HORTICULTURE RESEARCH IN NEPAL: PAST, PRESENT AND FUTURE

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ABSTRACTS

Nepal Agricultural Research Council (NARC) is conducting horticultural research based on need of the country. The research focus is mostly on vegetable crops and especially in plant breeding, however it lacks vegetable commodity dedicated breeders. The average horticultural research budget is 12% of total research budget of NARC. Of that total sum source seed/ sapling production and action research consumes at least 25% of horticultural budget. The horticultural research projects were mostly vegetable focused in past and now the attention is shifting towards fruit and plantation crops but still provided least priority to floriculture research. A coordinated effort by NARC, NGOs, universities and private sectors are needed to drive the horticultural research to fulfil present need.

Key words: *horticulture, research, resources, technologies*

Historical Background

Horticulture research in Nepal started in 1850with introduction of fruit genetic resources in PutaliBagaicha (Acharya &Atreya, 2014). This informal way of research was formalized with establishment of National Agricultural Research and Service Centre (NARSC) in 1987(Shrestha, 1998). A number of donor funded research and development projects (JADP, CADP etc.) helped in establishment of horticulture farms to carry out research activities throughout the nation (Gotameet. al. 2014). Most of the activities on these farms were introduction breeding of fruit and vegetable along with development of package of practices (PoP) for homestead cultivation. Along came Institute of Agricultural and Animal Science (IAAS) under Tribhuwan University in 1972 to conduct agriculture research along with its teaching mandate. Later in 1991, NARSC was reformed as Nepal Agricultural Research Council to carry out and co-ordinate nationwide agricultural research including horticulture. Furthermore, Kathmandu University (KU) established in 1991; Himalayan College of Agriculture Sciences and Technology (HICAST) in 2000 and Agriculture and Forestry University (AFU) in 2010 came on-board to conduct research and teaching in agriculture including horticulture sector. Beside these, Nepal Academy of Science and Technology (NAST) established in 1982 is also helping in biotechnology related horticultural research work. Additionally, there are a number of non-governmental organizations conducting horticulture research and development activities since last two decades. A few names to cite are: FORWARD (www.forwardnepal.org)andLI-BIRD (www.libird.org/). Furthermore, there are a fewgovernmental funding agencies which provide competitive grants to governmental and community based organizations to implement horticulture research and development activities such asNepal Agricultural Research and Development Fund (NARDF: http://nardf.org.np/) established in 2001. There are two other government bodies which provides grant for adaptive and soft research work along with development work to community based organization namely, Project for Agricultural Commercialization

and Trade (PACT: http://pact.gov.np/) in2011 and High Mountain Agribusiness and livelihood Improvement (HIMALI: http://himali.gov.np/) project established in 2013. Beside governmental organization, Agriculture Enterprise Centre (AEC: www.aec-fncci.org/) under Federation of Nepalese Chamber of Commerce and Industries (FNCCI) is also working in horticultural R and D activities under public private partnership model.

Present Scenario

Human Resources

Horticulture research in NARC is shouldered by 46 researchers based at eight agriculture research stations, 5 regional research stations, one disciplinary division and four commodity programmes (Citrus, potato, ginger and coffee). There are cross-cutting researchers from seven disciplinary divisions (entomology, pathology, food technology, agricultural engineering, agricultural environment, Socioeconomic and Biotechnology) based at Khumal Complex Lalitpur assisting in technology generation. Beside these from NARC, two researchers from NAST and 18 from universities (TU, AFU, KU, HICAST) are working as part time researcher in this sector. The horticulturists from Department of Agriculture (DoA) are not included in the list as they are more inclined to developmental activities and adaptive research.

Financial Resource Allocation

The sum of budget spent by all institutions in horticulture research is difficult to collect. Therefore, resource allocation within NARC system is dealt in this paper. NARC spent 10-12 precent of its total allocated research budget (Figure 1) which is not justifiable compared to 25.76% contribution (vegetable 14.92, fruit and spice 10.84%) of this sector to AGDP (MoAD 2015).Further, the commercial nature of horticulture products as depicted by export (USD 158.3 million) and import (USD 303.8 million) figure in FY 2013/14 (MoAD, 2014) support partial nature of budget allocation to this sectoral research within NARC system which in part is contributed to less number of researcher available to conduct horticulture research as NARC implements competitive grant based research projects. The detail of how research project is formulated and implemented within NARC system could be obtained from the paper of Paudel and Khatiwada (2012).

