# Recent Technologies and Varietal Development of Vegetable Crops Under NARC

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## Abstract

Horticulture has been recognized as an important sector for reduction of poverty and increase the income. It contributes 38.59 % in AGDP, of which 20.48% contribution is coming from vegetables. The recent trend of import of fresh vegetables is increased by 15% by volume and 19% by values. The major constraints of low production of vegetables are small scale farm, use of traditional technologies and lack of improved varieties. The main objective of this paper is to document the recent technologies and varietal improvement in vegetable crops. School gardens technology are more effective at influencing nutrition (+26%), healthy food practices (+5%) and vegetable consumption (+15-26%). Modified atmosphere packaging (MAP) in perforated 25-50 microns thick low density polyethylene (LDPE) was found effective for enhancing the self-life of tomato. Calcium chloride treatment of cucumber and carrot was found effective for increasing the storage life. Pot in pot storage, Evaporative cooling (EC) storage and Coolbot storage are cost effective and increase the shelf life of cauliflower (15 days), cabbage (15 days), carrot (21 days) and capsicum (30 days). One variety of cucumber Bhaktapur Local has been released. Two open pollinated varieties of French bean and Asparagus bean have also been registered. Nine F1 hybrids in different crops have been recently registered by this Division. Ramechhap Hariyo amaranth has been registered for dry season. One variety of Kang Kong and one Baitadi Local variety of onion have been proposed for registration. HRDRAD002 (63.7 t/ha) and HRDRAD005 (60.9 t/ha) of radish, AVON1027 (38.83 t/ha) of onion, HRDCAP004 and HRDCAP001 of capsicum has been found promising.

***Keywords:*** *Cultivars, Fruit crops, NARC, Post-harvest management, Registration, Recent technology*

## INTRODUCTION

Agriculture sector generates about 60 % employment opportunities in Nepal, the major part of which is created from horticulture sub-sector. Horticulture has been recognized as an important tool for reduction of poverty and increase the income of Nepalese farmers. Due to agro-climatic diversity Nepal offers an immense opportunity for cultivation of different fruits, vegetables, spices, flowers and plantation crops. Horticulture contributes 38.59 % in AGDP. Out of this, 20.48% contribution is coming from vegetables .The productivity of vegetables has been remarkably improved over the last 20 years. Area has increased by about 85% from year 1997/98 to 2016/17 whereas the production has increased by about 159 %. Likewise, the productivity has increased from 9.66 t/ha to 13.52 t/ha (Table 1).

| Table 1. Area, Production and Productivity of Vegetables in Nepal | | | |
|---|---|---|---|
| **Year** | **Area(ha)** | **Production (Mt)** | **Productivity(Mt/ha)** |
| 1997/98 | 149979 | 1449472 | 9.66 |
| 2002/03 | 165988 | 1799973 | 10.84 |
| 2007/08 | 208108 | 2538904 | 12.20 |
| 2012/13 | 246392 | 3301684 | 13.40 |
| 2016/17 | 277393 | 3749802 | 13.52 |

Source: MoALD 2016

The recent trade scenario of vegetables in Nepal is presented below. The import of fresh vegetables has increased by 15 % by volume and 19 % by values in the last three years. In comparison to 2014/15, the export of vegetables has decreased by 39 % in the year 2016/17 (Table 2).

| Table 2. Export and import scenario of fresh vegetables in Nepal | | | | | | |
|---|---|---|---|---|---|---|
| Fresh Vegetables | 2014/15 | | 2015/16 | | 2016/17 | |
| | Volume (Mt) | Values (NRs 000) | Volume (Mt) | Values (NRs 000) | Volume (Mt) | Values (NRs 000) |
| Export | 18174 | 182121 | 13650 | 131784 | 5717 | 75699 |
| Import | 151848 | 4065784 | 143166 | 3679926 | 169159 | 4582429 |
| Deficiency | 133674 | 3883663 | 129516 | 3548142 | 163442 | 4506730 |

Source: MoALD 2016

The national economy can be increased by manifolds with contribution of horticulture sector if the public and private sector focus on sustainable commercial production. Bulk production of vegetables is needed as it plays vital role in nutrition and food security, income generation and livelihood improvement. The major constraints contributing to lower production and productivity of vegetable crops in our country are small scale farming, use of traditional technologies and lack of improved varieties. Thus, several research projects have been carried out in varietal development/ breeding, package of practices, post-harvest management, organic production technology, etc.

Horticulture Research Division (HRD) has been continuously involved in the development of demand driven technologies with active participation of the stakeholders and has been significantly contributing to technology generation of vegetable crops. Value chain is one of the major challenges to compete in national and international markets. Despite weak infrastructures and facilities available, HRD with its goal of generating demand driven technologies is moving forward in the activities of scientific researches on various issues of vegetable crops.

