



Hydroponics Research and Development Strategy



DEPARTMENT OF AGRICULTURE

Ministry of Agriculture and Forests

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FOREWORD

The Department of Agriculture is pleased to bring out the publication on “Hydroponics Research and Development Strategy”. The strategy comes at a time when the whole world is facing major crisis such as climate change and the COVID-19 pandemic. The last few years in particular has shown that in order to survive and live sustainably one needs to adapt to rapid changes taking place. Bhutan is no exception and the agriculture being one of the main employment sectors in the country, Bhutan must be ready to adapt, innovate and be dynamic to meet the ever-increasing needs of the country in terms of making farming an attractive venture towards enhancing food self-sufficiency and food security.

One such innovation is hydroponics. Hydroponics means growing plants using no soil but water, oxygen and nutrients. Although hydroponics in some form has been in use at various times and places for many centuries, the science behind this technique has really only been understood over the last 70-80 years. Due to technological advancements within the industry and numerous economic factors, the global hydroponics market is forecast to grow by 18% per year between 2018 and 2023, making it the fastest growing method of food cultivation in the world. The size of the market is forecast to grow from US\$226.45 million in 2016 to US \$724 million by 2023. Whilst this is a tiny fraction of the total agriculture market, it is likely to gain significant market share over the next few decades mainly because of the many advantages hydroponics offers, a few of which are: a significant decrease in water usage in agriculture, less pests and weeds, less manpower, increased duration of production season to cite a few examples. However, it also needs regular monitoring and is largely dependent on the availability of electricity for smooth pumping of nutrients and provision of light at times.

Research initiatives on hydroponics farming in Bhutan has started in 2020. While it is a proven technology and adopted in countries like Canada and the US on a commercial scale, it is important to verify and adapt such technologies in the context of Bhutanese farming system. A research & development strategy is felt important so as to ensure the introduction of appropriate systems and methods for cost-effective and efficient crop production in the long run. It is hoped that with the adoption of the strategies outlined in this document, all stakeholders will work together in bringing advanced farming methods through hydroponics to a much higher level.

Tashi Delek



Mr. Wangda Dukpa

OFFICIATING DIRECTOR

1.0 Introduction

Increasing youth unemployment is a major concern in Bhutan with the current youth unemployment rate at 11.8% (MoLHR, 2020). Apparently, the agriculture sector stands out to be the major source of employment engaging 51.1% (NSB, 2019) of its population. However, modern educated youth are no longer interested in conventional and labor-intensive subsistence mountain farming. Interventions to engage youth in agriculture in a business-as-usual mode may be futile. Smart technologies that can address the issues of food scarcity, climate change, land degradation, drudgery and soaring youth unemployment is the need of the hour. Besides, modern smart farming technologies linked with Internet of Things (IoT) technologies could attract Bhutanese youths to food industry. As the 2040 draft RNR development strategy states “a systematic research, transformational innovation, and timely dissemination have to drive the RNR sector development”, hydroponics farming could be one of the much-needed innovation in the agriculture sector. With very limited arable land and harsh mountainous terrain, hydroponics farming has the charm to attract youth and the unemployed for gainful employment particularly in the urban and peri-urban areas where farming space is extremely limited.

Hydroponics is a subset of hydroculture that enables growing plants without soil using nutrients solutions and soilless substrates. The advantage of this system is that it does not depend on fossil fuel, is climate smart, can be developed anywhere, be it rural or urban areas irrespective of soil fertility, and production is quite independent of extreme weather events. Hydroponics farming is considered a gender-friendly farming option, which can produce more from a small area, reduces drudgery, reduce pest and disease incidences, increase peri-urban agricultural production, reduce weed growth, makes efficient use of space, water and nutrients for the production of safe food and high value crops. Though it is not without its challenges such as high initial investment costs, need for appropriate technical skills and knowledge, strict sanitation and daily monitoring requirements to name a few, it is a worthwhile system that could be adopted in urban and peri-urban areas where land is a limitation. Hydroponics is a high input and a high output system.

2.0 Current Status of Hydroponics Research & Development

Hydroponics research is in a nascent stage in Bhutan and was started on a custom-made system at ARDC Wengkhar in 2019. With the establishment of a nutrient film technique hydroponics structure in the other three ARDCs, research on cultivation of leafy vegetables and soft fruits started in 2020. As of mid 2021, six different systems of hydroponics were being evaluated for production of leafy greens, chilli and tomato at ARDC Wengkhar and ARDC Bajo. In addition, nutrient formulation for leafy vegetables and strawberry is being studied at ARDC Wengkhar.