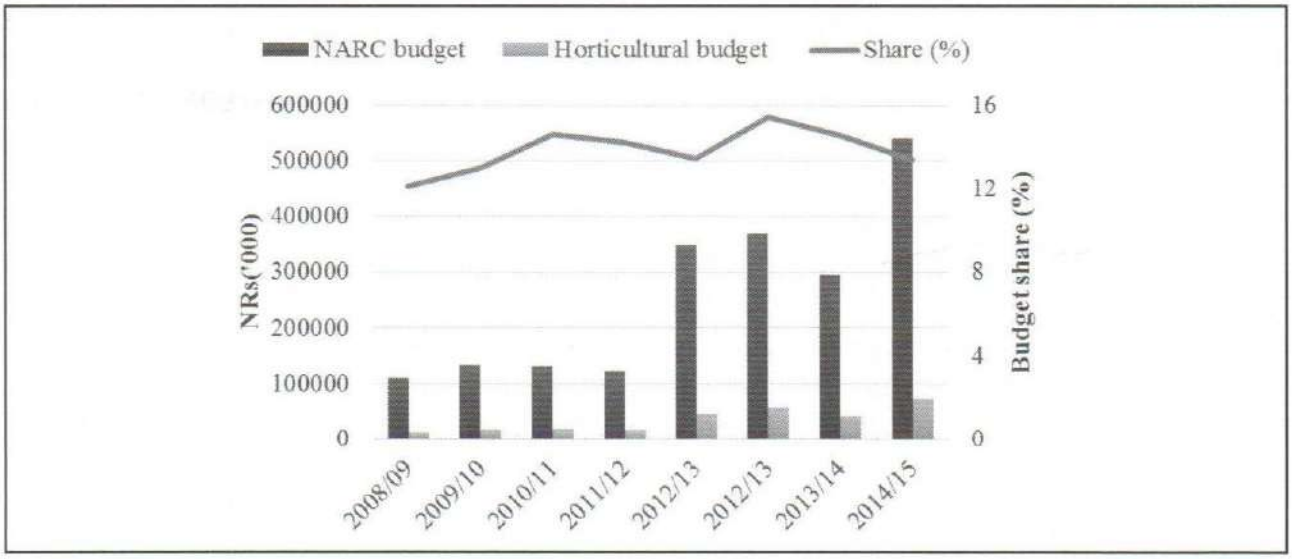

Figure 1. Horticultural research budget allocated by NARC over 8 years

In Fiscal year 2070/71 (2014), NARC allocated about NRs 65 million in horticulture research which is 13.4% of total allocated research budget. NARC implemented 496 research activities (not research projects) among five sectors (Table 1) with that allocated amount. Like in the past vegetable sector scored highest amount followed by fruit, spices and plantation (Figure 2). The resource allocation in flower is least as there were two projects on gladiolus and carnation flowers.

Table 1. Budget (NRs '000) and no. of research activities from NARC in Fiscal year 2014/15

Division/Sector	Vegetable	Fruit	Flower	Spices	Plantation
Plant Breeding	9830 (80)	7013 (39)	409 (6)	1287 (19)	1683 (6)
Husbandry	2669 (34)	1786 (21)	307 (11)	5017 (12)	1801 (1)
Entomology	2337 (25)	605 (10)	-	75 (1)	1132 (16)
Pathology	2147 (26)	2105 (10)	-	-	350 (1)
Outreach research	3418 (46)	1679 (18)	-	740 (4)	315 (1)
Seed production	6008 (29)	3040 (14)	-	495 (3)	590 (1)
Post-harvest	1051 (20)	1667 (18)	-	863 (7)	160 (1)
Biotechnology	1575 (2)	-	-	-	1870 (1)
Socioeconomics	545 (6)	185 (3)	-	-	-
Climate adaptive	-	285 (4)	-	-	-
Total	**29580**	**18365**	**716**	**8477**	**7901**

Numbers in parenthesis are no. of research activities conducted with allocated budget (in NRS'000)