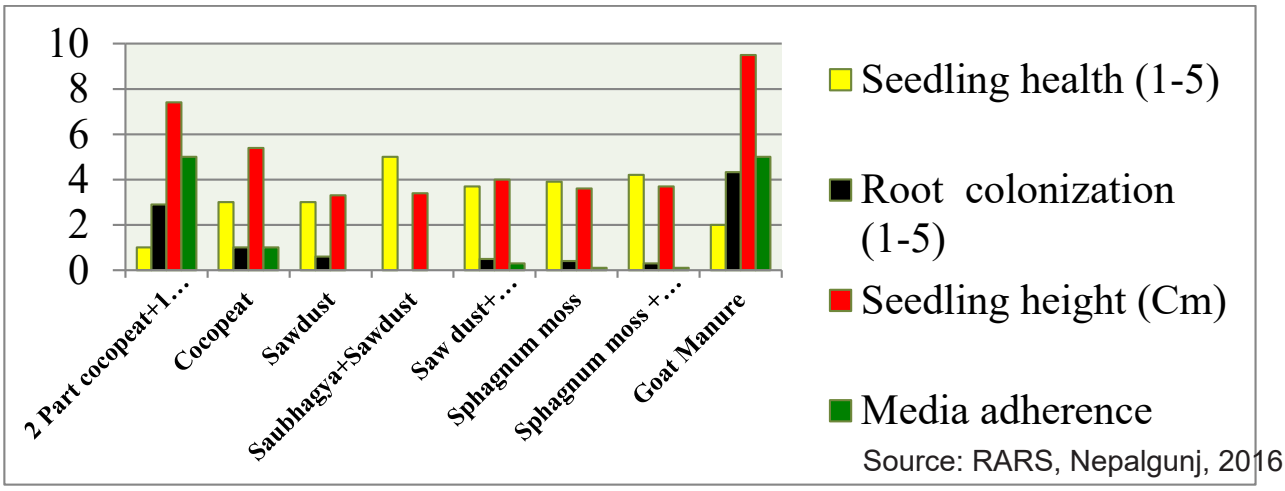
## Recent Technologies Developed On Vegetable Crops Under Narc

## 1.1 Use of goat manure in vegetable seedling production in plastic tray

The production of good quality vegetable seedling is essential for optimizing crop growth and yield for getting quality produce. The vegetable seedling production system is gradually changing from open field nurseries to production in protected raised beds or seedling trays. Expanded plastic trays are widely used by the commercial vegetable seedling producers

and recently rigid plastic trays are also being used. Trays differ in number, size and shape of cells. Criteria for tray selection include plant species, growing conditions, local availability and type of mechanical seeders used. Due to diverse climatic conditions and soil types, growing plants in soil is unpredictable, with an array of challenges such as changing temperature, moisture holding capacity, available nutrient supply, poor root aeration as well as diseases and pest control. Soilless production using growing media alleviates some of these problems, while giving the farmer better control over plant growth and development.

Eight different types of growing media were used in plastic tray for vegetable seedling production as: 2 part coco peat + 1 part vermicompost, coco peat, sawdust, saubhagya+ sawdust, sawdust + vermicompost, sphagnum moss, sphagnum moss+ vermicompost and goat manure + Trichoderma. Among these growing media, well decomposed goat manure mixed with 2 gram Trichoderma per kg manure has been found promising media as seedling health (1-5), root colonization (1-5), media adherence and seedling height (1-5) taken at the time of transplanting. (Figure 1.).




Source: RARS, Nepalgunj, 2016

**Figure 1:** Performance of different types of growing media for vegetable seedling production

## 1.2 Effect of Vegetable School Gardening

School gardens have become a widely used approach to influence children's food knowledge, preferences and choices in low- and high-income generating countries alike. However, evidence indicates that such programs are more effective in influencing food knowledge and preferences than actual food choices. This may be either because school gardens insufficiently influence the food behavior of parents or because healthy food items are not always available in children's homes. We tested this hypothesis using a one-year cluster randomized controlled trial in Nepal with 15 treatments (provided seeds, equipment's, tools materials and training to school teacher about vegetable gardening at school) and 15 control schools (without any support) and a matched sample of 779 school children (aged 8-12) and their care givers. Data were collected from children and care givers before and after the intervention during the 2018-2019 school years. In addition, children's food consumption data were collected monthly using a food log book. Average treatment effects were quantified with a double-difference estimator. For care givers, the results show a significant increase in their food and nutrition knowledge (+26%), agricultural knowledge (+5%), liking for vegetables (+10%), and home

garden productivity (+15%). For children, the results show no significant effect on food and nutrition knowledge but significant increases in their liking for vegetables (+6%), healthy food practices (+5%), and vegetable consumption (+15-26%, depending on the season) as shown in (Table 3).The results therefore indicate that nudging children toward healthier food choices through school gardens requires targeting children as well as their caregivers.

**Table 3.** Before and after intervention means and average treatment effects on children's and care givers' knowledge and preference

| Outcome (proportions) | Before | | | After intervention | | | Impact | |
|---|---|---|---|---|---|---|---|---|
| | C | T | p-value | C | T | p-value | ATE | p-value |
| **Nutrition knowledge:** | | | | | | | | |
| – Children | 0.48 (0.15) | 0.49 (0.14) | 0.431 | 0.54 (0.15) | 0.57 (0.15) | 0.213 | 0.01 | 0.666 |
| – Caregivers | 0.53 (0.17) | 0.53 (0.17) | 0.919 | 0.57 (0.17) | 0.70 (0.16) | <0.001 | 0.14 (0.03) | <0.001 |
| **Agricultural knowledge:** | | | | | | | | |
| – Children | 0.52 (0.11) | 0.53 (0.12) | 0.466 | 0.53 (0.12) | 0.57 (0.12) | 0.003 | 0.03 (0.02) | 0.119 |
| – Caregivers | 0.59 (0.12) | 0.59 (0.12) | 0.654 | 0.58 (0.11) | 0.61 (0.10) | <0.001 | 0.03 (0.01) | 0.022 |
| **Liking for vegetables:** | | | | | | | | |
| – Children | 0.63 (0.18) | 0.64 (0.18) | 0.700 | 0.58 (0.18) | 0.63 (0.17) | 0.021 | 0.04 (0.02) | 0.070 |
| – Caregivers | 0.59 (0.17) | 0.59 (0.17) | 0.943 | 0.53 (0.15) | 0.60 (0.18) | <0.001 | 0.06 (0.02) | <0.001 |
| – Caregivers' perception of children's liking | 0.56 (0.18) | 0.58 (0.18) | 0.191 | 0.54 (0.17) | 0.63 (0.16) | <0.001 | 0.06 (0.02) | <0.001 |
| – Children's healthy snack preferences | 0.63 (0.22) | 0.61 (0.22) | 0.541 | 0.66 (0.23) | 0.69 (0.22) | 0.257 | 0.05 (0.03) | 0.042 |

**Notes:** C=Means for the control; T=Means for the treatment. The numbers in parentheses indicate standard deviations for the means and standard errors for the average treatment effect (ATE).

