, a proper warehouse and surrounding condition should put as prerequisite that ultimately meliorate the seed postharvest system.

3.5. Seed Variety Identification Using DNA fingerprinting Technology

3.5.1 Assessment of genetic diversity in wheat cultivars using SSR markers

Genetic diversity is the basis for launching an efficient breeding program that aimed for the improvement of wheat productivity. Wheat breeding through hybridization also requires the selection of diverse genotypes, irrespective of whether the product is a pure line or a hybrid variety (Prasad et al., 2000; Zeb et al., 2009). Common wheat (*Triticum aestivum*) (2n = 6x = 42) belongs to family Poaceae, the most diverse and important family of the plant kingdom. Wheat (*Triticum spp*) is a worldwide cultivated and domesticated grass. The gradual increase in population demands a substantial increase in its productivity. Wheat has always been subjected to extensive and ceaseless research so as to maximize grain production but also to improve grain yield per unit area. However, there is still considerable room for improvement, especially to amplify efforts for continued genetic improvement of wheat to meet the growing requirements of an ever increasing population. The use of molecular markers for the evaluation of genetic diversity is very common. Simple sequence repeats (SSRs) (Tautz et al., 1989) have been widely exploited in wheat due to their high level of polymorphisms, co-dominant inheritance and equal distribution in the wheat genome (Khaled et al., 2015). SSRs are more abundant, ubiquitous in presence, hyper-variable in nature and have high

polymorphic information content (PIC) (Gupta et al., 2009). SSR have been used to study genetic diversity of wheat cultivars by Eujay et al., 2001; Grewal et al., 2007; Hai et al., 2007; Ijaz and Khan, 2009; Khaled et al., 2015; Szucs et al., 2000; Mohammadi et al., 2009. DNA fingerprinting is presently the ultimate method of biological diversification. This study was conducted to estimate the genetic divergence among twenty eight wheat genotypes with the help of SSR markers. The present study addressed the utilization of microsatellite markers, to determine genetic diversity and relationships at the molecular level among twenty eight genotypes of wheat to help in the selection of parents to develop high-yielding varieties in breeding programs. Twenty eight genotypes of wheat used for DNA finger printing were given in the following table.

Table 21. Wheat genotypes used for DNA finger printing

S.N.	Code No.	Genotypes	S.N.	Code No.	Genotypes
1.	W1	WK 1712	15.	W15	NL 1229
2.	W2	WK 2225	16.	W16	NL 1232
3.	W3	Chyakhura	17.	W17	BL 3623
4.	W4	WK 2123	18.	W18	BL 4407
5.	W5	WK 2278	19.	W19	BL 4406
6.	W6	WK 2286	20.	W20	BL 3629
7.	W7	WK 2370	21.	W21	BL 4463
8.	W8	WK 2414	22.	W22	BL 4606
9.	W9	WK 2422	23.	W23	BL 4667
10.	W10	NL 1204	24.	W24	BL 4721
11.	W11	NL 1164	25.	W25	WK 2432
12.	W12	NL 1190	26.	W26	WK 2508
13.	W13	NL 1193	27.	W27	WK 2517
14.	W14	NL 1227	28.	W28	WK 2538

Bulk DNA was extracted using the CTAB (Cetyltrimethylammonium bromide) method.

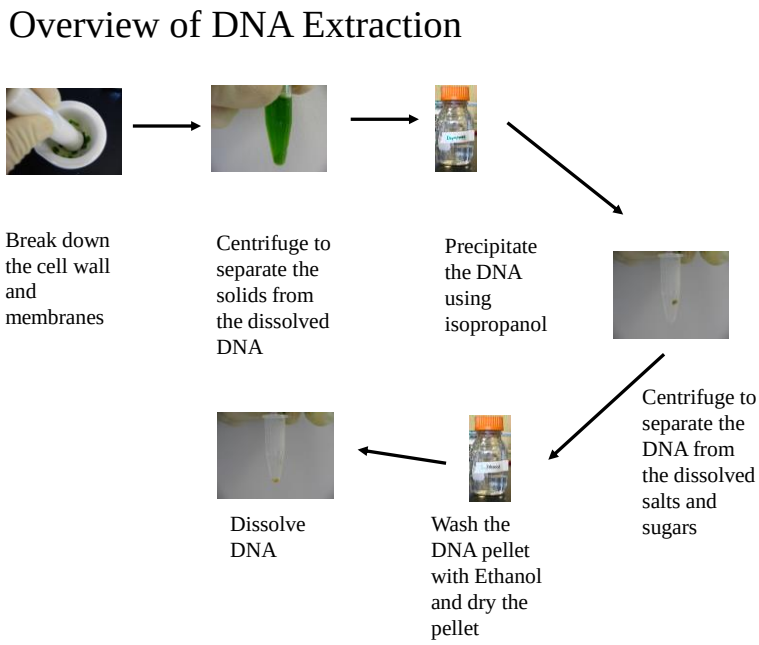


Figure 6. Overview of DNA Extraction

AMPLIFICATION OF MOLECULAR MARKERS

4 minutes of denaturation step at 94^0C followed by 35 cycles of 94^0C for 1 minute, 63^0C for1 minute and 72^0C for 1 minute followed by a final extension at 72^0C for 6 minutes.

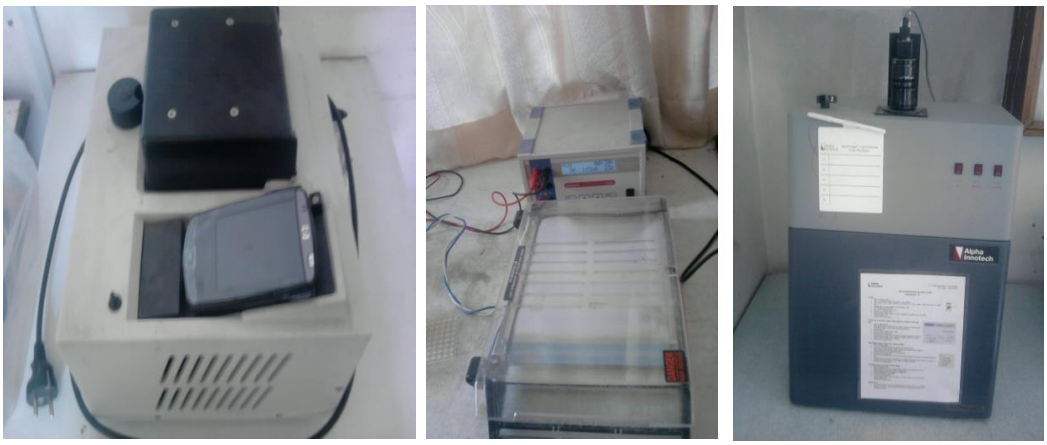


Plate 9. Instruments used for DNA fingerprinting

SSR markers are small (2-6 bp) DNA motifs, highly conserved and distributed among the genomes of all higher eukaryotes. SSR have been used extensively for designing primer sets which are not only highly polymorphic but also species specific (Pestova et al., 2000). Genetic diversity plays an important role in crop improvement and was demonstrated through SSR markers (Gupta *et al*., 2009). In the present study, 40 SSR primers were used to estimate genetic polymorphism and to find out most diverse genotypes for future breeding programs. The four primers did not show amplification. Among the 36 primers producing amplification in wheat genotypes, the 18 primers produced polymorphic bands and 18 primers produced monomorphic bands. From 19 primers, a total of 552 bands were produced with an average of 11.35 alleles per locus. Four SSR primers Xbarc 77, Xgwm 136-1A, Xgwm 174-5D and Xbarc 267 generated higher levels of polymorphism and any of them can be used to differentiate wheat genotypes. The PIC values ranged from a low of 0.18 (Barc 118) to a high of 0.98 (Xgwm 265) and averaged 0.545. PIC values also showed a significant positive correlation with the number of alleles and allele size ranged for microsatellites evaluated in this study. Among the various DNA based markers currently available, the set of microsatellite markers, used in the present study, provided a positive assessment of the ability of SSR markers in producing unique DNA profiles and establishing discrete identity of wheat genotypes, which otherwise, were not possible using morphological traits. The present investigations have helped to establish clear-cut identity of all the cultivars under consideration.

