PART-I: GENERAL INFORMATION

200 Project Code
2001 Institute code No.
2002 ICAR Code No.

201 Name of the Institute and Division
2011 Name and address of Institute
IGFRI, Jhansi-284 003
2012 Name of Division/ Section
Crop Improvement Division
2013 Location of project
Jhansi(U.P.)

202 Project Title
Genetic improvement of Barley for forage and grain yield

203 Priority Area
2031 Research approach
Applied Res 01.
Basic Res 02

 Genetic Improvement
03 Process/Technology Development
04 Transfer of Technology

204 Specific Area
2041 Previous project/projects in this specific area (Year, type of funding, cost etc.)
Forage crop improvement

205 Duration
2051 Date of start
2012-13
2052 Likely date of completion
2016-17

206 Total cost of the project
2061 Foreign exchange component (if any)
Not mentioned.
Nil
Barley (Hordeum vulgare L.) is one of the oldest and most widespread cereals of the world. The greatest share of the world’s barley grain is used for animal feed, followed by malting and human food. In India the crop is primarily grown for grain in rabi season on over 0.65 mha in the northern plains and northern hills. Selecting for barley cultivars in the past has largely occurred as the result of selecting for grain yielding ability. The crop, however, can be utilized as green forage plus grain crop i.e. barley as cut green forage (soilage), grain (feed, malt, food) and straw (fodder). In barley, vegetative and reproductive growths are separated in time. When grown as a green fodder plus grain crop, the first cut of barley at proper vegetative growth stage provides fresh and nutritious green fodder to animal at minimal cost. The ratoon is maintained for grain. The harvest at crop maturity gives satisfactory grain yield and straw yield. Barley straw is an important feed source for cattle and small ruminants during the dry season. The goal of this research project “Genetic improvement of Barley for forage and grain yield” is to develop a new pure-line barley superior to the existing one in per unit production of green fodder and grain through recombination breeding. Efforts will also be given to develop malting barley.

Key words: Barley, Hordeum vulgare L., dual-purpose (green fodder plus grain) barley, malting barley, breeding.

PART-II: INVESTIGATOR PROFILE

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PART - III : TECHNICAL DETAILS

220 Introduction and objectives:

2201 Origin of the project: (Problem identification)
India faces an acute shortage of over 23% green fodder, 31% dry fodder and 47% concentrate feed in the agriculture sector. In India barley is grown under rainfed and irrigated conditions. Barley area in India has decreased from 3.11 mha in 1950-51 to 0.69 mha at present. Its productivity, however, has increased from 7.46 q/ha to 22.5 q/ha. Principal uses of barley grain are feed for animals, malt for brewing and other purposes, food for human consumption, and seed. During past few years, the winters have become warmer in hills and drought is becoming a frequent occurrence. Because of the recent droughts in the drier parts of northern plains, acute shortage of green forage may occur during scarcity period (November to February). As oats, berseem and sugarcane require more water than barley, they are not better option for green forage under conditions of water scarcity. In such situation barley can be utilized as an alternative source of green forage in the drier parts of states (U.P., M.P., Haryana, Punjab, Rajasthan, Himachal Pradesh, Jammu & Kashmir and Uttrakhand). Northern hill people are also growing barley in apple orchard or utilizing barley as green forage. During recent years barley cultivation in India has got a boost because its use in malt industry. The impetus provided by the need to increase barley grain production has led also to increase green forage production before reproductive stage at minimal cost. A few barley varieties released for grain purpose such as Azad (K 125), K 141, and Ratna were also recommend for single-cut green forage. barley can be used as green forage and grain in India.

2202 Definition of problem:
Acute shortage of green forage may occur during scarcity period when green fodder is not easily available in the drier parts of northern plains. Assimilate supply during vegetative growth does not necessarily limit grain production in annual cereals. Breeding efforts are very much needed for developing dual-purpose (green forage plus grain) barley varieties capable of giving satisfactory grain yield even after cutting the crop for green forage at vegetative stage.