## 1.3 Post harvest Technology

### 1.3.1 Cauliflower handling trials integrating best practice and developed technologies to reduce postharvest losses in Nepal

In Nepal, farmers usually harvest cauliflower curds with few leaves and short stalk and transport to the market. A handling trial was conducted to determine the extent of loss reduction. Cauliflower var. 'Snow Mystique' at the tight-curd stage were harvested from a local farm and grouped into three treatments: retention of 5-6 small scale leaves (farmers practice), removal of all the leaves and removal of all the leaves followed by wrapping of curd with news print. Each group of curd samples were further divided into three subgroups representing the following packaging methods: nylon net bag, general plastic bag, plastic crate with news print liner, and 50µ low-density polyethylene bag (LDPE). Five packages of produce at 10 kg each were used for each treatment; each pack representing a replicate. They were then transported on the cargo load of a small truck from the farm in Kavre to Chitwan, about 200 km apart. After transport, the curds were taken out from the containers and stored at ambient (30.1 ± 0.9oC and 79.5 ± 9.5 % RH). Removal of

all leaves together with wrapping with newsprint was very promising not only to reduce damage but also to eliminate the cost of handling of the unmarketable leaves and stalks of the curds. During transport, weight loss was the highest in nylon net bag (4%), followed by plastic crate and general plastic bag (Table 4). The packaging materials and storage of cauliflower at ambient room temperature for 8 days showed significant effect on storage weight loss percentage and qualities. The minimum weight loss, abrasion and brushing was recorded the minimum in 50 micron LPDE treatment (Table 5).

**Table 4.** Effect of condition of cauliflowers and packaging method on temperature inside package at destination, weight loss (%), abrasion and bruising during transportation

| Treatments | Temperature inside package (0C) | Weight loss (%) | Abrasion (1-5 scale) | Bruising (1-5 scale) |
|---|---|---|---|---|
| With leaves | 31.31 | 2.29 | 1.04 | 1.16 |
| Without leaves | 30.39 | 1.92 | 1.06 | 1.1 |
| Newsprint wrapping | 31.44 | 1.86 | 1.03 | 1.14 |
| F-Test | ns | Ns | Ns | Ns |
| LSD (0.5%) | - | - | - | - |
| **Packaging method** | | | | |
| Nylon net bag | 30.03 | 4.08 | 1.02 | 1.06 |
| Plastic crate | 29.67 | 3.03 | 1.06 | 1.16 |
| Ordinary plastic bag | 32.19 | 0.98 | 1.07 | 1.16 |
| 50 micron LDPE | 32.29 | 0 | 1.03 | 1.15 |
| F-Test | ** | ** | * | Ns |
| LSD (0.05) | 1.82 | 1.3 | 0.04 | - |
| CV% | 5.99 | 65.49 | 3.71 | 10.3 |

Source: Gautam, et.al 2015

Scale: 1 – 5(1 = Minimum abrasion and bruising, 5 = Maximum abrasion and bruising)

**Table 5.** Vitamin C, TSS, TA and pH of cauliflower on 8th day in storage at ambient room condition (30.1 ± 0.9C0 and 79.5 ± 9.5 % RH)

| **Treatments** | **Vitamin C (mg/100g)** | **TSS (OB)** | **TA (%)** | **PH** |
|---|---|---|---|---|
| Initial | 45 | 6.13 | 0.41 | 6.3 |
| With leaves | 15.08 | 8.49 | 0.41 | 6.46 |
| Without leaves | 22.4 | 7.85 | 0.4 | 6.66 |
| Newsprint wrapping | 19.73 | 6.88 | 0.4 | 6.62 |
| LSD (0.5%) | ns | * | Ns | ns |
| Packaging method | | | | |
| Nylon net bag | 12.86 | 7.91 | 0.44 | 6.58 |
| Plastic crate | 13.83 | 9.25 | 0.42 | 6.45 |
| Ordinary plastic bag | 19.62 | 7.27 | 0.41 | 6.79 |
| 50 micron LDPE | 29.98 | 6.53 | 0.33 | 6.51 |
| F-Test | * | *** | Ns | ns |
| LSD (0.05) | 10.87 | 1.18 | - | - |
| CV | 58.3 | 15.54 | 27.9 | 5.02 |

Source: Gautam, et.al 2015

## 1.3.2 Modified atmosphere packaging to enhance the quality and shelf life of tomatoes

The study determined the efficacy of modified atmospheric packaging (MAP) in enhancing the quality and shelf-life of tomato var. 'Samjhana' under ambient conditions during winter (March 2015 – 15.5±4.5oC; 82±17% RH). MAP treatments were 25 micron-thick low-density polyethylene (LDPE), 50 micron-thick LDPE, 25 micron-thick polypropylene (PP), 50 micron-thick PP, and commercial cling wrap film. Samples held under ambient conditions in the open served as the control. Ten kg breaker fruits were used for each treatment per replicate; four replicates were used. Fruit were held in the MAP for 5 and 10 days respectively to simulate short-term and long-term holding and transport. After which, the samples were kept in the open. The MAP was found very effective in prolonging the shelf life of tomato. Fruit in 25-50 micron-thick LDPE showed better color retention and firmness, lower weight loss, and longer shelf life than the other treatments. The 5-day holding period in the MAP resulted in better quality and longer shelf life than the 10-day holding period. The results indicate the tomatoes can be successfully stored in the 50µ LDPE MAP to minimize perishability and reduce postharvest losses (Table 6 and 7).