3.6 Participatory Technology Verification and Dissemination

3.6.1. Seed testing services to farmers, seed producer, companies and stake holders

242 seed service samples (cereals, vegetables, oilseed, legume, forage and flower) and 180 seed research samples plus breeder seed of NARC (cereals, legume, vegetable, oilseed, forage, jute and flower) were analyzed for their quality attributes and reported to the concerned stakeholders.

3.6.2. Verification of seed storage and zeolite bead drying technology at farm level

Zeolite bead seed drying technology was verified and disseminated in tomato seed producer farm's condition. A tomato seed producer, Agrosala Private Ltd., Godawari was chosen and Shrijana-tomato hybrid seed from this farm was evaluated for moisture reduction through zeolite bead drying as compare to normal sun drying. Two kilogram seed with 3 replications was appraised for 24 hours in order to calculate to require amount of beads to reduce moisture percent from 9% to 6% and thus the experiment was organized accordingly and data were recorded in different time interval.

Table 22. Evaluation of zeolite beads over sun drying in hybrid tomato seed in farmer's condition, Lalitpur, 2073/74

	Initial reading				After 3 months		MC(%) after 3 months	MC reduction (%)
Rep	Temp. (°C)	RH(%)	Calculated Moisture	Zeolite beads required for 2 kg sample(g)	Temp. (°C)	RH (%)		
I	25.5	46	9.19%	400	23.7	21	5.97	35
II	24.8	46		400	23.5	21		
III	24.7	47		400	23.4	20		
Control	24.6	47		Sun drying	23.2	38	7.23	21

It was evaluated and verified that the zeolite beads can lower the moisture content by 35% whereas sun drying by 21% only (Table 22). In the given environmental condition, zeolite bead drying technology found 14% more efficient over the sun drying in hybrid tomato seed.

3.6.3. Monitoring of source seed production, processing and storage in NARC stations, private companies and cooperatives

Seed production program at Nation Rice Research Program, Hardinath, National Wheat Research Program, Bhairahawa, Oilseed Research Program, Nawalpur and Regional Agriculture Research Station, Nepalgunj monitored at different time interval. Similarly 170 seed samples from NARC station were drawn for internal quality testing and technical advice for improvement.

4. SPECIAL PROJECTS

4.1 Prime Minister Agricultural Modernization Project (PMAMP): NARC-Component

4.1.1. Seed Value chain study in Rice Super zone of Jhapa

Jhapa district is the largest rice producing district of Nepal with more than 87,500 ha area cultivated with rainy season rice and spring rice in around 19,700 ha with total production of 510,845 metric tons of rice production (DADO Jhapa, 2073).Thus, Jhapa occupied 13.27% of rice area with 8.41% of total rice production in the country. This year, spring rice area has increased by 600 ha due to the combine effort of government projects and speculative higher price (DADO Jhapa, 2073). Trade system becomes more efficient only when the value chain is well organized. Deficiency in participation of one sector in the value chain becomes limiting factor for the growth of others. Identification and understanding of structural behavior, organizational behavior and operational dynamics of the business are not feasible without knowing the value chain. This study

seeks to develop conceptual links among the value chain actors using value chain analysis as a tool for inquiring into institutional arrangements and distributional outcomes in rice seed production in Jhapa District.

Both normal random sampling and snowball sampling were used to identify the rice farmers, seed producers and traders so that more and more reliable information can be extracted. Similarly, face to face interview technique was used with semi structured and structured questionnaires to collect the quantitative data from the farmers. Also, Focus Group Discussion (FGD) with the traders/seed business owners were done to get qualitative data and to triangulate the information given by respondents of face to face interview.

A total of 30 households from Jhapa (Baniyani, Pathamari, Pathariya, Kechana, Baluwadi and Jhalthal VDCs) were interviewed using face to face interview technique. Similarly, Focus group discussion with seed producers, farmer groups, wholesaler, retailers/agrovets, line agencies, stakeholders were done and on farm visit done to understand the situation of seed producer cooperatives and firms.

More than two third of the land was found unirrigated while only below 30% of the cultivable land was all season irrigated. Similarly, among the means of irrigation facilities used, shallow tube well was prominent in that area. Also, found that, cultivable land area was found decreasing in recent five years although productivity of rice increased. 55% of the respondents used the rice seed purchased from nearby market while the rest 45% used the seed stored by own grown in previous year. Rice Seed Replacement Rate (SRR) was 17.3%. Among the rainy season varieties two Indian verities were found dominant in Jhapa with coverage of around 45% by Swarna and Ranjeet by 40% while, other verities were Thulo masuli, Radha-12, Ram dhan, Lalka basmati, Samba mansuli sub-1, Sworna sub-1 and Sukha dhan-3.Similarly, Hardinath-1 was found as the dominant (>90%) spring season rice variety and other were Chaite-2 and Pusa dalle. Rice is categorized into 3 groups on the basis of grain shape and size. Swarna, Hardinath-1, Pusa dalle etc are coarse type. These varieties are generally high yielding in comparison to other groups so are popular among farmers. These are popular among working class and indigenous communities (Rajbanshi community for steamed rice). But its price is relatively lower than medium and fine grain rice. Masuli rice like Ranjeet, Samba masuli sub-1, Thulo masuli, Kanchi masuli and Sukha dhan-3 are medium grain rice. These varieties fetch medium price which is higher than coarse grain and lower than fine grain rice varieties while the yield capacity is slightly lower. So, farmer with good farm management skill prefer to grow these varieties and are common in medium class families and urban residents. Basmati group (Lalka basmati, Kalo nuniya, Ram dhan) comes under fine grain rice. They are low yielder and is susceptible to adverse environmental, insect pest and drought. But is more tasty and preferred by

prosperous families so are cultivated in limited area for home consumption only. For rice seed production, most of the farmers rely on JT/JTAs guidance and supervision. In trend analysis of rice production over the five years, there was increasing trend of rice production while the land area was decreasing significantly. Also in rice seed production, there were slightly constant to decreasing trend.

There were 5 organized formal seed producing or business agencies in Jhapa district although it was found that many progressive farmers produce seed by themselves or sell at community level. The total seed production of rice through cooperatives/firms in Jhapa were estimated 1098 MT and dominant rice varieties were Ranjeet, Sworna, Hardinath-1, Sukha dhan—3, Sworna sub-1, Shamba masuli sub-1, Lalka basmati, Kanchi masuli, RP-1017 and Ram dhan (DADO Jhapa, 2073) (Table 23)

Table 23. Major Rice seed production pockets with their production volume.

S. N	Name of cooperative	Address	Seed production (MT)	Major varieties
1	Mechi Multi-Purpose Agriculture cooperative Ltd.	Mechi municipality-12	250.00	Ranjeet, Sukha-3, Shambamansuli sub-1, Swarna sub-1, Ram dhan, Lalka basmati, Kanchimasuli and Hardinath-1
2	Maharani Jhoda small farmer agriculture cooperative Ltd.	Gauradaha municipality-4	280.00	Ranjeet, Swarna sub-1, Ram dhan and Lalka basmati
3	Kanchan Seed Producer Cooperative Ltd.	Dhulabari-1	341.00	Sworna, Ranjeet, Hardinath-1, Kanchimasuli, Thulomasuli and RP-1017
4	Chandra Dangi seed and milk development committee	Shivasatakshi	38.00	Shambamansuli sub-1, Swarna sub-1, Sukha dhan-3, Hardinath 3
5	Anmol Seed Company Ltd.	Kankai-8, Surunga	34.30	Hardinath-1, Anmol masuli, Barkhe-2014, Kanchimasuli and Sukha dhan-3
6	Others (group/farmers)		155.00	Ranjeet, Sworna, Radha-12, Hardinath-1
	Total seed production (MT)		1,098.30	

Chandra Dangi farm is the only government owned multipurpose agriculture committee while other are privately owned. Among these all, Maharani Jhoda and Mechi Cooperatives were promoted by different government projects like PACT/ DANIDA/MOAD/DOA with support in infrastructures like: processing unit, storage building and seed drying floor. Although, Kanchan seed producers cooperative and Anmol seed does not have such infrastructure. They rely on farmers/processing mill in the market for processing, drying and storage.

Table 24. Major Rice seed production pockets with their capacity and infrastructure information.