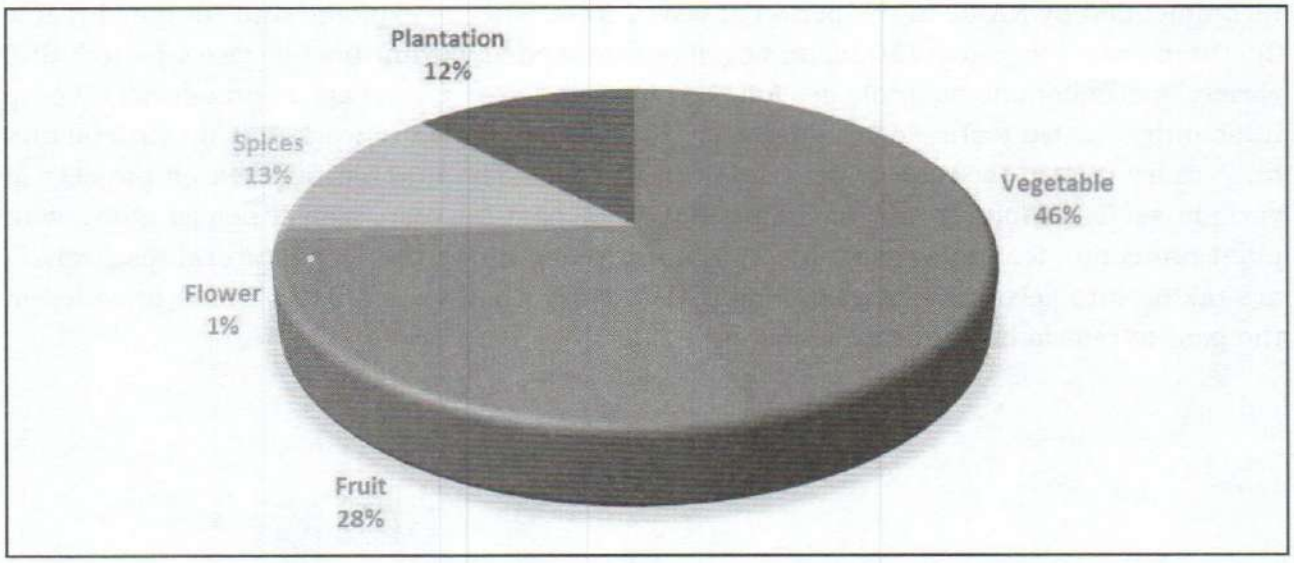

Figure 2. Resource allocation within horticulture research sectorin FY 2014/15

The allotted research money was disbursed in ten disciplinary divisions to carry out horticulture research (Figure 3). Plant breeding and crop husbandry were most resource demanding sectors in the FY 2014, while source seed production program used nearly 16% of the budget. New research frontiers like biotechnology and climate adaptive research are also getting attention in recent years while outreach research is consuming one tenth of research budget on testing and dissemination of recently developed technologies at out-reach site &/or model village.