**Table 6.** Physiological weight loss (%) of 5 day MAP hold tomato fruits at opening (5th day) and thereafter in different days interval in ambient condition (15.5±4.50C; 82±17% RH

| Treatments | Physiological weight loss (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Opening day | 3rd Day | 5th Day | 7th Day | 9th Day | 11th Day | 13th Day | 15th Day |
| 25µ LDPE | 1.49 | 2.51 | 3.57 | 4.46 | 5.47 | 5.97 | 7.89 | 9.97 |
| 50µ LDPE | 0.65 | 1.32 | 1.91 | 3.01 | 4.15 | 4.76 | 6.48 | 8.51 |
| 25µ PP | 1.6 | 2.71 | 3.96 | 5.24 | 6.02 | 7.31 | 9.34 | 10.34 |
| 50µ PP | 1.74 | 2.94 | 4.03 | 5.01 | 6.03 | 8.4 | 9.66 | 10.8 |
| Cling wrap | 3.85 | 4.92 | 5.77 | 7.15 | 8.32 | 10.1 | 11.9 | 13.93 |
| No MAP | 4.77 | 6.01 | 7.52 | 4.97 | 0 | 0 | 0 | 0 |
| GM | 2.35 | 3.4 | 4.46 | 1.21 | 5.99 | 7.31 | 9.05 | 10.71 |
| F-Test | *** | *** | *** | ** | *** | * | * | * |
| LSD | 0.63 | 0.45 | 0.79 | 0.79 | 0.81 | 1.54 | 1.63 | 1.31 |
| CV (%) | 14.84 | 7.39 | 9.82 | 12.93 | 7.18 | 11.22 | 9.57 | 6.52 |

Source: Gautam, et.al 2015

**Table7.** Physiological weight loss (%) of 10 day MAP stored at 5.5±4.50C; 82±17% RH tomato fruits at opening (10th day) and thereafter in different days interval in ambient condition (15.5±4.50C; 82±17% RH).

| Treatments | Physiological weight loss (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Opening day | 3rd Day | 5th Day | 7th Day | 9th Day | 11th Day | 13th Day |
| 25µ LDPE | 2.91 | 3.81 | 6.52 | 7.65 | 9.85 | 11.2 | 13.34 |
| 50µ LDPE | 2.35 | 3.38 | 4.3 | 5.82 | 6.88 | 8.54 | 9.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25µ PP | 2.96 | 4.14 | 6.14 | 8.42 | 10.12 | 12.8 | 15.43 |
| 50µ PP | 2.38 | 3.78 | 6.38 | 7.89 | 10.35 | 12.9 | 16.15 |
| Cling wrap | 5.52 | 6.22 | 8.88 | 12.06 | 14.09 | 15.72 | 18.81 |
| No MAP | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GM | 3.22 | 4.26 | 6.44 | 8.36 | 10.26 | 12.27 | 14.71 |
| F-Test | *** | *** | *** | *** | *** | *** | *** |
| LSD(0.05) | 0.95 | 0.75 | 1.83 | 2.01 | 2.06 | 2.29 | 2.45 |
| CV (%) | 15.78 | 9.4 | 15.09 | 12.77 | 10.69 | 9.94 | 8.85 |

Source: Gautam, et.al 2015

### 1.3.3 Effect of thin paper polythene wrapping in Cucumber

Thin paper polythene wrapping could be one of the approaches to increase the shelf life of cucumber in ambient condition. Various treatments on wrapping with or without hole in it and washing were studied on cucumber at RARS, Lumle. The study was carried out for 10 days where different parameters (physiological loss in weight, fruit firmness, decay loss, TSS, TA, and freshness of fruit) were recorded at alternate day interval. Washing of fruit according to treatment was done with 50 ppm chlorine water. After the analysis of all data, fruit washed with 50 ppm chlorine water and wrapped with cling wrap gave better results in terms of every postharvest quality parameter aspects. The reason could be due to killing and washing of pathogen while washing and no transmission of pathogens from infected to healthy fruits (Figure 2).

**Figure 2.** Trial set up of cucumber in thin polythene wrap in RARS, Lumle

### 1.3.4 Postharvest Supply Chain Study of Carrot in Kathmandu valley during 2016/17

A study was conducted in Bhaktapur-Kalimati road corridor and laboratory of Nepal Agricultural Research Council, Horticulture Research Division (HRD), Khumaltar in 2016-2017. Major carrot production sites in this corridor are Manohara Khola, Bodephant and Mulpani. The main collection point is Garcha Bazar and Bhaktapur. From this collection center, the produce goes to the Kalimati market. In carrot production pockets, grading is not practiced. The farmers mention that grading is labor intensive. Carrots are mostly packed in 75-85 kg capacity jute sacks. The postharvest loss of carrot was found to be 35%. The loss occurred

at farm gate was 10%, at collection point it was 2%, at wholesale market 5% and finally at retail market 18%. According to wholesalers, carrots are graded into 2 categories viz. branched/cracked and normal roots and branched/cracked ones are sold at 50% less price. It was found that during the production season, the wholesale price was very low (NRs. 26/kg) while during the lean period, the prices were significantly high (up to NRs. 137/ kg). Furthermore, a research conducted in the laboratory of Horticulture Research Division, Khumaltar during February- March, 2016 and 2017 showed that calcium chloride treatment of 2.5% was found to be effective in increasing the storage life of carrots (Table 8 and 9).