S.N	Name of cooperative	Membership	Infrastructure/facilities available
1	Mechi Multi-Purpose Agriculture cooperative Ltd.	1500 members and 300 seed producing farmers	Newly constructed and modern processing unit and storage building but do not have big and modern rice production machinery.
2	Maharani Jhoda small farmer Agriculture cooperative Ltd.	1800 members and own farm of 105 hectare	Newly constructed and modern processing unit, combine harvester and storage building. Milk production with around 55 cattle.
3	Kanchan Seed Producer Cooperative Ltd.	Community based and have 10 seed producing groups	Do not have proper modern machinery and infrastructures. Contract with other seed processing cooperatives for processing of seed.
4	Chandra dangi seed and milk development committee	Government owned farm with 100 hectare land	Old buildings and shed houses without modern machineries. Livestock production with cattle sheds.
5	Anmol Seed Company Ltd.	120 members	Do not have large and modern machinery and infrastructures. But have small machineries and drying centers.

Total improved seed produced in Jhapa were 1097 m ton and 880.5 m. ton seeds were sold. Among the total producers, Kanchan seed was the highest producer and seller while Maharani Jhoda Agriculture Cooperative comes second in production while it sold only around 40% of the seed produced. Mechi Cooperative became second leading organization for selling rice seed.

Table 25. Rice seed business record of Jhapa, FY 2073/74

Firm/Cooperative	Seed sold (MT)	Jhapa	Morang	Sunsari	Saptari	Major varieties	Remarks
Mechi Cooperative	213.5	199.5	5	5	4	Kanchi masuli, Ranjeet	10 mt more demand of Ranjeet
Kanchan Seed	334.35	169	83	82	0	Kanchi masuli, Ranjeet, Swarna	50 mt more demand of Ranjeet
Maharani Jhoda	109.5	32	32.5	45	0	Ranjeet/Hardinath-1, Lalka basmati/Masuli	150 mt of Sworna sub-1 and 15 mt of Lalka basmati on stock (not sold)
Chandra Dangi farm	37.89	8	12	12	7	Hardinath-1, Lalka basmati/Masuli	
Anmol seed	31.3	16.3	7	8		Anmol Masuli, Kanchi Masuli, Sworna sub-1	
Other private org/individuals	155.05	124.	15.50	15.50		Swarna and Ranjeet	
Sub total	881.59	548.8	155.00	167.5	11		
National Seed Company Ltd Itahari		50				Hardinath-1, Shamba masuli, Sworna sub-1, Sukha dhan-2	
RARS Tarahara		1.93				Shamba masuli, Sworna sub-1, Sukha dhan-3	
Private company (Siraha/Sunsari)		12				Swarna and Ranjeet	
From Indian market		750				Swarna and Ranjeet	Ranjeet and Swarna has more demand than supply
Total	881.59	1362.	155.00	167.5	11		

Total rice seed consumed in Jhapa district from different sources were found to be around 1362.77 mt while, the production in district was found to be 1098 mt. Among the total rice produced, around 62% sold within the district, 19% in Sunsari, 18% in Morang and rest 1% in Saptari district. Although the information shows that Jhapa was not self-sustained in rice seed. It rely heavily on nearby Indian market (more than 55%), while other rice seed suppliers were National Seed Company Ltd Itahari, Private seed companies of Siraha/Sunsari and Regional Agriculture Research Station (RARS) Tarahara.

Similarly, sold varieties viz., Ranjeet Masuli leads with 43% followed by Swarna with 18% share in market. Similarly, Hardinath-1, RP-1017, Kanchi masuli and Sworna sub-1 comprises 10%, 6%, 5% and 5% market share respectively. Also, it was found that, Ranjeet Masuli and Swarna were short supplied to fulfil the demand.

At well managed condition, the cost of rice production reached to Rs. 60,000 per hectare while of minimum management level, the cost of rice production reached to Rs. 35,500 only. Rice seed production, most farmers have well managed to partial managed condition applying the recommended dose of fertilizer, insect pest control and weed management in addition to normal practices, the cost of production reached around Rs. 60,000/ha although the product are not perfect for seed so, addition cost incurred for roughing of off type panicles/ weed plants and post-harvest activities like grading, winning and drying.

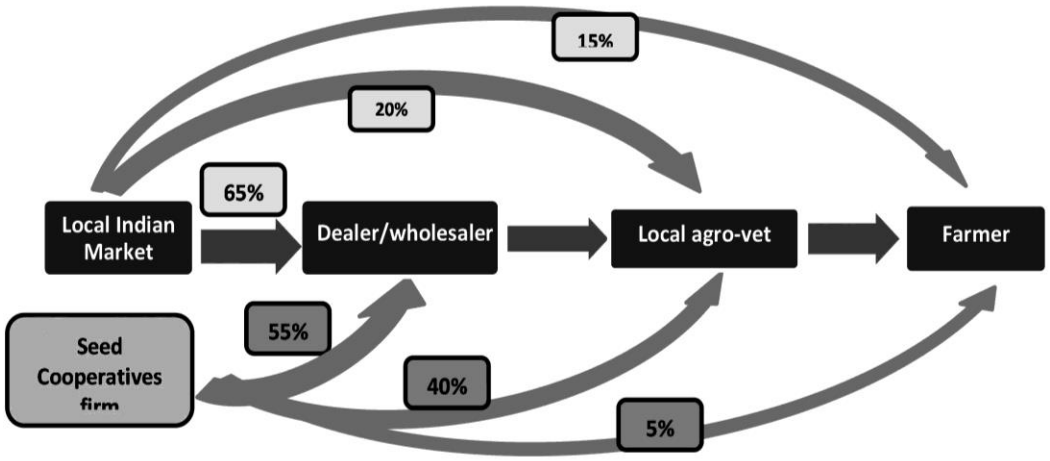


Fig 7: Rice seed trade channel in Jhapa

Rice seed trade channel of Jhapa district illustrates that rice seed are generally supplied from Indian market or from seed cooperatives or firms. Among the seed supplied from Indian market, around 65% reached to farmers via wholesalers/dealers while 20% via local agro vets and around 15% directly reached to farmers. Similarly, from the Nepalese local producers (seed cooperatives or firms), around 55% of the seed rice reached to farmers via wholesaler, 40% via local agro vets and rest 5% direct to farmers.

This shows the wholesaler/dealer and local service providers have played a major role in rice seed trade. Similarly, it was found from farmers/cooperatives that Indian market had played the prominent role in rice seed especially of Ranjeet, Swarna and other high yielding varieties including hybrids although there was no concrete information to verify it.

4.1.2 Seed Value Chain study in Maize super zone of Dang

Maize is the second most important crop after rice in terms of area and production in Nepal. It is a traditional crop grown for food, feed and fodder. Maize contributes 43% of cereal's area and 53% of its production. In 2016, it was planted in 0.89 million ha, where mid hills, high hill and Terai represented 70%, 10% and 17%of its total area. However, this is a growing tendency of maize farming in the Terai and foot hills due its increasing demand for poultry feed. Nepal produces about 2.23million tons of maize annually, but the national requirement is estimated to be 6.46 million tons. The gap is fulfilled by importing it from foreign countries. There is an increasing trend in diversification of maize products for human nutrition such as soups, vegetables, maize grits, and edible oils. This amply shows the importance of maize crop for food security, livelihoods and cash income. Under such circumstances, the import substitution can only be done by increasing the productivity of maize with the available land. Although, winter maize following rice has been emerging as a new intervention in the Terai to increase the maize production, there is ample opportunity for sustainable intensification of maize even in the main season. SSTD has conducted seed value chain study in few VDC of maize super zone to understand the maize seed demand, production and varietal portfolio in the super zone.