2203 Immediate objectives: Identification of sources for high green forage yield and high grain yield components in barley germplasm, and development of dual-purpose (green forage plus grain) barley cultivars with improved forage quality.

2204 Long term objectives: Development of malting barley cultivars, and development of novel germplasm.
Barley (\textit{Hordeum vulgare} L.) is the world's fourth most important cereal crop in terms of total production after wheat, maize and rice. The use of barley for human food is most common in regions where other cereals do not grow well because of altitude, latitude, low rainfall or soil salinity (Poehlman 1985). Barley is grown mainly as a grain crop, although in some regions it is grazed or harvested during vegetative stage for green forage. In the winter barley region of the United States, the barley crop may be used for pasture, or for hay or silage, and so forage quality is important in the winter varieties (Poehlman 1987). Barley straw is an excellent candidate as a cellulosic ethanol feedstock.

Cultivated barley (\textit{Hordeum vulgare} L.) is derived from its wild relative (\textit{Hordeum spontaneum} C. Koch) and was domesticated about 10 thousand years ago in the Fertile Crescent of the Near East. The progenitor of cultivated barley has a brittle two-row spike and a hulled grain. The first cultivated barleys were 2-rowed types. In high-production irrigated and rainfed areas, 6-rowed types quickly became the predominant barleys (Harlan 1979). The weed forms of barley are \textit{Hordeum spontaneum} K. Koch., \textit{Hordeum agrocrithon} Aberg., \textit{Hordeum intermedium}, \textit{Hordeum bulbosum}, etc. \textit{Hordeum spontaneum} C. Koch represents a genetically diverse source of diverse phenotypes for barley improvement (Henry and Brown 1987). Whilst a white cross may offer a better chance of producing superior recombinants, most barley breeders concentrate on a narrow crossing strategy (Rasmusson and Phillips 1997).

Barley is a cool season self-fertilizing diploid annual species with determinate growth. Barley breeding began with the development of agriculture in the Middle East. To some people, barley was an important food and/or feed crop, but to most, it was also the basis for beer production. Originally barley was mainly cultivated and used for human food but it is now used primarily for animal feed and to produce malt, with smaller amount used for seed and direct human consumption. Modern barley breeding began in England, Sweden and the United States with the selection of pure-line cultivars from the land races that were being grown e.g. Atlas in US, O.A.C. 21 in Canada, Chevallier in England, Svanhals, Hannchen, Gull in Sweden. The best-known breeding populations are the composite crosses (CCs) in barley, dating back to 1923 (Harlan and Martini 1936). Transgressive segregation has been reported in barley (Aksal and Johnson 1961).

The barley productivity has been increasing globally for the past thirty years though the area decreased from 79.36 mha during 1981-85 to 47.89 mha in 2010-11. In 2004 up to 57.0 mha were planted with barley gaining an average yield of about 27.2 q/ha (FAO 2005). Simmons et al (1982) found that high tillering lines had higher tillering mortality and increased lodging. Benbelkacem \textit{et al} (1984) reported yield increases obtained by increasing tiller number. Kitchen and Rasmusson (1983) concluded that genetic variation in duration of the growth periods in barley might be used in breeding for increased yield. Fowler and Rasmusson (1969) studied leaf area relationships and inheritance. Berdhal \textit{et al} (1972) concluded that lines with small leaves produced more heads per unit area and that large leaves favoured higher kernel weights.
Grain development progresses through a number of stages: watery ripe, milk, soft dough, and hard dough, grain hard and harvest ripe (Nelson et al 2001). The contribution of preanthesis reserves to grain yield appear to be important in barley, contributing 20% of final grain weight (Cock and Yoshida 1972) to 30% (Biscoe et al 1975). If grain number per ear is reduced in barley the remaining grains may not grow to a greater size in barley (Buttrose and May 1959) suggesting that assimilate supply was not limiting grain growth in intact ears. Kirby (1969) reported that in barley final grain yield was virtually unaffected by plant density over the range from 50 to 800 plants/m². Soil fertility and water supply, and the usual seasonal sequence of conditions, may favour a particular balance among the yield components, as Grafius and Okoli (1974) argue for barley.