**Table 8.** Effect of calcium chloride on shelf-life and TSS of carrot root at room temperature in HRD, Khumaltar during 2016/17

| Treatment | TSS0 (Brix) | Shelf life (Days) |
|---|---|---|
| 0.5% CaCl2 | 7.47 | 6.67 |
| 1.0% CaCl2 | 5.86 | 7.33 |
| 1.5 % CaCl2 | 6.23 | 7.33 |
| 2.0% CaCl2 | 7.13 | 8 |
| 2.5 % CaCl2 | 6.60 | 10.67 |
| 3.0% CaCl2 | 7.30 | 9 |
| 3.5% CaCl2 | 6.93 | 7 |
| Control(Tap water) | 6.07 | 6 |
| F-Test | Ns | * |
| LSD(0.05) | 2.054 | 1.413 |
| CV% | 17.7 | 7.75 |

Source: Bhattarai, et.al 2018

**Table 9.** Physiological weight loss (%) of carrot roots at various days after storage at HRD, Khumaltar during 2016/17

| Treatment | Physiological weight loss (PWL %) | | | | |
|---|---|---|---|---|---|
| | 2DAS | 4DAS | 6DAS | 8DAS | 10DAS |
| 0.5% CaCl2 | 8.84 | 7.6 | 5.65 | 6.1 | 10.91 |
| 1.0% CaCl2 | 7.82 | 7.13 | 4.81 | 5.74 | 9.87 |
| 1.5% CaCl2 | 7.24 | 6.99 | 4.68 | 5.5 | 9.48 |
| 2.0% CaCl2 | 7 | 6.87 | 4.28 | 5.15 | 9.02 |
| 2.5% CaCl2 | 6.12 | 6.02 | 3.75 | 4.56 | 7.54 |
| 3.0% CaCl2 | 6.75 | 6.69 | 3.9 | 5.02 | 8.52 |
| 3.5% CaCl2 | 8.39 | 7.25 | 4.9 | 5.86 | 10.11 |
| Control(Tap water) | 9.88 | 7.86 | 6.35 | 6.23 | 11.25 |
| F-Test | * | * | * | * | * |
| LSD(0.05) | 1.336 | 1.067 | 0.952 | 0.9 | 1.968 |
| CV% | 10 | 8.7 | 11.5 | 9.4 | 11.9 |

Source: Bhattarai, et.al 2018\

## 1.3.5 Modified atmosphere Packaging (MAP) of capsicum under coolbot storage condition at HRD Khumaltar during 2018/19

A study was conducted to identify the suitable perforation on modified atmospheric packaging for storing the carrots. Freshly harvested defect free roots of New Kuroda variety was collected from farmers field of Jurikhet of Makawanpur district. Carrots were allowed to pre-cool for overnight. A unit sample of 10 (1 kg) carrots were packaged in modified atmospheric packaging without perforation, modified atmospheric

packaging with 8 perforations, modified atmospheric packaging with 16 perforations, modified atmospheric packaging with 24 perforations and without modified atmospheric packaging at the laboratory HRD, Khumaltar with three replications. Observations were made on TSS, PWL % (Physiological Weight Loss), vitamin C and overall consumer acceptability. The results showed that there were no significant changes in the vitamin C content of the carrots with different perforation of the packaging materials. On seven days of storage, carrots stored without any packaging materials had the highest (28.8 %) physiological weight loss whereas the lowest (0.2 %) was found in carrots packaged in MAP without perforation. Overall consumer acceptability was found the highest (6.62 scale) in carrots packaged in MAP with eight perforations. Carrots in open tray have the shelf life of 14 days but carrots packaged in MAP have the shelf life of 21 days. After 21 days carrots has been started to sprout. MAP with 8 perforation found to be effective for storing carrots.

**Table 10.** Shelf life and qualities of carrots at different days of storage under modified atmospheric storage conditions at HRD, Khumaltar during 2018/19

| Treatments | Physiological wt. loss (%) | | | TSS (o Brix) | | | Vit. C content (mg/100g) | | | Overall consumer acceptability (1-9 scale) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 days | 14 days | 21 days | 7 days | 14 days | 21 days | 7 days | 14 days | 21 days | |
| MAP without perforation | 0.2 | 0.15 | 0.45 | 5.40 | 6.20 | 6.08 | 5 | 2.82 | 3.17 | 5.75 |
| MAP with 8 perforation | 0.3 | 0.20 | 0.30 | 5.95 | 5.83 | 6.15 | 3.44 | 4.03 | 2.18 | 6.62 |
| MAP with16 perforation | 0.5 | 0.45 | 0.67 | 5.87 | 5.70 | 4.97 | 4.37 | 3.26 | 2.18 | 5.50 |
| MAP with 24 Perforation | 0.8 | 0.58 | 1.67 | 5.58 | 6.97 | 5.77 | 3.12 | 4.19 | 2.38 | 5.37 |
| Without MAP (Control) | 28.8 | 12.36 | - | 8.38 | 10.35 | - | 2.8 | 4 | - | - |
| GM | 6.1 | 2.75 | 0.77 | 6.24 | 7.01 | 5.74 | 3.75 | 3.74 | 2.48 | 5.81 |
| F-test | ** | ** | ns | ** | ** | ns | ns | ns | ns | * |
| LSD(0.05) | 7.02 | 5.56 | - | 1.09 | 1.55 | - | - | - | - | .72 |
| CV % | 76 | 134.4 | 104.5 | 11.6 | 14.7 | 21.5 | 31.6 | 28 | 25.3 | 8 |

