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Challenges, Coping Strategies and Potential Grain Legume and Cereal Crops for Dry Land Rain Fed Agriculture in Nepal

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ABSTRACT

Rain-fed agriculture is commonly practiced in Nepal which relies on seasonal precipitation, often shows a grim picture of a fragile environment due to water scarcity, drought, soil degradation, low rain (water) and nitrogen use efficiency. It was reported that large chunk 72% area covers under rain-fed farming in Nepal. It was estimated that about 42% of children in the dry lands of Asia are malnourished. Mixed (crop-livestock) farming systems are predominant agricultural system. Due to the ever increasing emissions level of greenhouse gases, especially carbon dioxide, nitrous oxide and methane causing 0.74°C earth's temperature during the 20th century. It was reported that the average temperature in Nepal increased at an annual rate of 0.06°C between 1977 and 2000, with a 0.04°C increase in the Terai and 0.08°C increase in the mountain regions, which was higher than the global average. Rain-fed agriculture in Nepal is highly vulnerable to climatic abnormalities because of its geographic settings and the greater reliance of smallholder farmers on seasonal precipitation for growing crops. A great number of farm families in the country face poverty, food insecurity and malnutrition. There are negative impacts on grain legumes due to the climate changes as the shrinkages of seed sizes of lentil and soybean, increases the temperatures and carbon dioxide leads to incidences of new sorts of diseases like stemphylium and mosaic in lentil and chickpea, hallo blight disease in Phaseolus bean (Rajma), etc. Similarly devastation of army worm/caterpillars in soybean, black gram and aphids in lentil was seen since last few years. Flower/pod abortion due to the heat stress and drought in lentil/chick pea/pigeon pea/grass pea consequently yield was reducing trends drastically in lentil and other legumes. To cope with the vulnerable situations, need to follow climate-smart adaptation strategies and farmers friendly low cost technologies.

Keywords: Agriculture, Dry lands, Challenges, Strategies, Grain legumes

INTRODUCTION

Rain fed agriculture, where crop production relies on seasonal precipitation, often shows a grim picture of a fragile environment due to water scarcity, drought, soil degradation, low rain (water) and nitrogen use efficiency, poor infrastructure and inappropriate policies. Though rain-fed agriculture is commonly practiced in Nepal, it provides much of the food consumed by poor communities in developing countries. In Nepal, only about 28.8% area is the cultivable land, out of which large chunk 72% area covers under rain-fed farming [1]. Globally, 40% of the world's agricultural lands fall into the category of dry lands [2]. About 2.5 billion people live in the dry land agriculture systems [3]. The majority of the poorest people live in such semiarid areas. About 644 million people are the poorest of the poor in the world [4]. One third of these rely on agriculture for their livelihoods. It was estimated that about 42% of children in the dry lands of Asia (SSA) are malnourished [5]. Mixed (crop-livestock) farming systems are predominant agricultural system. Due to the ever increasing emissions level of greenhouse gases (GHGs), especially carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) causing 0.74°C earth's temperature during the 20th century [6]. It was reported that the average temperature in Nepal increased at an annual rate of 0.06°C between 1977 and 2000, with a 0.04°C increase in the Terai and 0.08°C increase in the mountain regions, which was higher than the global average [7]. Rain fed agriculture in Nepal is highly vulnerable to climatic abnormalities because

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of its geographic settings and the greater reliance of smallholder farmers on seasonal precipitation for growing crops. A great number of farm families in the country face poverty, food insecurity and malnutrition, where rain-fed agriculture is the main agricultural activity. These problems are intensifying by adverse biophysical growing conditions and poor socio-economic infrastructure development. Poverty and lack of information as well as technical know-how hinder their capacity to implement climate-smart adaptation strategies.

MAJOR CHALLENGES

- Land fragmentation (e.g. Nepal- per capita land holding size 0.14 ha)
- Increasing labor cost and availability
- High inherent climate variability and severe threat of higher temperatures/lower rainfall and higher variability due to climate change
- Global warming and changes in niches of cropping system
- Increasing stresses (heat stress, water stress, extreme weather events, floods)
- Vulnerability in food legumes prices
- Severe environmental degradation
- Increases the rate of reproductive cycle of insect and pest and gradually shifting to hills and mountains
- Negative impacts of climate change lead to food and nutritional insecurity for poor, disadvantages and marginalized populations
- Various biotic (pest and disease infestations) and abiotic (high temperature, water scarcity, drought, erratic precipitation and soil degradation) limitations
- Low input systems, low soil fertility and poor agronomic management in dry lands