Barley is the principal feed grain in northern and eastern Europe, Canada and in northern United States. The largest use of barley is for livestock feed, in order to supply digestible energy. In most cases, the whole barley kernel is rolled, ground, or flaked, prior to being fed, to improve digestibility (OECD 2004). About 15% of barley grain feed to cattle is excreted whole and undamaged (Kaiser 1999), suggesting these is the potential for livestock to disperse viable barley seed after consumption. High protein barley is best suited for animal feed. Bowman et al 2001 studied feed-quality variation in the barley core collection.

The crop is also produced for the grain, to be used for malt. The barley is converted to malt by the process known as malting. Malting is a controlled, limited germination process of the barley grain used to activate and synthesize enzyme system (Peterson and Foster 1973). The malt soon ferments and becomes slightly alcoholic. Malting barley has usually lower protein i.e. low grain nitrogen. Both 6- and 2-rowed barley varieties are utilized for malting; the 6-rowed varieties are characterized by high enzymatic activity and the 2-rowed varieties by high extract (Poehlman 1987). Each spike may carry 25-60 kernels in 6-rowed barleys or 15-30 kernels in 2-rowed barleys (Briggs 1978). Six-rowed barley typically has broad fleshy leaves and a higher LAI compared to 2-rowed barleys. Two-rowed barley has lower protein content than the 6-rowed barley, thus more fermentable sugar content. Sisler and Banasi (1951) found that selection in the F3 generation of barley cross for kernel weight, per cent nitrogen, diastatic power, and per cent extract increased the proportions of lines with acceptable quality. Bell and Lupton (1962) have aptly described the breeding of malting barley varieties and associated problems. The barley breeder’s efforts must be to develop varieties which contain suitable levels of agronomic and disease characteristics for given environments and the proper combination of malting quality traits.

Improvements in barley grain yield really started after 1940 with the release of cultivars derived from deliberate crossing. No significant increases in biological yield have been reported; the increased grain yields have been due to an increase in grain/straw ratio. Despite many barley mapping studies in the public domain, barley breeders are largely relying on conventional phenotypic selection to maintain this progress. Recently, barley has been gaining renewed interest for food due to its hypo-cholesterolaemic effect.
In India, barley is an important rabi cereal crop after wheat and the total area sown to barley during 1950-51 was about 3.11 mha and the productivity was 7.64 q/ha. After 60 years, barley area in India has decreased to 0.65 mha but its productivity has increased to thrice (24.8 q/ha). More production of barley with decrease its area is due to the coordinated research effects under varietal improvement and better production technology under varietal improvement project. In India, spring-type barleys are fall seeded, early varieties are needed to reach maturity ahead of the onset of summer weather.

Barley and wheat are grain crops but can be used for feeding animals. India is shorter in animal feed (dry fodder by 31%, green fodder by 23%, and concentrate feed by 47%). Both crops selected largely for grain yield. Barley is fast growing crop with high biomass at early stage and is alternate forage cum grain crop in water deficit and salt affected soils. Compared to barley, Berseem and Oats require frequent irrigation. Barley is grown in the northern plains (Rajasthan, UP, MP, Punjab, Haryana, Bihar) and in the hills (HP, Uttarakhand, Jammu & Kashmir). Barley as a dual-purpose crop (green forage & grain) may meet the requirements. The double-ridge stage in small cereal grain crop indicates the transition from leaf to ear formation. The crop can be given one cut at 50-55 DAS in plains and 70-75 DAS in hills for green forage and satisfactory levels of grain yield from the regenerated crop can be utilized as feed or food. Dual-purpose barley can produce about 170 q green forage/ha at cut and after rejuvenation can produce 40 q grain/ha.