Consumers acceptability Scale (1-9), 1= highly acceptable, 9 = Unacceptable

## 1.3.6 Study of Carrot packaging materials

Freshly harvested defect free roots of Nepa Dream variety was collected from the farmer's field of Fulbari of Chitwan district. Carrots were allowed to pre-cool for two hours and packaged. A unit sample of 20 kg carrots were packaged in Plastic crates, Doko, Jute sacks, Plastics sacks and Nylon net bags and transported to HRD, Khumaltar, Lalitpur which was 162km far from Fulbari, Chitwan. After transporting to Khumaltar, bruising damage % were calculated. For further postharvest study a unit sample of 13 kg carrots were kept in ambient storage with three replications and observation were made on TSS, rotting %, and PWL %. During handling, the highest (3.2 %) bruising damage was found in carrots packaged in nylon net bag and the lowest (0.16%) in plastic crates. There was no

significant difference among the treatments on TSS content during the storage days. On third day of storage, carrots packaged in plastic sacks and stored in ambient condition had the highest rotting (24.5%) and the lowest in jute sacks (1.5 %). The highest loss on third day could be due to low oxygen and high carbon dioxide and temperature inside the plastic sacks. On ninth day of storage, the highest rotting (15%) was found in plastic sacks and the lowest (4%) in plastic crates. On third day of storage the highest (6.7 %) physiological weight loss was found in plastic crates and the lowest (2.0%) was in nylon net bag. On nine days of storage the highest (9.8 %) physiological weight loss was found in plastic crates and the lowest (7.3 %) was in nylon net bag. Overall consumer acceptability was found the highest (6.77 scale) in plastic crates. The detail effect of packaging materials and storage on TSS, rotting and PWL percentage in different treatment is given in (Table 11). Results showed that plastic crates have been found effective for transporting the carrots as it causes minimum bruising damage during transportation and subsequent storage. Plastic sacks were not suitable for transporting the carrots because it caused more rotting of the carrots during storage.

**Table 11.** Effect of packaging materials and storage on TSS, rotting , PWL percentage and overall acceptability of carrots at Khumaltar. (2018/19)

| Treatments | TSS (o Brix) | | | Rotting (%) | | | PWL(%) | | | Overall consumer acceptability (1-9 scale) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3rd day | 6th day | 9th day | 3rd day | 6th day | 9th day | 3rd day | 6th day | 9th day | |
| Plastic crates | 8.93 | 8.17 | 9.47 | 2.7 | 2.8 | 4 | 6.8 | 9.6 | 9.8 | 6.77 |
| Bamboo basket | 7.63 | 8.73 | 9.73 | 4.3 | 2.5 | 6.3 | 4.2 | 6.2 | 8.3 | 6.22 |
| Jute sack | 7.83 | 6.57 | 9.2 | 1.5 | 4.8 | 5.5 | 2.5 | 8.8 | 9.3 | 6.22 |
| Plastic sack | 6.67 | 7.53 | 7.8 | 24.5 | 14 | 15 | 4.7 | 7.6 | 9.2 | 5.11 |
| Nylon net bag | 8.40 | 6.63 | 7.5 | 3.0 | 4.3 | 7 | 2 | 7.5 | 7.3 | 6.22 |
| GM | 7.89 | 7.53 | 8.74 | 7.2 | 5.7 | 7.56 | 2.8 | 7.9 | 8.8 | 6.12 |
| F-test | ns | ns | Ns | ** | ** | * | * | * | ns | ** |
| LSD(0.05) | - | - | - | 8 | 4.6 | 5.6 | 2.8 | 2.2 | - | 0.70 |
| CV % | 12.9 | 23.2 | 13.4 | 61.3 | 44.7 | 40.9 | 38.3 | 15.3 | 24.7 | 6.3 |

Consumers acceptability Scale (1-9), 1= Highly acceptable, 9 = Unacceptable

## 1.3.7 Study of different storage conditions on qualities of carrots

Similarly an experiment was conducted to identify the suitable storage condition for storing the carrots. Freshly harvested defect free roots of Nepa Dream variety was collected from the farmer's field of Mulpani of Bhaktapur district. Carrots were allowed to pre-cool for overnight. A unit sample of 4 kg carrots were stored in Coolbot storage, Zero energy storage, Double earthen pot storage and Ambient storage at the laboratory of HRD, Khumaltar with four replications. Observations were made on TSS, rotting %, PWL% and overall consumer acceptability. ANOVA table showed that there was no difference in TSS content among the treatments during the storage days. On 5th day carrots stored in coolbot storage had the lowest (0 %) rotting and storage done in double earthen pot had the highest (5.7%) rotting. On 20th days of storage carrots stored in coolbot storage has the lowest (0.58%) rotting whereas stored in zero energy storage has (5.5%) rooting

(Table 12). On 5th days of storage, the highest (6.1%) physiological weight loss was found in carrots stored in double earthen pot storage and the lowest (0.8%) was in coolbot storage. On 20th days there was no significant difference in weight loss of carrots. Overall consumer acceptability was found the highest (6.0 scale) in carrots stored in zero energy storage condition and the lowest (2.75 scale) in carrots stored in ambient condition. This study showed that coolbot storage was effective for storing the carrots as it caused minimum rotting and physiological weight loss during the storage.