Focal group discussion with seed producer groups and cooperative members was made at Lalmatiya, Dang. Similarly, consultation was done with DADO, Ghorahi, Agriculture Service Center (ASC) Lamahi and technical person of KISAN projects. Secondary information was collected from DADO, Dang. Bela, Rampur, Tripur and Tulsipur municipality were the seed production pockets in the district. Similarly, Bela, Lalmatiya, Sishniya, Lamahi municipality, Gangaparaspur, Laxmipur, Rampur, Loharpani, Syuja, Saudiyar, Phulbari, Duruwa, Tulsipur municipality, Pawannagar, Shantinagar, Panchkule, Purandhara, Baghmare were the cereal food grain production pocket in the district. Dang district has 65980 ha land under cultivation with 30 % round the year irrigation facility. Maize area was 23955 ha where winter maize area was 250 ha with production of 473 ton; spring maize area was 530 ha with total production of 1431 ton and rainy season maize area of 23200 ha with the production of 46168 ton. There were 18 seed producer groups in the districts with 386 members. The average productivity of maize was 2.02 t/ha (irrigated/rainfed). However, in some pocket area maize productivity was realized up to 2520 kg/ha. There were 111 Licensed Agrovet in the district.

The population structure in maize super zone was 4475 in Lalmatiya, 3259 in Sishniya, 2640 in Sonpur, 2501 in Satbariya. All VDC in super zone was connected with Pucca road. Deukhuri Bahumukhi Campus, Lamahi; Erawati Multiple Campus, Lalmatiya and Rapti Technical School are located in Lalmatiya within maize supar zone. In technical school A.N.Mi. CMA, Agri, Vet and Engineering subjects were taught. Seed storage

house was constructed in Saunepani Krishi Sahkari Sanstha, Shantinagar-7, Saunepani. Maize seed production area was covered in 75 ha in the districts. Altogether 12 maize pockets were identified in Dang with seed store capacity of 160 mt within 8 seed stores. However, actual seed stored was 132 t this year. Dang districts possess eight combine harvestors, 352 tractors, 174 Power tillers and 56 Threshers.

Fields are irrigated with canal and boring. Rice-wheat-maize; Rice-lentil+tori-maize and Rice-lentil-maize were the cropping pattern in maize super zone Dang.Arun-2, Bioseed, Srinath, Subarna, 9220, Rajkumar, Rampur yellow, 10B10 were the maize variety/hybrid grown by farmers. Seeds were procured through cooperatives and agro-vets. Maize is grown in three seasons. Spring maize planted in Phalgun (March) and harvested in Jestha/Asar. Arun-2 and hybrid maize were grown in spring season. Summer maize - planted in Baisakh-Jestha or upto Asar (May-June) and harvested in the month of Badra/Aswin (September/October).Rampur composite, Local, Rampur Yellow, Seto local and hybrid-Pioneer are grown in summer season. Winter maize is planted in Aswin/Kartik/Mangsir and harvested in Baishakh/Jestha. In winter Arun-2, Pioneer, Kanchan, Rajkumar are grown. Agrovet are the main source of maize seed in the locality. Maize seed rate used is vary from 15-60 kg/ha. Stem borer and stalk rot were the main problems in the locality. Maize seed price vary from Rs. 250-500 /kg. Farmers generally used DAP (Rs 46/kg) and urea (Rs 21/kg) in maize and no use of potassium fertilizer. Daily wages charge is Rs. 350-400. Land rent is Rs 1000-2000/katha/year. Bulloock cart and Tractor hire charge is Rs700 and 3000/hr.

Maize hybrid trial was conducted in maize super zone along with Rampur composite as check and hybrid CP 808 (7.12 t/ha), Rampur hybrid 6 (7.0 t/ha), Rampur hybrid 4 (5.96 t/ha), RML 95/RML-96 (5.84 t/ha), RML 86/RML-96 (5.72 t/ha) and Rampur composite (4.76 t/ha) produced grain yield in the decreasing order. It is evident Nepalese hybrid maize were equally competent with Indian maize hybrids.

Suryodaya Krishi Sahakari Sanstha , Bela was involved in seed production of rice, wheat and maize since long time. Mr. Mohan Khanal was the manager of this cooperative. It is old cooperative involved in truthful label seed production since long time. Harit Kranti Krishi Sahakari Sanstha, Sonpur, Keruniya was involved in rice and wheat seed production. Mr. Deepak Chaudhary was the manager of this cooperative. Digo Khadhya Bali Krishi Sahakari Sanstha, Dhikpur, Tripur Municipalaty (Deepak KC) also involved in rice, wheat and lentil seed production. Deep Krishi Sahakari Sanstha Baghmare (Nep Bahadur Rokaya) involved in tori seed production. Saunepani Krishi Sahkari Sanstha, Shantinagar (Goman Bahadur Woli) involved in rice and maize seed production. Jaibik Bibidhta Krishi Sahakari Sanstha Ltd. Rampur (LIBIRD) involved in rice and wheat seed production. Shivshakti Krishak Samuh Rampur also produced Rice

seed. Bageshori Krishi Sahakari Sanstha Dhikpur involved in rice and wheat seed production. Ichchhuk Smriti Krishi Sahakari Sanstha involved in rice and maize seed production.

4.1.3. Seed value chain study in Wheat super zone of Kailali

Wheat is the third most important cereal crop in Nepal after rice and maize in terms of area and production. It shares 16% and 20% of the total calorie and total protein supplied from plant products in Nepalese diet (FAO, 2012). In 2015, wheat was cultivated in 0.75 million ha with the average yield of 2.29 t ha^{-1} (MoAD, 2016). Though wheat is cultivated from Tarai to hills, share of Tarai to the total area and total production is 59.3% and 69.3%, respectively (MoAD, 2014). Wheat is important not only from nutritional perspective but also from livelihoods and industrial purpose. People get income by producing and selling wheat products and engaging in wheat value chains, and wheat grain serves as an important raw material in food industries. Despite these benefits, there is huge yield gap between farmer's field and potential yield. Major reasons behind this are poor seed quality, low variety replacement rate, poor adoption of improved crop management practices including fertilizer, weed management, irrigation and modern farm machineries. Nepalese government has launched Prime Minister Agriculture Modernization Project (PMAMP) and identified Kailali district as Wheat Super Zone to initiated commercialization and industrialization in wheat sub-sector in the country by strengthening and engaging wheat value chain actors in the same zone. In this context, it was realized to study wheat seed value chain for better targeting, technology scaling and prioritization of research efforts.

Key informant survey was conducted in wheat super zone Kailali and Dhangadhi bazar. Secondary information was collected from District Agricultural Development Office, Dhangadhi, Kailali and seed industries located at Dhangadhi bazar. Consultations were carried out with Agrovet and cooperatives at Dhangadhi and Masuriya. Rice wheat system was dominated in wheat super zone of Kailali. Rice was rainfed lowland type and Sarju 52, unregister Indian variety was dominated in the district. Radha 4, Sabitri, Sukkhadhan 3, Sukkhadhan 5, Ramdhan were the popular rice variety in the districts. Wheat cultivation was covered by all improved variety. NL 297, Vijay, Aditya, Gautam and Bhrikuti were the dominant variety in this area. Some farmers were planted Indian variety of wheat i.e. PBW 343. About 85% area was covered with wheat in winter season. Partial Irrigation facility from groundwater (boring in cooperative) was found in almost Super zone area. Rice yield was about 2.1 t/ha in Masuria and wheat yield was about 2.5 t/ha . About 37 % wheat produce was sold and remaining consumed at household level in Masuria. The production cost was about Rs. 41000.00/ha. The farm gate price of wheat was Rs. 2600/quintal (in the month of Baisakh). Fertilizer use in wheat was nominal i.e. 30 kg DAP and 30 kg Urea/ha as basal and 30 kg/ha Urea in top

dress. Generally 8 -10 t/ha FYM was used in wheat field in Masuriya. Land preparation and threshing operation were performed by machine. Own seed (Rs. 30/kg) was used for wheat cultivation as grain. Wheat productivity was felt increasing due to integrated use of organic and inorganic fertilizers. The existing sandy loam soil was suitable for wheat cultivation in the super zone. Wheat seed production activities was not there except in some cooperatives in wheat super zone. Phalaris minor (ragate jhar) become problematic in wheat seed production in these areas.