**Fig. 1:** Forage & grain productivity (q/ha) in dual-purpose Barley cut at different dates after sowing

AICW&BIP has released many wheat and barley varieties of which some grain varieties also do well for dual-purpose.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Situation</th>
<th>Variety</th>
<th>Parentage</th>
<th>Station</th>
<th>Year</th>
<th>Forage (q/ha)</th>
<th>Grain (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWPZ</td>
<td>Irrigated, timely sown</td>
<td>RD 2035</td>
<td>RD 137/ PL 101</td>
<td>ARS, SKRAU, Durgapura</td>
<td>1994</td>
<td>228</td>
<td>27.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RD 2552</td>
<td>RD 2035/ DL 472</td>
<td>ARS, SKRAU, Durgapura</td>
<td>1999</td>
<td>216</td>
<td>27.7</td>
</tr>
<tr>
<td>NEPZ</td>
<td>Irrigated, timely sown</td>
<td>Azad (K 125)</td>
<td>K 12/K 19</td>
<td>CSAUA&amp;T, Kanpur</td>
<td>1975</td>
<td>198</td>
<td>33.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RD 2552</td>
<td>RD 2035/ DL 472</td>
<td>ARS, SKRAU, Durgapura</td>
<td>1999</td>
<td>233</td>
<td>34.7</td>
</tr>
<tr>
<td>CZ</td>
<td>Irrigated, timely sown</td>
<td>RD 2715</td>
<td>RD 387/ BH 802/ RD 2035</td>
<td>ARS, SKRAU, Durgapura</td>
<td>2008</td>
<td>160</td>
<td>27.7</td>
</tr>
<tr>
<td>NHZ</td>
<td>Rainfed, timely sown</td>
<td>HBL 276</td>
<td>HBL 233/ HBL 238</td>
<td>CSKHPKV, Bajaura</td>
<td>1999</td>
<td>52.8</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BHS 169</td>
<td>Kailash/ Briggs</td>
<td>IARI RS, Shimla</td>
<td>1997</td>
<td>53.0</td>
<td>15.7</td>
</tr>
</tbody>
</table>

(Source: Verma et al. 2012)
Barley grain has been traditionally used as animal feed and grain crop for human consumption in India. During the late seventies a few varieties like Azad, K141 and Ratna, were also recommended for single cut for green forage (Verma et al. 2012). Barley is the staple food crop in the tribal areas of hills where it is also used in preparation of local beverage in addition to food and cattle feed. It is predominantly grown under rainfed conditions in the northern hills and farmers use very low inputs (Verma et al. 2005). During past few years winters have become warmer in hills and drought is becoming a frequent phenomenon. Therefore most of the farmers now prefer to grow barley over other crops as it supposed to be drought tolerant (Verma et al. 2005). Sharma et al. (1999) pointed out scarcity of fodder and availability of limited feed during the rabi season in high altitude of northern hills of India, is a serious problem for livestock production. The areas of Haryana, northern Rajasthan, western UP and southern Punjab with sandy soils and shorter vegetative phase with grain development under relatively low temperature, have been identified suitable for malt barley cultivation. The Barley Network in association with AICRP(FC), Jhansi recently took an initiative to look at the possibility of utilizing barley as a dual-purpose crop. There is also a need for evaluation of the forage quality traits to improve the overall suitability as barley green forage.

Chaudhary et al. (1974) estimated genetic parameters in barley and suggested that high specific combining ability effects for plant height, ear length, no. of grains per ear, grain yield and 1000-grain weight were the result of cross having high x low general combining abilities.

Mishra and Bhagmal evaluated 256 lines of barley for fodder and grain yields at I.G.F.R.I. (Jhansi) during 1981-87 and found BP/RB-98, IC-36959, Icarda-105 and BP/RB-18 high fodder yielding. They also subjected the accessions to cutting treatments and selected 18 promising multi-cut types. They also identified 40 promising lines showing good regeneration capacity and attempted inter-varietal crossings (IGFRI QRT Report 1981-85, IGFRI Annual Report 1985, 1986).