**Table 12.** Effect of Storage condition on storage life of Carrots at HRD, Khumaltar (2018/19)

| Treatments | TSS (o Brix) | | | | Rotting (%) | | | | PWL(%) | | | | Overall consumer acceptance (1-9) scale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5th day | 10th day | 15th day | 20th day | 5th day | 10th day | 15th day | 20th day | 5th day | 10th day | 15th day | 20th day | |
| Coolbot storage | 7.70 | 7.28 | 7.95 | 10.13 | 0 | 0 | 0 | .58 | 0.8 | 3.7 | 3.5 | 3.8 | 5 |
| Zero energy storage | 6.55 | 6.42 | 6.25 | 6.95 | 3.39 | 8.82 | 9.14 | 5.50 | 5.1 | 9.9 | 10 | 6.2 | 6 |
| Double earthen pot storage | 7.20 | 6.55 | 6.42 | 8.35 | 5.77 | 6.80 | 7.25 | 5.44 | 6.1 | 8.0 | 2.9 | 8.6 | 6 |
| Ambient storage | 9.08 | 7.10 | 7.67 | 9.85 | 1.88 | 3.47 | 4.8 | 4.41 | 5.4 | 11.1 | 1.5 | 8.7 | 2.75 |
| GM | 7.63 | 6.84 | 7.08 | 8.82 | 2.76 | 4.77 | 4.22 | 3.98 | 4.3 | 8.2 | 4.4 | 6.8 | 4.94 |
| F-test | ns | ns | ns | ** | * | ** | ** | * | * | * | ** | ns | ** |
| LSD(0.05) | - | - | - | 1.29 | 3.43 | 2.48 | 4.12 | 3.81 | 3.4 | 4.4 | 3.6 | - | 0.96 |
| CV % | 15.8 | 11.8 | 21.3 | 9.5 | 82.2 | 33.8 | 63.4 | 62.1 | 50.9 | 35 | 56.7 | 40.7 | 12.7 |
| CV % | 12.9 | 23.2 | 13.4 | 61.3 | 44.7 | 40.9 | 38.3 | 15.3 | 24.7 | | | | 6.3 |

Consumers acceptability Scale (1-9), 1= Highly acceptable, 9 = Unacceptable

## 1.3.8 Modified atmosphere packaging (MAP) of capsicum under coolbot storage condition

The study was carried out at Coolbot storage installed at the laboratory of HRD, Khumaltar. The capsicum fruits of medium early variety Almirante grown under the semi hi-tech greenhouse were harvested at green matured stage on 29 April, 2019 in the morning hour from the farm at Pithuwa, Chitwan, and were packed in a cardboard box and brought to HRD on the same day of harvest. Fruits were kept at shade condition for pre cooling and the experiment was setup on the next day. A single variety of capsicum was tested using modified atmosphere packaging with different number of pinhole sized perforations (i.e. 8, 16 and 24) under Coolbot condition at 9.8 degree Celsius and 86 % RH (average of daily record). An experimental unit consisted of 10 fruits. The 25 µ Low Density Polyethylene (LDPE) was used as a modified atmosphere packaging (MAP) material. The storage temperature and relative humidity was recorded daily up to the last days of the storage. The research was carried out in Completely Randomized Design with 5 treatments and 4 replications altogether with 20 total observations. The total loss in fruit during transportation in cardboard box lined with the plastic bag was 6.29 % due to bruises. The influence of modified atmosphere packaging on shelf life of capsicum is presented in Table 13. From the study, it was found that the physiological weight loss (PWL) was found significantly the minimum in MAP storage than that of control in each date of observation. The MAP without

pinholes showed the lowest weight loss (0.23%) on 11th days of storage followed by MAP with 16 pinholes (0.73%) whereas 1.71% loss was observed on the last day of storage. Similarly, the maximum weight loss (4.95%) was observed in control on 11th day of storage and 19.32% on 30th day of storage. However, no significant changes in vitamin C content and firmness were observed over the storage period.

**Table 13.** Effect of packaging materials and coolbot storage on postharvest qualities of capsicum fruits at HRD, Khumaltar during 2018/19

| Treatment | 11th Day | | | 21th Day | | | 30th Day | | |
|---|---|---|---|---|---|---|---|---|---|
| | PLW (%) | Firmness (lb) | Vitamin C (mg/100g) | PLW (%) | Firmness (lb) | Vitamin C (mg/100g) | PLW (%) | Firmness (lb) | Vitamin C (mg/100g) |
| MAP without pinholes | 0.23 | 4.90 | 65.59 | 0.99 | 4.71 | 54.93 | 1.71 | 4.57 | 54.93 |
| MAP with 8 pinholes | 0.86 | 4.66 | 64.03 | 2.68 | 4.68 | 51.19 | 4.15 | 4.38 | 51.19 |
| MAP with 16 pinholes | 0.73 | 4.64 | 64.82 | 3.66 | 4.40 | 50.90 | 4.93 | 3.61 | 50.90 |
| MAP with 24 pinholes | 1.65 | 5.05 | 62.85 | 4.01 | 4.30 | 50.56 | 5.54 | 3.79 | 50.56 |
| Control | 4.95 | 4.43 | 63.08 | 14.06 | 3.99 | 47.01 | 19.32 | 3.76 | 47.01 |
| F-Test | ** | ns | ns | *** | ns | ns | *** | ns | ns |
| LSD(0.05) | 1.75 | 0.66 | 31.18 | 1.72 | 0.55 | 21.35 | 2.01 | 1.23 | 21.35 |
| CV% | 55.13 | 7.41 | 25.84 | 18.03 | 6.65 | 22.27 | 14.99 | 16.23 | 22.27 |

# 2. Varietal improvement in vegetable crops

## 2.1 Variety Released

### 2.1.1Bhaktapur Local

'Bhaktapur Local' variety of cucumber was released in 2018, has red skin, white flesh color, has attractive color and better taste, multiple branching habit; fruits: elongated, 26-30 cm long and 5-7 cm in diameter, predominant fruit skin color is white: male: female ratio:11:1, recommended for mid hills (600 to1600 masl).