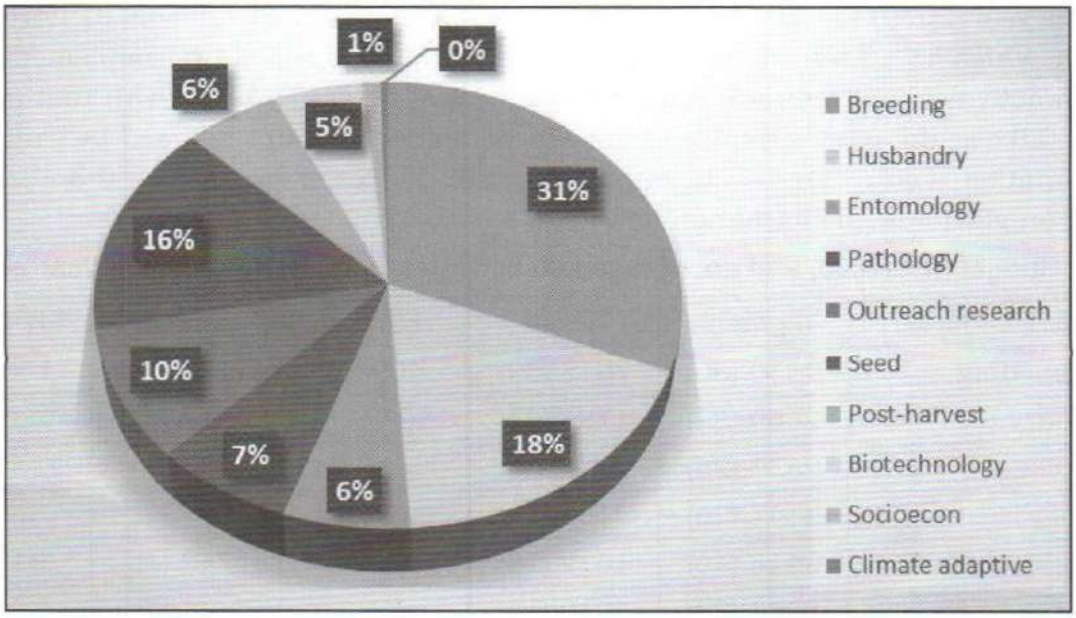

Figure 3. Resource allocation within disciplinary research in FY 2014/15

Research Achievements

The research achievements in horticulture are difficult to track as there is no system of patenting or registration of technologies in Nepal except varieties. A compilation of horticulture research in by Paudel and Subba (2012) named as 'The bibliography of horticulture research in Nepal (1968-2012)' is an excellent resources to explore but still the compilation is incomplete. In this paper an exclusive list of technologies developed and recommended by NARC in the period of year 2009-2014 are explored and compiled (Table 2). There are all together 130 technologiesrecommended within this five years period. Still variety is number one technologies followed by post-harvest, package of practices and crop husbandry related technologies (Figure 4). NARC was blamed to work only on varietal and husbandry related technology generation in the past. The number of research projects in various sector (Table 1) and recommendation of post-harvest, biotechnology along with plant protection technologies (Table 2)in recent years shows that horticultural researchers are taking into account of suggestions by Paudel & Khatiwada (2012& 2013) provided in the past to reform horticulture research.

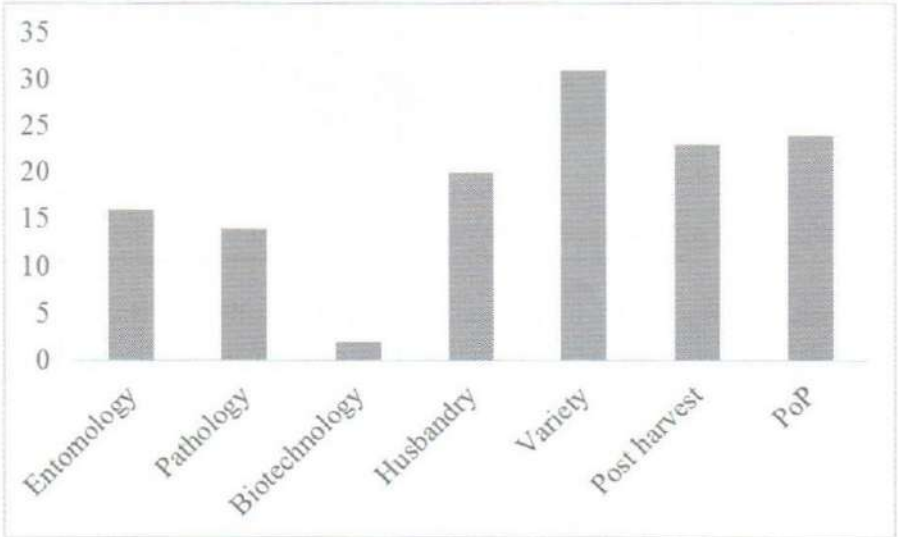

Figure 4. Technologies recommended by NARC in last five years (2009-2014)

Table 1. List of technologies recommended in last five years.