Cultivation of new barley variety ‘Himadari’ (yield potential 38.6 q/ha, resistance to blotch and stripe rust) would stabilize the barley productivity in the hills of northern India (Kumar and Pal 2004).

Green forage productivity and barley grain productivity can be increased to a significant level by increasing seed rate and fertilizer dose by 25% (Anonymous 2007).

Pal and Kumar (2009) using 21 barley genotypes (6 parents and 15 F1s) studied genetic analysis of forage yield and other traits in barley so as to breed dual-purpose varieties and suggested scope to improve forage yield per plant, tillers per plant, ear length, biological yield per plant and grain yield per plant through bi-parental mating.

Vishwakarma et al. (2011) evaluated 22 elite lines of barley on partially reclaimed saline-sodic soil in replicated field trial for green forage yield (range 97.95-131.3 q/ha at single cut at 50 days after sowing), grain yield from regenerated lines (range 16.1-28.1 q/ha), and crude protein in grain (range 11.3-15%) and found 8 entries promising for dual-purpose barley crop.

In India the minimum quality standards of barley grain and malt have been finalized as desirable limits to classify any barley variety as malt type (Verma et al. 2005).

Kant et al. (2012) evaluated 30 barley germplasm cultivated in northern hills of India for malt traits and suggested that hills can be promising areas for malt barley cultivation.
References


Harlan, H.V. and M.L. Martini (1936) Problems and results of barley breeding. USDA Yearbook, 303-346.


221 Project Technical Profile:

2211 Organization of work elements
(For each objectives and participating investigator giving man-months involved)

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Designation</th>
<th>Contributions</th>
<th>Man-months</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P. Saxena)</td>
<td>Pri. Scientist, Pl. Pathology</td>
<td>Screening barley germplasm and segregating generations against major diseases and pests to facilitate selection for diseases and insect resistance in the breeding material.</td>
<td>2</td>
</tr>
</tbody>
</table>

2212 Methodology:

A) Barley is a seed-propagated self-pollinating annual diploid cereal grain crop which is planted in thick spacing, in which it is difficult to separate and identify individual plants.

B) 1. Recombination breeding method will be used.

2. A narrow crossing strategy will be used to produce desirable recombinants.

3. The crosses will be stratified for selection of parents based on yield values.

4. The bulk-population method of selection for line development following hybridization will be used.

5. Off-season planting of segregating generation will be used for speeding breeding process.

6. After accomplishing bulking, single-plant selections and their evaluation will be made for dual-purpose types as in the pedigree method of breeding.

7. Screen for resistance against important diseases and insect pests and selection for agronomics and yield based on phenotypes will be done.
**Plan of action**

A Plan of action following collection of barley germplasm is detailed below.

<table>
<thead>
<tr>
<th>Generation</th>
<th>Procedure</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial crossing</td>
<td>Making $F_1$ seed.</td>
<td>Identifying desirable parents and crossing between them.</td>
</tr>
<tr>
<td>$F_1$</td>
<td>Space planting $F_1$ seeds.</td>
<td>Harvesting $F_2$ seed in bulk.</td>
</tr>
<tr>
<td>$F_2$</td>
<td>Space planting $F_2$ seeds.</td>
<td>Testing $F_2$ bulk pronging from crosses and harvesting $F_3$ seed in bulk; selection of parents.</td>
</tr>
<tr>
<td>$F_3$</td>
<td>Space planting the progeny of the selected cross in bulk.</td>
<td>Harvesting $F_4$ seeds in bulk.</td>
</tr>
<tr>
<td>$F_4$</td>
<td>Space planting the progeny of the selected cross in bulk.</td>
<td>Harvesting $F_5$ seeds in bulk.</td>
</tr>
<tr>
<td>$F_5$</td>
<td>Space planting the progeny.</td>
<td>Making plant or head selections.</td>
</tr>
<tr>
<td>$F_6$</td>
<td>Growing plant or head rows of selected plants.</td>
<td>Selecting superior rows;</td>
</tr>
<tr>
<td>$F_7$</td>
<td>Growing superior progenies harvested in $F_6$ in a PYT.</td>
<td>Selection for agronomics, important diseases and insect pests and yield (green forage, grain and straw).</td>
</tr>
</tbody>
</table>