In line with the objective to enhance knowledge and skills of our youth and interested entrepreneurs for employment opportunities, a training module on hydroponics has been developed coordinated by the Agriculture Research and Extension Division (ARED), Department of Agriculture. The first ever 15 days pre-training and 45 days post-engagement training was conducted at the ARDC Bajo

and ARDC Wengkhar in 2020 to a total of 31 Desuup participants who comprises mostly of unemployed youth through the Desuung Skilling Program (DSP).

3.0 Hydroponics Research

Research on hydroponics system should be conducted with the overall guiding goals of achieving the following objectives;

- a) Generation of information (including costs benefit analysis) and technologies through conduct of research on the potential and applicability for hydroponics farming in the Bhutanese context.
- b) Demonstration and or provide training to youth and any interested entrepreneurs

3.1 Research Mandate

As per the research protocols developed by the ARED, research on hydroponics shall be conducted in all the existing ARDCs including the NCOA, Yusipang and the relevant central programs such as NSSC, AMC, NPPC and NSC.

3.1.1 National mandate

The national mandate for coordination of hydroponics research has been assigned to the National Center for Organic Agriculture (NCOA), Yusipang. The NCOA will therefore take the lead role in the drafting of policies and strategies and seek endorsement of the Department. NCOA Yusipang will also coordinate consultation meetings, monitor, evaluate and report at the national level while also implementing hydroponics research activities.

3.1.2 Regional mandate

All ARDCs shall coordinate research and development programs and activities as per their national commodity mandates. For example, as the national coordinating center for commodity chilli crop, ARDC Bajo will lead and coordinate hydroponics research on chilli at the national level. Such an arrangement will ensure team work, prioritization and avoid duplication of efforts.

3.2 Research protocol

Each research activity should have a standard research protocol following the existing standard research formats developed by ARED for crop species. As outlined in the above section 3.1.2, the protocol for research on mandated crops shall be developed by the respective mandated ARDCs and shared with the coordinating centre/NCOA Yusipang after being endorsed by the respective Research Management Committee. This applies to those research that are conducted at the regional level as well. This means that the development of protocols does not lie solely with the National Hydroponics Coordinating Centre, which currently is the National Centre for Organic Agriculture, Yusipang.

Since hydroponics is a new technology in Bhutan, research will be confined to on-station before release of any technology for adoption. For nationally coordinated trials, technology release can be proposed after one season of production research if found worthwhile. However, those research

that are conducted in silos may need at least two years crop production data and information in order to be eligible for release.

The researchers should meet at least twice a year to plan activities (NCTs) before the ARCM during winter and review activities in summer months which will be coordinated by the designated coordinating center.

Once the production is started, an assured market is necessary. As far as possible, market led production of high value crops should be the major factor while selecting any crop for production research under hydroponics systems. Collaboration with DAMC on market led production of high value crop species should be a major criterion while conducting any research particularly for new crops.

3.3 Hydroponics Types

Various hydroponics systems that already exist elsewhere and new innovations can be built at all the research centre and do not have to be restricted to any one type. Various types of hydroponics are Nutrient Film Technique (NFT), Drip Hydroponics Technique, Aeroponics technique, Deep Water Culture (DWC) Technique, Ebb and flow/ flood and drain technique, vertical tower and Substrate Culture systems.

A system may or may not use medium (substrates) for holding plants. Substrates can also vary and may include both organic and inorganic materials that are inert which may vary such as oasis cubes, rice husk biochar, rockwool, vermiculite, wood chips, expanded clay, coco peat, pine bark chips, rice husk, gravels, wood chips and any other potential materials available locally. Cost effectiveness, eco-friendly substrates that can be locally made and available should be given priority over imported and costly ones.

Also, automation of the functioning system within the hydroponics should be the way to move forward to reduce overall costs, time and labour.

3.4 Priority research areas

3.4.1 Structural design and automation: Appropriate structural design and automation of the hydroponics system shall be one of the research priorities and shall be led by Agriculture Machinery Centre (AMC), Paro in collaboration with the National Coordinating Centre and other ARDCs. There is a need to study and identify designs that are most effective in terms of ergonomics (effective space utilization, convenience, and safety), flexibility in accommodating various crops, and suitability at different agro-ecological zones. As for automation, effectiveness of manual operation, automation through use of internet system and mobile network needs to be studied.