SN	Technologies
1	**Varieties***
	Cauliflower (Jyapu Local 1); Tomato (Shrijana!); Potato (eight varieties);Cucumber (Madhu!), Radish (Bhedetar local);vegetable bean(Malepatan-1);Kidney bean (LB-37);Broad leaf mustard (Tankhuwa, Manakamana); Ginger (Kapurkot -1); Turmeric (CI-9801); TPS potato (HPS II/67);Dolichusbean (ML-02); lime (Sunkagati 1 & 2); Mandarin (Okitsuwase); Sweet Orange (Washington Navel and Valencia late); Banana (FIA-01, Harichhal, William Hybrids); Kiwi (Soyu, Bruno, Hayward); Coffee (Catturaamarelo)
2	**Husbandry**
	Arkel pea three times/year; Spring BLM spacing; TPS variety spacing; New potato variety spacing and IPNS; tomato grafting technology;tomatoOrobanke weed management; Walnut budding time (Chaitra 3rd and Jestha 2nd week); improvement of bio fertilizer (EM bokasi and vermi-compost) production technology; Coffee IPNS (10 t FYM + 100:30:60 Kg NPK/ha); Organic coffee IPNS (15Kg FYM + EM treatment); organic tea (Azotobactor and vermicomposting); gladiolus bud dormancy breaking for early flowering; banana IPNS; clump management (single plant/clump) and spacing for eastern river basin production system; banana cold tolerancy with bordeaux mixture (4:4:50); Citrus orchard IPNS; Potato planter; Banana-berseem grass intercropping; hydroponic PBS production;
3	**Entomology**
	IPM of potato tuber moth management; IPM of diamond back moth of cabbage; Chinese fruit fly control (protein bait);IPM of apple woolly aphid (Aphelinusmali); Terrestrial snail management (5% CuSo4), Vegetable fruit fly (Pheromone trap+ mice trap); tomato fruit borer (Helilure); protocol of rapid bioassay of insecticide residue on fresh vegetable and fruit, potato leaf minor (Abamectin 1.5 ml/l and movable trap- grease in yellow flex print);Granulo-virus production method to manage potato tuber moth; mango stem borer (Imidacloprid or Thiomethexam); IPM for mango mealy bug; IPM for ginger rhizome fly management; Brinjal fruit and shoot borer IPM; tomato white fly (Nikoneem& Verticillium lecanibiopesticide); apple nursery white grub management (Chlorpyrifos)
4	**Pathology**
	IPM potato late blight, Cabbage damping off, Club root (Nebijin and Trichoderma), Tomato grafting for polyhouse Nematode management, IPM of ginger rhizome rot management, Onion and garlic purple blotch, Citrus gummosis (antiriot), Citrus powdery mildew (Insuf), Citrus scale insect (Atso and Servo petroleum product), IPM of blister blight of tea, IPM of hot chilli phytopthoradiseasemanagement, IPM of okra yellow mosaic virus management, Papery bark (1% Bordeaux mixture),

5	**Post-harvest technology/Engineering**
	Potato chips production method using variety KhumalUjjawal; tomato seed processing technology for small scale farmers; vegetable seed storage with zeolite; mango fruit rot management (2% CaCl2 + warm water treatment); gladiolus harvesting time (before 1st bud brust) for better shelf life and corm quality; carnation shelf life (2% Thiosulphate treatment in solution);ginger storage method; potato digger hitched with tractor; coffee pulper (Solar, Paddle and electric operated); low cost solar drier for apple; walk-in-solar drier; Ginger washing machine; citrus fruit grader; apple packaging cartoon (5 ply and 160 PSI); Pear and kiwi fruit wine production protocol, kiwifruit jam, juice and dried slices production protocol; Junar and banana nectar production protocol; papaya candy (Osmotic dehydrated) production protocol
6	**Biotechnology**
	Virus clean potato seedlings through tissue culture; leaf streak disease free cardamom production protocol
7	**Package of practice (PoP)**
	Carnation (var King Lion); Strawberry plasti-culture; Mecademia nut, Sweet pepper (Californe) seed production, Khumaljyapu cauliflower; Winter bean M02; CI 9801 turmeric; Offseason lime production in terai; Organic coffee production; Avocado production; Kiwi fruit production; Ground apple production; Polyhouse Zucchini production; polyhouse rainy season tomato production; rainy season onion production; elephant foot yam production in hill; winter bean production; Seed production of Arkakartikpea;Manakamana BLM, Pokharalurki brinjal, Haripate spinach and Basmati luffa for mid hills; Colocasia production; high b-carotene containing sweet potato

* Many of the varieties listed are registered or notified and others are in process of registration;! Hybrid varieties

(Source: NARC 2011, NARC 2012, NARC 2013, NARC 2014, KC 2014)

Research Need

Sound breeding system with true fruit and vegetable breeders are lacking in NARC system. Further, utilization of indigenous horticulture resource utilizing modern breeding tools such as biotechnology and molecular genetics demands big cohorts of cutting edge researchers in this sector which is still lacking. The need of biotechnological research cannot be fulfilled by present laboratory system at NARC facilities and which needs massive refurbishment and, therefore, financial investment too.