**Time schedule of activities (milestone)**

i) Acquisition and assessment of barley germplasm. [from 1st yr. onward]

ii) Making crosses between elite parents and stratifying crosses for selection of parents based on yield ($F_2$ bulk progenies) values. [from 1st yr. onward]

iii) Selection of parents with cross. Space planting the progeny of the selected cross in bulk. Harvesting $F_4$ seeds in bulk [from 3rd yr.]

iv) Space planting the progeny of the selected cross in bulk. Harvesting $F_5$ seeds in bulk [from 3rd yr.]

v) Space planting the progeny. Making plant or head selections. [from 4th yr.]

vi) Growing plant or head rows of selected plants. Selecting superior rows. [from 4th yr.]

vii) Growing superior progenies harvested in $F_6$ in a PYT. Selection for agronomics, important diseases and insect pests and yield (green forage, grain and straw). [5th yr.]

**Annual targets for each activity:**

First year
i) Acquisition and assessment of barley germplasm.
ii) Making crosses between elite parents and identifying desirable parents.

Second Year
i) Acquisition and assessment of barley germplasm.
ii) Making crosses between elite parents and identifying desirable parents.
iii) Off-season planting.
Third Year
i) Acquisition and assessment of germplasm.
ii) Selection of parents with cross. Space planting the progeny of the selected cross in bulk. Harvesting F4 seeds in bulk.
iii) Off-season planting. Space planting the progeny of the selected cross in bulk. Harvesting F5 seeds in bulk.

Fourth Year
i) Space planting the progeny. Making plant or head selections.
ii) Growing plant or head rows of selected plants. Selecting superior rows.

Fifth Year
i) Growing superior progenies harvested in F6 in a PYT. Selection for agronomics, important diseases and insect pests and yield (green forage, grain and straw).
ii) Project report preparation and submission.

2216 Estimated man months (yearly)
   a) Scientific: 7
   b) Technical: 4
   c) Supporting: 2

222 Proposed Research Details

2221 Importance of the project (gaps in knowledge/ products/ process technology) to the institute mandate.

In India barley production is mainly result from cultivation of grain barley. There is an urgent need for the research institute to plug knowledge gaps and ensure development of dual-purpose barley varieties to augment the green fodder production in the country. Since dual-purpose barley (green forage plus grain) is harvested twice, first for vegetative yield during proper phenological phase and second for grain yield at the end of reproduction stage, breeding for green forage yield and grain yield in barley also depends upon regeneration capacity of the genotypes after cut for green forage. Thus, the plant parts of interest are green forage (young, fresh stems and leaves) and dry grain. All yields is at first biological yield and the potential biomass of a crop is determined by factors including genotype, local environment and the agronomic practices used to grow it. Dual-purpose barley may differ from grain barley in a number of attributes, including the pattern of dry matter partitioning. Here the grain yield may be altered because of cut at vegetative stage and difference in regeneration ability of the genotype. For breeding dual-purpose barley crosses will be designed in which the parents complements each other for target characters (green forage yield components and grain yield components) and to select recombinants that offer a better balanced overall phenotype. The F2 bulk progenies from the process will be tested for vegetative and grain yields and crosses will be judged based on yield performance; whole crosses will be discarded if yield performance of the progenies found poor. Identification of the best recombinants will be the breeding challenge for breeding barley varieties. Of course, the product of research will be pure-line varieties as for grain barley but for serving two different purposes (green fodder and dry grain).
Proposed parameters

*Dual-purpose barley (green forage plus grain)*: early vigor, tillering ability, vegetative yield and its components, regeneration ability, green forage quality, disease resistance, grain yield and its components: days to heading, days to maturity, plant height, harvest index, 1000-kernel weight, straw yield.