NEGATIVE IMPACTS ON GRAIN LEGUMES DUE TO CLIMATE CHANGE

- Shrinkages of seed shape and size of grain legumes like lentil and soybean
- Increases the temperatures and CO_2 leads to incidences of new diseases like stemphylium and mosaic in lentil and chickpea, hallo blight disease in rajma, etc.
- Devastation of army worm/caterpillars in soybean and black gram and aphids in lentil
- Flower/pod abortion due to the heat stress and drought in lentil/ chick pea/pigeon pea/grass pea
- Yield reduce drastically in lentil and other legumes

COPING STRATEGIES

- Adaptation practices such as on-farm (*in situ*) water conservation, water harvesting and reduction in soil evaporation are the first line defense mechanisms
- Grow drought tolerance varieties such as Cowpea: IT98K-1399, IT98K-131-2, IT97K-568-19 and IT98K-452-1; Pigeon pea: ICPH 8, ICPH9, ICPL88039 and ICPL86005; Lentil: ILL-7979, ILL-10960, ILL-10973, ILL-10897, ILL-10821, ILL-10826 and ILL-10835
- Adjustment of cropping calendar and pattern
- Management of soil organic matter, mulching and conservation (minimum or zero) tillage help to conserve soil moisture
- Conservation of local ago-biodiversity and selection of water efficient and drought tolerant crop varieties offer other ways to cope with the climatic extremes.
- Adjustments in the planting dates to escape the high temperature, especially during the crop reproductive stage, can be used to reduce yield instability, use of heat-resistant varieties
- Diversified farming, intercropping, crop rotation and food-feed systems
- Development of early warning systems
- Improvement of irrigation efficiency
- Use of short duration, early maturing crop varieties
- Shifting of cropping pattern or advancement in sowing dates
- Use of balance fertilizers and irrigation
- Strictly follow ICM technologies
- Maintain grain legumes in crop rotations
- Reduce in the plant population per unit area and skip-row configurations in dry land areas to conserve soil moisture
- Plant crops in spaced planting (growing 3-4 plants in clumps like maize and sorghum under dry land environments)
- Crop diversification, contract farming and crop insurance are some risk management strategies
- Follow integrated farming system (small ruminants, grow climate smart crops like grain legumes (lentil, chickpea, pigeon pea, soybean, mung bean, black gram, cowpea, rice bean, horse gram , rajma, etc.), barley, durum wheat, oat, Uwa and pasture crops etc.) in the dry land agriculture.

ADAPTATION GRAIN LEGUMES TECHNOLOGIES FOR DRYLAND AGRICULTURE

- Relay sowing lentil in rice field is an age old commonly practice in Nepal (more or less 50% area covered by this practice).
- Under rain fed lowland conditions, the optimum time for relay sowing is 10-15 days before harvest of the rice for getting higher seed yields.
- 30 kg lentil seed and 2 kg seed of mustard per ha or 20 kg lentil seed and 6 kg seed of mustard per ha was the best seeding ratio for realizing higher yield and profit from mixed cropping under rain fed condition [8].
- Lentil intercropped with rapeseed in 1:1 row ratio.
- Intercropping lentil with autumn planted sugarcane was the most profitable combination with a high land equivalent ratio.
- Pigeon pea + maize intercropping in 1:1 or 1:2 row ratio (pigeon pea varieties RR-1, ICPL86005, Pusha-9, Pusha-14 and ICPL88039).
- Maize + soybean intercropping in 1:2 row ratio (maize variety Arun-1 or Arun-2 and maize RR spacing - 100 m).
- Soybean genotypes Puja, PK 327 and PK7394 and cowpea varieties Surya and Prakash were also found suitable relay intercrop in maize Bari land system.
- Chickpea + mustard or chick pea + coriander or chick pea + wheat intercropping in 4:2 row ratio.
- Ridge planting on soybean is recommended for temporary waterlogged condition in Bari land system owing to help in need based spray and weeding operation.

SEED PRIMING AND NUTRIENT LOADING TECHNOLOGIES

- 12 h soaking with water improved establishment and grain yield in lentil var. Khajura-2 [9].
- In dry and marginal areas with low soil molybdenum seed priming in 0.5% sodium molybdate with addition of rhizobium (5 g/kg seed) for 4-6 h accelerated the seedling emergence by 2-3 days earlier and increased nodulation by 30-70% and grain yield by 10-30% in chickpea [10-12].
- Lentil seed priming with 2% soluble fertilizer potassium dihydrogen orthophosphate (KH_2PO_4), cow dung (1 kg cow dung + 2 L of water), plain water priming for 12 h followed by 2 h air drying prior to sowing and non-primed.

TECHNOLOGIES FOR DISEASES ADAPTATION

- Lentil + linseed and lentil + rape seed mustard at 2:1 row ratio showed the least stemphylium blight severity (3 in 1-9 scale) followed by lentil + coriander in 2:1 ratio (3.33).
- Lentil sole showed the highest disease severity (4.33) followed by lentil + rape seed (4) in 3:1 ratio.
- Genotypes LN00136, ILL7538, ILL3338, ILL4139, IL-1, AERIAL, Shital, ILL2712, ILL7164 and ILL6447 were found resistant to stemphyllum blight.
- First November sowing date was recorded the optimum both for the higher yield and the low severity and incidence against the stemphyllium blight.
- The optimum plant spacing was also found 25 cm in terms of yield while low score in 30 cm apart against stemphyllium in lentil genotype ILL8006 [13].