3.4.2 Selection of priority crops: Not all crops are suitable for production under hydroponics. In terms of the selection of crops to be evaluated under hydroponics, focus should be given

on high value crops such as medicinal and aromatic plants, culinary herbs, soft berries, followed by the three mandatory vegetables; tomato, chilli and bulb onion that the country is currently in deficit.

- 3.4.3 Nutrient formulation:** Research should cover both in-organic and organic nutrient solution formulations. Currently, the nutrient requirements for the In-organic systems are met through import of generalized pre-formulated nutrient mixtures. While Bhutan's vision is to go organic in the long run, in the absence of ready-made organic formulations, research on various types of nutrients formulations including bio manures/organic formulations and chemical formulations available should be conducted. However, more concerted efforts should be made to develop various bio-organic formulations and study their efficacy. To streamline and avoid duplication of efforts, NSSC will be the apex body and take lead in the research and development of all types of nutrient formulations for hydroponics use in the country. ARDCs will need to carry out nutrient formulation research in collaboration with the NSSC.
- 3.4.4 Organic nutrients:** NSSC should collaborate with all the research centers to come up with a locally made low-cost organic nutrient mixtures including the recommended doses and time of replenishment for different crops based on different stages of plant growth and species.
- 3.4.5 Substrates:** All ARDCs should focus their research to identify and evaluate locally available substrates such as sphagnum moss, rice husk biochar, rice husk, wood chips, pebbles and others for long term sustainability.
- 3.4.6 Plant protection:** Hydroponics systems are not free of pest and disease incidence. Research on pest and disease management in hydroponics should be undertaken for both inorganic and organic production systems. Evaluation of bio-pesticides, natural extracts, natural formulations and other cultural pest management and control strategies must be formulated for control of pests and diseases under hydroponics for which lead role by NPPC is imperative.
- 3.4.7 Cost benefit analysis:** All ARDCs should keep proper record of all costs incurred (installation, operation and management) and to develop a cost of production on any systems of hydroponics adopted. Breakeven cost should be worked out so that interested entrepreneurs could be informed. Where ever possible, comparative studies under natural /open and hydroponics systems of a crop should be undertaken to verify the benefits and advantageous of hydroponics production.

4.0 Promotion of hydroponics technology

- 4.1 Development of Package of Practices:** Any hydroponics technologies released and recommended should come with the Package of Practices (PoP). PoP should be developed for

adequate dissemination of technical information required by the entrepreneurs interested in hydroponics farming.

4.2 *Capacity building:* A pool of staff identified at all ARDCs will be trained on the specifics of hydroponics farming culture who will lead and conduct research and developmental activities in their respective region. Besides, the team will also serve as the experts on hydroponics and provide overall guidance at the national level.

4.3 *Upscaling of hydroponics:* Once a technology is released, promotional activities through the provision of trainings and demonstrations to urban youth and women can be carried out within the respective region wherever appropriate. All ARDCs should support interested entrepreneurs to develop project proposals integrating hydroponics as a climate resilient technology and explore fund to upscale the technology for youth engagement and development of an agriculture enterprise. Hydroponics promotion should always be encouraged on a business mode with appropriate models and types for different areas with end-to-end market links

5.0 Funding

5.1 Funding for Research

For research on hydroponics, NCOA, ARDCs and the respective relevant central programs shall create the activity with budget head and allocate budget for hydroponics research and development into their annual budgeting system.

5.2 Funding for promotion

For promotion of hydroponics technology to farmers and entrepreneurs, funding would be mobilized through various projects and RGOB with the Agriculture Production Division of the Department of Agriculture.

6.0 Reporting

Reporting of all research and development on hydroponics activities should be sent to the coordinating centre at least twice a year for compilation, review, planning and reporting purposes.

7.0 Conclusion

With this strategy in place, it is expected that research and development on hydroponics in Bhutan is streamlined and boosted. It is also expected that this type of farming will not only provide gender-friendly farming options and youth employment but also bring about a substantial change that will directly contribute to the national adaptation against the impacts of climate change on farming and ensuring food security, nutrition and income in the long run.

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