*Malting barley (grain)*: grain yield, grain shape, protein content, germination disease resistance.

Questions attempted to be answered:

i) Is it possible to develop dual-purpose *(green forage plus grain)* barley varieties with high green forage yield and grain yield?

2223 **Anticipated Process/ Products/ technology/ Knowledge Expected to be evolved by pursuing the project:**

Dual-purpose barley, a speciality crop for green forage plus grain is anticipated product through conventional breeding. The economic product will be vegetative parts and then sexual parts.

2224 **Practical Utility of anticipated results of the project:**

a) *Immediate benefits.*
Production of new dual-purpose *(green forage plus grain)* barley varieties for rainfed and drier areas.

b) *Medium Term benefits.*
Increase in green forage and grain of barley as fodder, feed, food in the country.

c) *Long Term Benefits.*
Augmentation of green fodder availability and barley grain production.

2225 **Expertise available with investigator group/ Institute.**

2226 **Expertise (if any) to be obtained by investigator group from outside the Institute.**

a. Within Country

b. Outside Country  --
230 Budget Summary (Recurring)

<table>
<thead>
<tr>
<th></th>
<th>Year (1)</th>
<th>Year (2)</th>
<th>Year (3)</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Scientific</td>
<td></td>
<td></td>
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<tr>
<td>Technical</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2302 Consumables:

| i. Chemicals  | ---      | ---      | ---      | ---   |
| ii. Glasswares| ---      | ---      | ---      | ---   |
| iii. Others   | ---      | ---      | ---      | ---   |

| Sub Total      | ---      | ---      | ---      | ---   |

2303 Travel    ---          ---          ---          ---

2304 Miscellaneous ---          ---          ---          ---

2305 Sub Total (Recurring) ---          ---          ---          ---

231 Non-Recurring Expenditure (Equipments)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th>---</th>
</tr>
</thead>
</table>

232 Total (230&231) ---

233 Salaries / Wages:

2331 Justification (for technical/wages/labour in terms of work content)

234 Consumables Rs. 2 lakhs

2341 Justification ---

235 Travel Rs. 50,000

2351 Justification ---

236 Other Cost/ Miscellaneous Year 1 Year2 Year 3

2361 Field preparation / planting / harvesting (man days / cost)

2362 Inter cultivation (man days / cost)

2363 Animal maintenance

2364 Any other items

2365 Justification for above

237 Equipment

2371 Equipment already available to be used in project

2372 Equipment to be purchased with cost: ---

2373 Justification for each additional equipment

2374 Equipment to be imported

2375 Justification for import

238 Additional infrastructure facilities (if needed)

2381 Works

2382 Land (sq. meter)

2383 Animals

239 Financing Organization

If funded by an organization other than the institute, then give the following information:

(a) Name the financing organization:

(b) Title of the project

(if the project forms a part of a larger project)
PART-V: DECLARATION

This is to certify that

- The research work proposed in the scheme/project does not in any way duplicate the work already done or being carried out in the institute on the subject.
- The same project has been/has not been submitted to any other agency(ies) for financial support (if already submitted identify project and agency).
- The investigator/co-investigators have been fully consulted in the development of project and have fully undertaken the responsibility to carry out the programme as per the technical programme.

(A.K. Singh)
Principal Investigator

(P. Saxena)
Co Project Investigator

Signature and comments of the Head of the Division/Section

[Signature]

Signature and comments of the Joint Director (Research)

The project had been approved in PI 1RE-2012 as suggested, Nt Pi submitted Nt revised. In incorporating NT suggested given by Nt 1RE.

Signature and comments of the Director

[Signature]