Seed Companies were flourished in Kailali, Dhandagi and found involved in rice, wheat, lentil seed production. Company produces seed in contact farmers' field in pre agreed terms and conditions. Company raised NL 297, Vijay, Gautam , Aditya, Dhaulagiri, WK 1204, Bandhganga, Tilottama and Bhrikuti variety of wheat of different categories like FS, CS and IS. Average seed yield collection of 1.3 t/ha in wheat. Vijay was preferred variety due to high yielding, tolerant to water logging and good taste of chapatti. Aditya also good variety with bold grain type and heat stress tolerant. Gautam was less preferred due to early in lodging, hard chapatti and difficult in threshing. Similarly, collection price of wheat seed was 10% plus from market price i.e. Rs. 23/kg. Wheat seed collection was started from Chaitra to Jestha second fortnight. Sales price of wheat seed was Rs. 60-65/kg. Seed was packed manually in jute bag (30 kg Rice and 40 kg wheat). Company felt seed business was good and profitable but risky and troublesome. Land fragmentation and small holding were the barrier in seed production and small farmers were not interested to multiply seed. Farmers were not interested in roguing operations. Similarly, it was difficult to get big farmers for seed multiplication. No matching in demand and supply site of seed. Last year wheat production was bumper, seed price was low and seed did not sold. Seed market was highly competitive in Kailali. Packaging materials (gunny bag) were also costly. Manpower shortage and high cost of labour (Rs.800/day) felt mechanized seed industry in days to come.

Company got written agreement with contact grower and seed growers received 10% premium. Cooperative society who involved in seed production they receive 3% extra premium. Transportation cost is bear by company itself. Seed growers got training on quality seed production aspect. Company used own foundation seed for certified/improved seed production. Maize seed demand was higher followed by wheat and rice.

Company → Cooperative/Agrovet → DADO → Farmers were the seed channel in the district.

No policy on seed production system in Nepal. All groups, cooperatives, NGO/INGOs, DADO, NSC were involved in seed production. No demand recorded for a particular crop variety. All projects subsidized the materials in seed production. Excess production

may not be sold as seed. Seed business should be one door system (National seed producer Federation). Source seed of wheat seed was brought from National wheat Research Program, Bhairahawa. Wheat seed was distributed up to Biratnagar, Hetauda and Lahan.

5. TECHNOLOGY TRANSFER AND SERVICES

5.1. Training/Workshops/Meetings

During the fiscal year 2073/74 (2016/17) there was no budget for training program for the clients in regular program. However, three days training for seed production technician was organized at NMRP, Rampur under PMAMP (Annex 4.1).

5.2. Services

SSTD has ever since been working in close association with crop breeding and national seed programs and provides the seed testing and information services to respective seed stakeholders. Followings were the seed quality attributes tested in Central seed laboratory following ISTA 2011 rules and guidelines as well as norms developed by NSB. Seed analysis reports were provided to respective seed producers, seed companies, researchers and farming groups. 422 seed samples were analyzed and reported to the clients (Annex 4.2). Seed testing services focused on:

- Moisture content, analytical purity, number count test, germination test (general testing)
- Tetrazolium salt test, vigor test, ageing test, cold test, field plot and biochemical and molecular marker test (special testing)
- Proficiency seed sample testing

5.3. Publications

In 2073/74, two publications were prepared, of which one is Annual Report, 2072/73 and another Manual on varietal maintenance and source seed production of cereals crops (Annex 4.3).

5.4 Visits

Students and technicians were guided to have technical information and facilities of SSTD with regard to the seed quality testing services. Students, agriculture extension staff of DoA, also visited the SSTD laboratory (Annex 4.4).

6. BUDGETAND EXPENDITURE

Total SSTD project and office administration cost for the year approved and released was NRs 12607000.00. Out of total budget, only NRs 12383053.16 was expended.

Likewise under the special project PMAMP annual budget was NRs 9024,000.00 and under National Reconstruction Authority NRs 1500000 was approved. Expenditure details are provided in annex 6.1 and 6.2 respectively.

During the year, a total revenue of NRs 84399.90 was collected through seed testing services and sales of research crop production and others (Annex6.3). The budget expenditure has been audited by attorney journal and Rs. 27000 was kept as beruju for the year 2073/74 (Annex 6.4).

7. KEY PROBLEMS

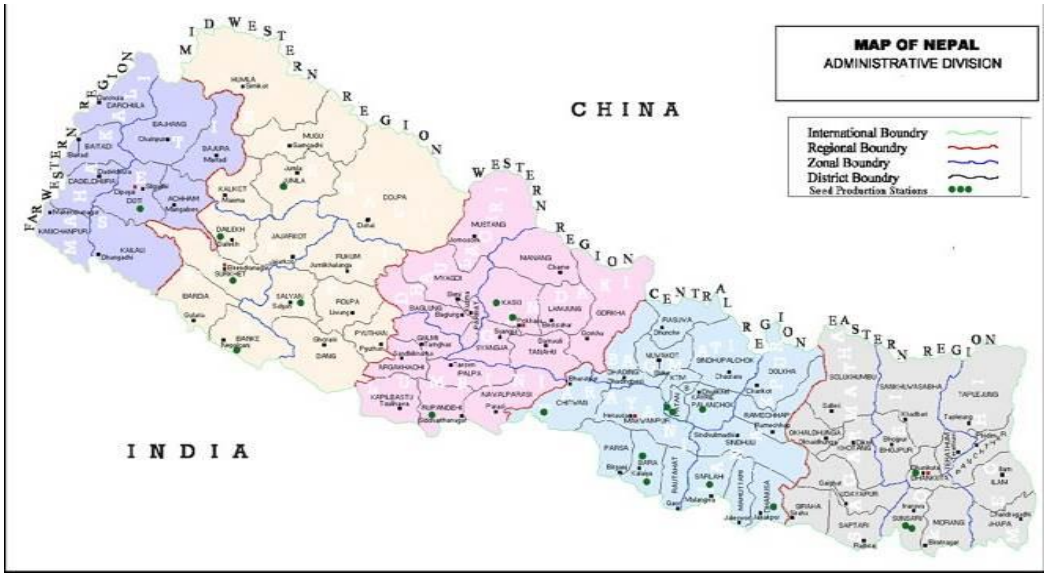
Technical human resources and limited laboratory space are still the key problems in the division. The division has been successful in facilitating and strengthening the service and research resources with support of collaborative seed projects, however, due to the limitation of space in the building they could not have been brought into full operation. In human resources, there is limited trained technical and lower admin staff. As a result, there is difficulty to justify the extra costing of labors for seed assistants and guard (chaukidar).Recruitment of additional proposed staff along with additional technical officers and support staff will help in increasing the efficiency of SSTD services and research. For the limitation of the space, SSTD would suggest to allocate whole building and premises for SSTD as 'Seed Bhawan'.

8. WAY FORWARD

A good amount of research in the field of seed science and technology have been carried out and significant contributions made on seed regulatory frameworks formulation and implementation in past and recent years by the division. The field is wide as it includes a cadre of disciplines of seed biology to its marketing, management and uses. But in present context following research areas on quality seeds for improving the production per unit area are felt to prioritize and carry out the studies:

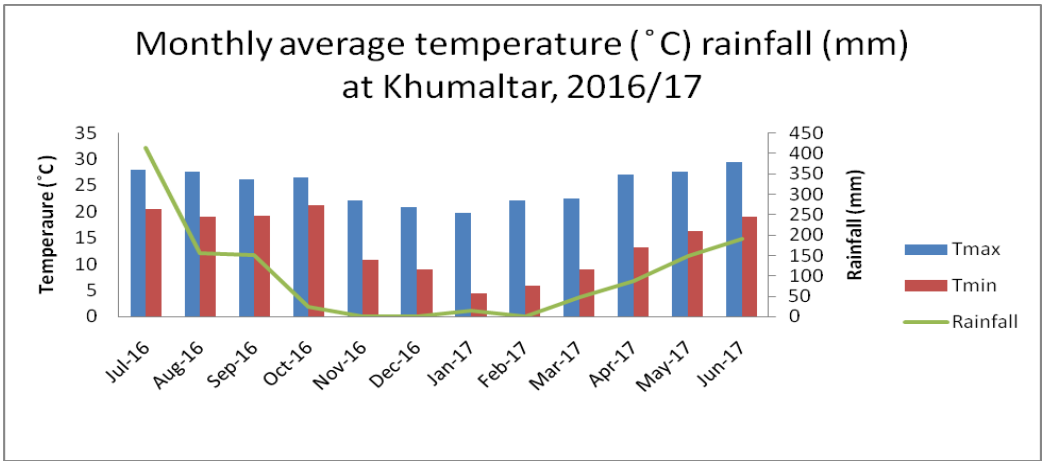
Basic studies on seed biology, morphology and physiology of different agricultural crop species,
Resiliency of seeds to climate change,
On-farm seed management and improvement of farmers saved seeds which dominates the national seed system,
Use of biotechnology and molecular techniques in support of seed technology and genetic studies of local crop diversity,
Collaborative research with different seed stakeholders,
Harmonizing the seed quality and their use,
Hybrid seed production research in maize and rice.