BARLEY, BUCKWHEAT, FINGERMILLET AND DURUM WHEAT CROPS FOR DRYLAND AGRICULTURE IN NEPAL

- Barley varieties: Solu Uwa, Bonus
- Buckwheat varieties: Mithe Phapar-1, ACC#9251
- Finger millet varieties: Kabre kodo-1, Kabre kodo-2, Okhle-1, Dalle-1, Sailunge, KLE-159
- Durum wheat varieties: Khajura Durum-1, Khajura Durum-2

HISTORICAL PROSPECTS OF NARC/GLRP-ICARDA COLLABORATION

- Initiated limited lentil improvement in the early seventies.
- Officially released three varieties: Sindur, Shishir and Simrik in 1979.
- Recognition of lentil importance in the national economy, in 1985, IDRC, Canada grant project focused on lentil research and development [14].
- In the late eighties, EU provided funds through Trade Promotion Centre (TPC) to stabilize the lentil production and promotion in the early nineties.
- During 1990-1999, ADB funded secondary crops development project (SCDP) supported for the research and technology transfer of lentils and wider disseminated of lentil varieties in mid and far western regions.
- In 1995, GLRP received funds from ACIAR through CLIMA project PN 9436 and terminated in July 1999.

- ACIAR funded new project PN CS1/1999/064 "Lentil and Lathyrus in the cropping systems in Nepal" and utilized the ICARDA genetic materials and other sources for enhancing lentil crops.
- From 1999 onwards, ICARDA-NARC/GLRP started works effectively to improve the lentils through conventional breeding approaches and technical support.
- In 2014, GLRP headquarters shifted to Nepal gunj, Province No. 5, Mid-West, Nepal.
- Continue R and D activities of GL across the country in collaboration with International organization (ICARDA, ICRISAT, AVRDC, IITA, etc.).

MAJOR ACHIEVEMENTS UNDER NARC-ICARDA COLLABORATION

- Supply and exchange of genetic materials in lentil, chickpea, grass pea and faba bean.
- Received >3500 exotics lines of lentil, chickpea, grass pea and faba bean from ICARDA in the forms of IEN, stress tolerance and grain quality nurseries.
- Capacity building up of researchers and farmers.
- Technical backstopping and financial support.
- Expert study visits.
- Collaboration with IFAD/Harvest plus/OFID projects.

FUTURE PROSPECTS OF NARC-ICARDA COLLABORATION

- Manpower development for molecular breeding, statistical tools and strengthening lab facilities
- Fill the gap of technology adoption in the farmers' field continuing ICARDA-IFAD and lentil bio fortification projects for few more years.
- Improve seed replacement rate (SRR) in lentil for further strengthening VBSE and make lentil growers more prioritized in national seed value chain
- Herbicide tolerance in lentil
- Germplasm collection, conservation, characterization, including tagging and mapping of genes and QTLs in Nepalese landraces and genetic enhancement must be fully strengthened using conventional as well as molecular techniques
- Collaboration for management of stemphylium blight in lentil by developing mega project with help of induced biotechnology and molecular characterization of *Stemphylium* spp.
- Need of drought tolerant, water logged tolerance, early maturing, high nodulating grain legumes to justify climate change resilience research
- Need to collaborate in the field of new science (biotechnology, genomics, etc.).
- Mechanization on grain legume cultivation and processing
- Linkage of commercial lentil grower farmers in international market for capacity building
- Barely breeding for hulled and naked barley separately and extension of naked barley research in low land area.
- Malt barley research for mid hill and terai/low land
- Varietal development for higher rutin content in buckwheat.
- Identification for potential use of different plant parts in amaranths and buckwheat.
- Characterization of prevalent pathogens of different diseases.
- Value addition and product diversification and linked to local market and export markets.
- Molecular/biotechnology approaches in varietal development as well as in pathotype

LOOKING AHEAD

- Initiate breeding program on GL for diverse stress tolerance (diseases, pests, drought and cold)
- Identify QTL in the context to climate change, drought, etc., through GWAS and genomic selection mapping
- Application of new technologies for water harvesting, conservation and recycling
- Integrated nutrient management for soil fertility improvement
- Sustainable intensification of improved crop-animal systems
- Crop simulation modeling on pulse crops to predict the crop productivity and sustainable use of water and other resources
- High yielding short duration varieties of lentil, mung bean and chickpea fitting into short windows available between the two main crops in southern latitudes.

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