There is research need on newly introduced fruit crops (Kiwi, spur type apple etc) as well as tropical fruit crops (mango and banana) and vegetables having a number of production problem. These need to be addressed with creation of separate working unit under NARC system.

In last five years, NARC developed a few technologies related to organic tea, coffee and apple production which is just a drop of water as compared to the demand of technologies for organic agriculture (OA) production system. Research focus is to be shifted towards OA technologies generation related to vegetable and fruit production.

At present horticulture research is giving some attention toward post-harvest related issues; however, which is not sufficient and it needs more focussed research on post-

harvest supply chain management. For example, packaging material, storage containers, mode of transportation and storage etc.

The agriculture engineering research on less labour requiring technologies generation needed for intercultural operation and post-harvest handling for small to medium scale commercial farmers are the present day need. For example, potato planter, harvester and grader, ginger washing machine etc. Agriculture engineering division is working towards it but there are demand of such technologies on other horticulture crops like coffee drier, grader; ginger peeler and slicer to make dried ginger; fruit graders for different commodities. The research focus should be directed to light to medium weight less power requiring agriculture tools suited to Nepalese farmers.

Way Forwards

Formulation of Horticultural Research Policy

In past effort were made to draft a horticulture development master plan with the support of Asian Development bank but this plan was never been endorsed by government. Similarly, NARC vision 2010 was approved by NARC Council but is still awaiting approval from government of Nepal. Recently Agricultural Development Strategies (ADS) has been approved by government which also includes commercial crops as a component but separate plan for horticulture sector development is still lacking.

Formation of Separate Horticultural Research Institution within NARC

NARC works for research of whole agriculture system and, therefore, the effort on horticulture research is diluted competing with other research areas. Solely to work on horticulture research as envisioned by Agricultural Development Strategies, NARC immediately has to restructure its horticulture division as National Horticultural Research Institute (NHRI) comprising of human resources of all horticulture components (fruit, flower, vegetable, plantation crops and spices) as well as cross cutting sections. Full authorities with both administrative and technical responsibilities has to be provided by NARC head office working only on agricultural policy formulation and monitoring authority.

Formation of an Umbrella Institution for Horticulture Research

Horticulture research is constrained by a few numbers of researchers and limited resources allocated in Nepal. Moreover, there are a few international organizations (AVRDC and CIP) collaborating in Nepalese horticulture research which is negligible compared to number of CG centres working in cereal crop research. Further, there is lack of clear information whether other institutions (except NARC) are doing what kind research work in horticulture in Nepal, which is also causing waste of resource due to duplication of work. To mitigate this problem one door system of research lead by NARC or horticulture consortium composed of all stakeholders could be an efficient means. The consortium prioritizes research need, mandates specific task to proper institution and allocates resources to conduct research.

Prioritization of Researchable Horticultural Commodities

Nepal can produce a range of horticultural commodities at one or another part of nation. Because of this, resources are broadcasted like birdseeds without visible economic gain. At least prioritization of two or three crops or commodities where focus could be given based on business plan and economic of scale has to be identified by each district. Then horticulture R and D effort should be made on those selected commodities by all stakeholders.

Matching Fund for Industry Demanded Technology

The need of commercial and large scale growers for technology could be different from small growers and they can pay for the technology they need. Such commercial farmers could provide matching grant money for horticultural R and D which ultimately helps on raising funds for research.

Infrastructure Management

At present NARC has five farms dedicated to horticulture research. The four of them are in mid hills and one in high hills. These are not enough to cover all ecological zones and important horticulture commodities to work on. Further, there are 20 horticulture farm/ centres across nation but all are under Department of Agriculture.These farms are used for source seed production of vegetable and fruit commodities, and adaptive research. These farms/centres could be used for collaborative horticulture research and especially needed for fruit crops. Additionally, all research centres (NARC) and farms (DoA) lack laboratory facilities and resource need to be allocated to develop facilities in all centres.

Use of Mass Media

The developed technologies are not properly used by end users until they know about it. NARC is working towards dissemination of developed technologies. But still more efforts are needed using paper, digital and other means of communication for the spread of NARC generated horticulture technologies. At present many farmers are using smart phones and development of user friendly application which provides updated information of horticultural commodities cultivation, post-harvest handling and marketing could be better option for technology transfer.

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