Annex 1.1. Map of the Seed Production Stations

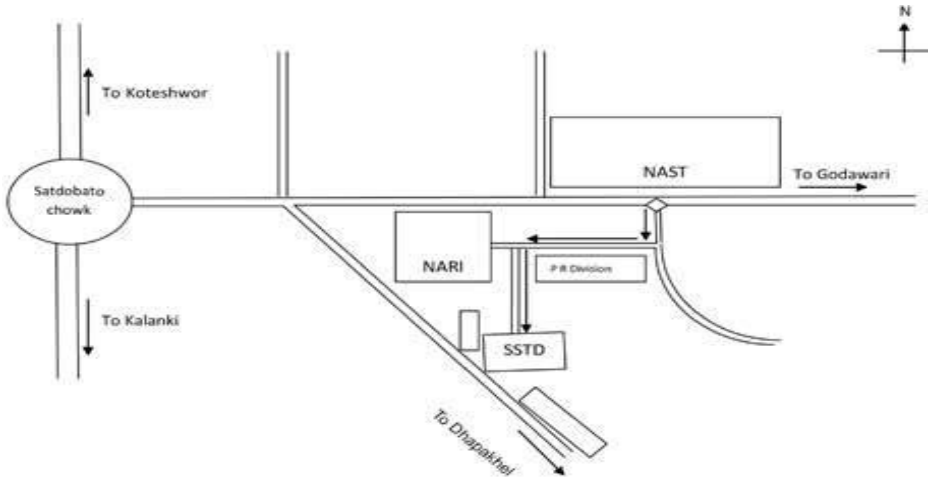


Annex 1.2. Monthly agro-meteorological data of Khumaltar

(Maximum and Minimum Temperature and rainfall of 2016/17)



Annex 2.1. Map of the Office/Station



Annex 2.2.1. List of Seed Testing Laboratory Facilities

SN	Major instruments	Testing facilities
1	Seed Purity Board	Seed purity
2	Sieve set *(B.B. allauf mfg.co.inc. washington D.C)*	Sampling unit
3	Microscope *(Vitascope-borrows equi. co., Leitz-HM-LUX-3, Wild M3Z- Heerbrugs Switzerland, Olympus SZ51, Leitz-Laborluz K)*	Seed identification and seed micro-organism infection
4	Calliper *(Digital and Manual)*	Seed measurement unit
5	Moisture Meter *(Universal Moisture Meter, Grain Moisture Tester (dole), Digital Moisture Meter, Wile)*	Seed moisture content
6	Seed Grinder and mixer *(Rico and Victor)*	Seed moisture content
7	Divider *(Boerner Seed Divider, Precision divider, Soil Seed Divider*	Working sample preparation
8	Balance *(Electric balance, Triple beam balance, Pan balance, Torsion balance, Digital counting balance/ Weighing scale, Electronic kitchen scale, Denver instrument-counting balance,4-digit balance-Kern ABJ,3-digit balance-Grain density meter- Phoenix instrument and electronic balance of 100 kg capacity)*	Working sample preparation and seed purity component weighing
9	The pHep Famile Hanna Instrument*(Min./Max. temp. record)*	Seed conductivity test
10	Thermometer	Calibration of germinators
11	Altimeter	Measuring the altitude
12	*Hygrometer (Tem./Clock/Humidity)*	RH /T measurement
13	Hanna EC meter *(meters for EC/ TDS/^{O}C/^{O}F)*	Conductivity test
14	Desiccators *(Big size, medium size and small size)*	Seed moisture content
15	Fiber Measuring tape *(Field tape)*	Field trials
16	Seed Germinator *(ELE-single chamber, Labline Technocracy- single chamber and double chamber)*	Germination, ageing, cold test etc.
17	Sealing Machine *(Vacuum sealer & Impulse sealer)*	Relative to post- harvest study

SN	Major instruments	Testing facilities
18	Refrigerator *(Normal fridge-white)*	
19	Oven *(Memmert, Lg, Heraeus, Electric Baking Oven, Cenco-DTC 203)*	Moisture testing and drying beads
20	Stabilizer and Voltage Regulator *(Stavol-matsunaga, Powertech-3KVA, Powertech-2 KVA, Premier Servo motor control PS 2000 VA and 1500VA*)	Power supply to sensitive machinery and digital balance
21	Sample Trier	Sampling unit
22	Soil Auger *(Screw type-98 mm)*	Soil sampler
23	Steel cupboard *(plain and locker type)*	Chemical storage
24	Filing cabinet *(steel and glass door cabinets)*	Record filing
25	GPS- *GARMIN (e-Trex Legend H & Vista H, Rugged and high sensitivity GPS)*	Measurement of altitudes and others
26	Altimeter *(Multifunction digital altimeter, Model no. ZD-2028/ 6 in 1)*	Measurement of altitudes on sample collection
27	Eye piece-digital camera (*Coslab- MDCE-5C)*	Microscopic photography
28	Digital Camera- *Sony, Cyber- shot14.1 mega pixels, Carl Zeiss, Vario-Tessar*	Photography
29	Photocopy machine *(Canon-iR 1024)*	Xerox copy, photocopying
30	Chlorophyll meter	Chlorophyll test
31	Laminar flow	Health test
32	Dickey john *(Moisture meter)*	Moisture test
33	Seed analyzer with scanner	Seed analysis
34	Desktop Computer sets *(Goldkist, Lenovo, Acer)*	Data recording and technical works
35	Mobile set *(Huawei)*	Communicating
36	Water pump *(Crompton Greaves)*	Water supply
37	Seed grinder Lab mill 3310 perten S/N 160611	Seed grinding
38	Gas Air Quality Meter-CO2, O2, CO, RH, 42Temp 6 in 1	Gas analysis
39	Computerized seed counter	Seed counting
40	ZH 3500 Generator	Power supply

SN	Major instruments	Testing facilities
41	Chlorophyll meter spad 502	Chlorophyll reading
42	Digital vernier caliper	Quantitative trait reading
43	Digital vernier caliper DL.S1 Lutron	Quantitative trait reading
44	Grain moistiure wile	Moisture test
45	Soil moisture meter	Soil moisture test
46	Grain moisture tester wile	Grain moisture test
47	Camera canon DSLR	Photo
48	Germinator single chamber	Germination
49	Check point of O2/Co2 recharge adapter	
50	Vaccum seed counter	Seed counting
51	Canon 3010 3 in 1 printer	Printing
52	Seed blower complete set	Purity
53	Laborator aspirator	Purity
54	Single ear thresher	Threshing
55	Digital temperature and humidity	Temperature and humidity reading
56	Seed coating machine	Seed coating
57	Plant growth chamber	Gemination
58	Seed sampling tyres, light weight	Seed sampling
59	Digital thermo hygrometer	Temperature and RH reading
60	Seed sampler 30 inches×5 holes	Seed sampling
61	Hand scoop SS large	
62	Seed sample 30 inches×5 holes	Seed sampling
63	Seed germinator, single chamber,14 ,trays, digital brand, accumax, India	Seed germination
64	Seed trier 200mm brass heavy	Seed sampling
65	Ag seed magnifier W/light seed, Buro Ag-MC110/c	Magnifying seed
66	Vaccine carrier 1.6 liter w/4 Ice packs Aov	Cooling
67	E.Q.F Disintegrator high speed speed mill 24000 RPM 100 GFW100	Seed milling
68	Sieve set 75mm SS with 20 sieves	Sieving
69	Seed ageing chamber 10 cu ft. All stainless steel accumax India	Vigour test
70	Grain moisture tester wile	Moisture test

SN	Major instruments	Testing facilities
71	Seed Germinator single chamber-2	Germination test
72	Seed coating machine-1	Seed coating
73	Plant growth chamber-1	Germination
74	Single panicle/head thresher-1	Threshing
75	Dansensor O2 and CO2 gas analyser-1	Gas analysis
76	Seed Moisture Meter Wile 78 Crusher-7	Moisture test
77	Seed Laboratory Aspirator-1	Aspiration
78	Seed blower Dacota type-1	Blowing
79	Vacuum seed counter-1	Seed counting
80	Xerox set 3 in one Canon MF 3010-2	Printing
81	Seed sampling tier-33	Seed sampling
82	Hygrometer-50	Humidity
83	Digital vernier caliper-5	Diametre
84	Soil moisture meter-1	Soil moisture test
85	Digital temperature and RH indicator-2	Temperature and RH
86	Digital Camera Canon-1	Picture capture
87	Seed Aging Chamber-1	Vigour test
88	Seed Enlarger seed Buro-1	Magnification
89	High Speed Grinder-1	Grinding
90	Portable Sieve Set-1	Seiving
91	Seed scoop-7	Seed lifting
92	Ice box-1	Cooling

Annex 2.2.2. List of Molecular Laboratory Facilities

SN	Major Instruments	Testing facilities
1	Centrifuge *(REMI, CAT No. R-24, Serial no.-VCDP-5338)*	Homogenizing unit
2.	Spectrophotometer (*JENWAY, Model no. 6705, Serial no. 3651-single cell holder)*	Quantification of DNAs
3.	Medifuge *(Heraeus Sepatech RPM X 1000)*	Homogenizing unit
4.	Micro-centrifuge *(PPW Med. Instrument, Model no. MPW-55, Ref no. 10055)*	Homogenizing unit
5.	Magnetic stirrer *(SONAR, CAT No. MS-1, Serial no. F0034910311)*	Shaking and mixing unit
6.	Vortex mixer *(Accumax- Touch type and Talboy USA-digital)*	Shaking the solutions
7.	Ice Crusher (*RMP 1450 r/min, Model no. I110 and Ice flack machine-SIMAG)*	For making ice Flakes
8.	PH meter *(Chemi line, Digital PH meter with ATC CL-120)*	Determining PH
9.	Vitascope *(Burrows equipment co., Evanston, Illionis, USA, Serial no. S104)*	X-rays of seed and Florets
10.	Deep fridge *(Philips, Whirlpool and Yasuda)*	Preserving the DNAs
11.	Fridge *(LG- GL-M282 VML.APTQGSN, Serial no. 104NRNK 19651)*	Storing the chemicals and reagents
12.	Micro Oven *(LG- ECN.MS-2344BB/01, Serial no. 803TAUL 00070)*	Preparing gel
13	Electrophoresis *(power supply - Serial no. 93086, EV 243, Made in Belgium)*	Supply of power and gel electrophoresis unit
14	Water Distillation Unit *(Accumax, India)*	Making distillation of water
15	Autoclave *(Accumax, India)*	Sterilization unit
16	Polymerase Chain Reaction *(PCR - Corbet, Model no. CGL-96, Serial no. C-10081)*	DNA sequence amplification unit
17	Water bath *(SONAR)*	Warming the PCR Recipes
18.	Gel documentation (*Alpha Innotech*)	Documenting the banding of DNAs on gel
19.	Air Conditioner *(Panasonic and Chunlan)*	Cooling lab
20	Aniamx Real Time PCR, PC system, Power backup solar Hybrid (3 pieces)	DNA Finger printing
21	Incubator Machine (Water bath)-18X18X18)	Incubation

Annex 2.3. Human Resource in 2073/74 (2016/17)

SN	Name	Position	Qualification	Specialization/Working area
1	Tara Bahadur Ghimire	S5	PhD.	Agronomy
2	Sangita Kaduwal	S1	MSc. Ag.	Agronomy
3	Gopal Bhandari	T6	MSc. Ag	Entomology
4	Subhadra Wagle	A6	BA	Administration
5	Devi Kumari Dhakal	A6	BA	Store management
6	Sunil Shrestha	A5	MBS	Accounting and tax
7	Pragnya Pokharel	T5	B.Sc Ag	Agricultural Economics
8	Goma Bajgain	T1	Literate	Lab Assistant
9	Bishnu Maharjan	T1	Literate	Lab Assistant
10	Madan Man Dangol	T2	Literate	Driver

Annex 3.1. Summary Progress of Research Projects in FY 2073/74 (2016/17)

PN/ AN	Name of project/activity	Project/Activity leader	Budged	Major progress/achievements
172	**Storage and post harvest technology development in agricultural crops**	**G.Bhandari**		
1	Effectiveness of modified atmosphere (Co_2 fumigation) in hermetic storage in different moisture contents in quality attributes of maize (Zea mays)	G.Bhnadari	479.00	Trials are just installed.
2	Monitoring on seed storage condition and pest effects on seed producing farms of GO, NARC, Seed Company and farmers groups	G.Bhandari	89.00	Almost all warehoused except CG seed Processing House found below the standard of warehouse audit.
3	Study of O_2 and CO_2 level in different container/bags in different moisture level in storage condition	G.Bhandari	225	Trials are just installed.

PN/ AN	Name of project/activity	Project/Activity leader	Budged	Major progress/achievements
4	Study on compressed CO2 fumigation in sealed container	G.Bhandari	165	Trials are just installed.
173	**Qualitative and quantitative characterization of pre-released varieties of agricultural crops**	**TB Ghimire**	**395.00**	
1	Agro morphological characteristics study of hill varieties of rice	S.Kaduwal	105.00	Descriptors of 6 genotypes of rice Viz: NR-11011, NR-11105, NR-11052, 08 FAN10, NR-10769 and Khumal-4(as Check) were prepared.
2	Agro morphological characteristics study of wheat	S.Kaduwal	105.00	Ten genotypes of wheat (hill set) characterized and their descriptors prepared
3	Agro morphological characteristics study of lentil	S.Kaduwal	75.00	Eight genotypes of lentil along with black lentil of Rasuwa characterized and their descriptors prepared
4	Agro morphological characteristics study of barley	S.Kaduwal	80.00	Eight genotypes of naked barley characterized and their descriptors prepared
5	Notification in national gazette	T.B.Ghimire	30.00	Data was not sufficient for notification
234	**Seed vigour enhancement technology development**	**T.B.Ghimire**	**500.00**	
1	Seed vigour enhancing technology development in maize	**T.B.Ghimire**	145.00	No any significant difference was observed among the treatments however higher yield and maximum plant population was observed in salt treated seeds.
2	Effect of seed priming with botanical extracts	S. Kaduwal	135.00	There was no any significant difference

PN/ AN	Name of project/activity	Project/Activity leader	Budged	Major progress/achievements
	on seed vigour and growth in wheat			among the treatments however highest yield was obtained in neem extract and maximum plant population in asuro soaked seeds.
3	Effect of seed pre-treatment on direct seeded rice (DSR) under flooded condition	S.Kaduwal	130.00	No treatment effect on DSR rice
4	Assessment of seed invigoration technique in jute	S.Kaduwal	90.00	Jute genotype O-4 stored in super grain bag resulted higher vigour index among the studied genotypes
235	**Participatory technology verification and dissemination on quality seed**	**TB Ghimire**	**668.00**	
1	Seed testing services to farmers, seed producer, companies and stakeholders.	S.Kaduwal	410.00	242 service samples and 180 research samples were tested and reported to concerned agencies.
2	Verification of seed storage and zeolite bead drying technology at farm level	T.B.Ghimire	183	Zeolite bead reduces the tomato seed moisture from 9% to 7% in 3 month storage period.
3	Monitoring of source seed production, processing and storage in NARC stations, private companies and cooperatives		75	NARC station seed and private seed companies were monitored for their seed processing and storage techniques.
246	**Seed variety identification and diversity analysis using DNA fingerprinting technology**	**TBGhimire**	**1131.00**	
1	DNA profiling (fingerprinting) and diversity study of the	S.Kaduwal		28 different promising lines were collected for DNA profiling and finger

PN/ AN	Name of project/activity	Project/Activity leader	Budged	Major progress/achievements
	wheat varieties in national list			print prepared for diversity study
2	Collection of authentic samples of wheat varieties in national list	S.Kaduwal	50.00	Different promising lines of wheat were collected from NWRP, Bhairahawa and Agri-botany divison, Khumaltar for DNA study.
3	Extract DNA of wheat varieties for genetic profiling	S.Kaduwal	250.00	Bulk DNA extracted using C-TAB method
4	SSR marker diversity analysis for DNA fingerprinting of wheat	S.Kaduwal	300.00	40 SSR primers were used, four primers did not show amplification. From 19 primers, a total of 552 bands were produced with an average of 11.35 alleles per locus. Four SSR primers Xbarc 77, Xgwm 136-1A, Xgwm 174-5D and Xbarc 267 generated higher levels of polymorphism
5	DNA profiling (finger priniting) and diversity study of nationally enlisted released varieties, landraces and promising genotypes of jute	S.Kaduwal		20 different, released and promising genotypes were used for DNA profiling
6	Management of different seeds for molecular study along with the required chemicals	S.Kaduwal	62.00	20 entry of jute (released and pipeline) seeds collected from JRP Itahari and initial seed quality were tested following ISTA rules at SSTD lab.
7	Germination of jute seed for DNA extraction from the seedling obtained	S.Kaduwal	150.00	Seed were sown in a tray, 7 days old jute leaf were taken for DNA extraction
8	SSR based DNA	S.Kaduwal	319.00	Out of 30 SSR markers,

PN/ AN	Name of project/activity	Project/Activity leader	Budged	Major progress/achievements
	fingerprinting for different genotypes of jute			12 SSR markers generated banding pattern. A total number of 262 bands were scored of which none was monomorphic. SSR primers namely MJM 489, HK-7 and HK-22 generated higher levels of polymorphism.
247	**Efficacy of different neonicotinoid insecticides on seed treatment against early damaging insect pests of vegetables**	**G.Bhandari**	**411.00**	
1	Monitoring of early damaging insects of vegetables in different location		176.00	The monitoring results revealed that most of the sap sucking insects found to be infested in vegetable crop in early stage.
2	Seed treatment efficacy study		235.00	Neonicotinoid insecticide found effective against early damaging insect pests of cowpea.

Annex 3.2. Summary progress of PMAMP Projects of SSTD FY 2073/74 (2016/17)

Project code number	Name of project/activity	Project/Activity leader	Budged allocated for this year	Major progress/achievement
1	Seed value chain study of rice, wheat, and maize and source seed improvement within NARC	TB Ghimire	2600	Seed Value Chain Study of rice, wheat and maize in 3 super zone area was completed.
2	Training to NARC personnel	TB Ghimire	600	Completed successfully by participating 26 participants from different station with 13 experts.
3	Monitoring to the Super zone and NARC Station.	TB Ghimire	400	All Super zones except apple and Fish SZ monitoring was done by Chief, SSTD.
4	Machinery/Equipment purchase	TB Ghimire	5000	Seed germinator, Seed counting machine, Seed moisture meter, Seedling growth chamber, Single panicle thresher, Seed blower, Seed Lab Aspirator, O2 & CO2 gas analyzer, Hygrometer, Digital temp. and RH indicator, Digital veneer Caliper, Zerox set 3 in one, Seed sampling tier and Digital camera
5	Administration expenses	TB Ghimire	424	Monitoring

Annex 4.1. Training/Workshop/Seminar Organized in FY 2073/74 (2016/17)

SN	Name of Training/ Workshop/ Seminar	Duration	Target group	Location	No. of participants
1	Training on source seed production, post-harvest handling and internal seed quality control	3 days 2073-11-23 to 2073-11-25 BS	Seed production technicians	NMRP, Rampur	26

Annex 4.2. Services Provided in FY 2073/74 (2016/17)

SN.	Laboratory test services	Commodity	Numbers	Major clients
1	Routine seed testing	Rice, wheat, maize, legume, vegetable, fodder, tori, flower	242	Commodity programs (NWRP, NRRP), Disciplinary Divisions (AGD, ABD, HRD), SQCC, Fodder Research Division, Everest Seed Company, Co-operatives and farmers
2	Seed research sample	Rice, maize. wheat, finger millet, legume, tori, vegetable, forage, jute and flower	180	
	Total		422	

Annex 4.3. Publications in FY 2073/74 (2016/17)

SN.	Name of publications	Type *	Language	Authors	No. of copies
1	Annual Report (2072/73) of SSTD	Book	English	SSTD	200
2	Manual on variety Maintenance and source seed production of Cereal crops	Book	English	Dr. Tara Bahadur Ghimire	300

**Books, leaflet, brochure, manuals, pamphlets, audio visual etc*

Annex 4.4. Visits of the Office by Farmers, Extension Officials / Technicians, Entrepreneurs, Cooperatives, Farmer Groups, NGO/CBO Officials etc.

SN	Category	Number	Districts	Area of major interest
1	Students	20	Sato Thimi campus, Bhaktapur	Seed testing facility and laboratory visit Molecular lab activities. Technical information about seed quality and seed testing services.
2	Student	31	Meridian International School, Baluwatar	Visit of seed testing laboratory. Information of seed quality testing.
3	Trainees	10	Kathmandu Training Center	Seed lab activity and seed research aspect

Annex 5.1. Training/Workshop/Seminar Attended by Staff in FY 2073/74 (2016/17)

SN	Name of staff	Position	Name of Programme	Duration	Place/ Country	Organizer
1	T.B. Ghimire	S-5	Exchange Visit	7 days	China	NARC
2	G Bhandari	T-6	Hybrid Rice Seed Production Technology intensification for Developing Countries	2 Month	China	NARC

Annex 6.1.Regular Annual Budget and Expenditure of FY 2073/74 (2016/17)

(in Nepalese Rupees)

Budget Code: 3121363 Current Expenses

Code	Budget Heads	Annual budget	Expenses	Balance
21111	Staff Basic Salary	4886000.00	4825448.67	60551.33
21113	Staff Allowance	168000.00	136033.33	31966.67
21121	Staff Uniform	105000.00	82500.00	22500.00
21123	Staff Medical Expenses			
22111	Water, electricity cost	50000.00	49393.15	606.85
22112	Communication Insurance Fund	100000.00	100000.00	0
22211	**Fuel**	346,000.00	337827.50	8172.50
22212	Operational and repairs maintenance	260000.00	259902.80	97.20
22213	Insurance	35000.00	25640.10	9359.90
22311	Office supply	400000.00	399845.89	154.11
22521	Production input and service expense	3728000.00	3637926.04	90073.96
22612	Travel expenses	700000.00	699960.69	39.31
22711	Miscellaneous	40000.00	39997.00	3.00
	Total	**10818000.00**	**10594475.17**	**223524.83**

Budget Code: 3121364 Capital Expenses

Code	Budget Heads	Annual budget	Expenses	Balance
29311	Furniture and Fixtures	100000.00	99599.99	400.01
29411	Vehicle	14000.00	14000.00	0
29511	Machinery & equipment	1675000.00	1674978.00	22.00
	Total	**1789000.00**	**1788577.99**	**422.01**

Annex 6.2. Special Project Budget and Expenditure Records of FY 2072/73 (2015/16)

(in Nepalese Rupees)

Name of the project	Funded by	Project period	Annual budget	Expenses
PMAMP	Nepal Government	**FY 2073/74 (2016/17)**	9024000.00	8991462.73
National Reconstruction Authority	EU	**FY 2073/74 (2016/17)**	1500000.00	1492622.00

Annex 6.3. Revenue Status of FY 2073/74 (2016/17) *(in Nepalese Rupees)*

Source	Total	Remarks
Income from Crop and Horticulture Research(Seed testing service charge)	70299.90	Routine seed testing service charge
Income from Other administrative services	14100.00	Sales of tender form
Total	84399.90	

Annex 6.4. Beruju Status of FY 2073/74 (2016/17)

Beruju	Amount(Rs.)	Remarks
Beruju till last year	106175.00	In the process of clearance
Beruju cleared this FY	106175.00	
Remaining Beruju	27000.0	
Document processed for clearance of Beruju	27000.00	

Seed multiplication of local barley of Rasuwa

WK 1712 - Promising genotype of awnless wheat for high hills

Agromorphological Characterization of Rice

Seed testing services at Seed Science and Technology Division, Khumaltar