## 2.2 Variety Registered

### 2.2.1 Asparagus Bean

**Great Wall 02:** Open pollinated variety, has light green pod, pod length: 65-75 cm, number of pods per plant: 46, yield: 20-25 t/ha, recommended for Kathmandu valley and similar environment conditions in mid hills of Nepal.

**Great Wall 03:** Open pollinated variety, has green pod, pod length: 70-80 cm, number of pods per plant: 46 with least rust and virus disease, yield: 25-30 t/ha, recommended for Kathmandu valley and similar environment conditions in mid hills of Nepal.

### 2.2.2 French bean

**Semi Light Long:** Open pollinated variety, light green pod, days to harvest from seeding:70-75 DAS, pod length:15-20 cm, days to 50% flowering: 55-58 DAS, pod length:15-20 cm, number of pods per cluster:4.5, number of pods per plant:110-115, yield: 30-33 t/ha, recommended for Kathmandu valley and similar environment conditions in mid hills of Nepal.

**Long Green Bean:** Open pollinated variety, green pod, days to harvest from seeding: 75-78 DAS, pod length: 20-22 cm, days to 50% flowering: 58-62 DAS, number of pods per Cluster: 4.5, number of pods per plant: 80-85,

yield: 26-28 t/ha, recommended for mid hills condition near Kathmandu valley???

## 2.2.3 Zuccini

**Super Squash Ball:** F1 Hybrid, yield (30 t/ha), round shape, light green, average fruit weight: 800-850 gm, days to mature after transplanting: 40-45 days, recommended for Kathmandu valley and similar environment in mid hills of Nepal in irrigated condition.

## 2.2.4 Bitter gourd

**CG-01:** F1 Hybrid, yield 18-22 t/ha, medium spiny on fruit and slight tapering ends, dark green color fruit, harvestable from seeding: 80-99 days, average fruit weight: 307.5gm, fruit length: 25.6 cm, fruit diameter: 4.8-5.1 cm, fruit shape: stout at the center and tapering towards both ends, mild bitter in taste, tolerant to rainy season, recommended for eastern terai of Nepal.

**CG-02:** F1 Hybrid, yield (15-19 t/ha), white color fruit, harvestable from seeding:80-99 days, average fruit weight:302 gm, fruit length: 25-26 cm, fruit diameter:4.7-4.8 cm, fruit shape: increase size at the center and tapering towards both ends, mild bitter in taste, tolerant to rainy season, recommended for eastern terai of Nepal.

## 2.2.5 Cabbage

**Wonder Ball:** yield 70-75 t/ha, days to head initiation:56 days, days to harvest from transplanting: 90-100 days, average head weight: 1622 gram, average head length:38 cm and width: 39.7 cm, recommended for mid hills condition.

**Green challenger:** F1 hybrid, yield 50-60t/ha, days to head initiation: 55 days, days to harvest from transplanting: 90-100 days, average head weight: 1387 gram, average head length: 33.9 cm and width 33.7 cm, recommended for mid hills condition

**Shaurya:** F1 Hybrid, yield 60-67 t/ha, days to head initiation :56-62 days, days to harvest from transplanting:86-97 days, average head weight :1306 gram, average head length: 18 cm and width 17 cm, recommended for terai condition.

**Millenium111:** F1 hybrid, average yield 65-70 t/ha, days to head initiation: 51-60days, days to harvest from transplanting: 86-97 days, average head weight: 1400-1450 gram, average head length: 13-18 cm and width 12-17 cm, recommended for terai condition.

## 2.2.6 Cauliflower

**Barkha:** F1 Hybrid, yield: 34-39 t/ha, days to curd initiation: 33 days, days to harvest from transplanting: 60-65 days, average curd weight: 1039 gram, average plant length: 51 cm and width 38 cm, recommended for mid hills condition.

**Girija:** F1 Hybrid, yield: 34-39 t/ha, days to curd initiation: 53 days, days to harvest from transplanting: 85-90days, average curd weight: 1259 gram, average plant length: 46 cm and width 37 cm, recommended for mid hill condition.

**Whistler:** F1 Hybrid, yield 30-40 t/ha, days to curd initiation: 57-63 days, days to harvest from transplanting :77-80 days, average curd weight: 1307 gram, average curd length:18 cm and width 19 cm, recommended for terai condition.

## 2.2.7 Tomato

**Aviral :** F1 Hybrid, yield 83 t/ha, days to flowering from transplanting:35 days, average fruit weight:59 gram, average fruit length: 4.2 cm and width 5.2 cm with round fruit shape, recommended for terai condition.

**Abhilash:** F1 hybrid, yield 79 t/ha, days to flowering from transplanting:32 days, average fruit weight:72 gram, average fruit length:4.6 cm and width 5.6 cm with flat round fruit shape, recommended for terai condition

## 2.2.8 Amaranthus

**Ramechhap Hariyo:** Yield 137.39 quintal / ha, harvest duration days:61 days, number of harvest :6, free from disease and insects, soft texture after cooking, green in color with glabrous leaf texture,10.07% dry matter content, 4.33 % nitrogen content, 27.06% crude protein,10.15% crude fiber content, 23.90% total ash content, 2.06% potassium content. This variety is proposed by registration by CEAPED with collaboration with NARC.

## 2.3 Proposed for registration

## 2.3.1 Onion

**Baitadi Local:** Plant height:50-60 cm, days to 50% flowering 150-180 days, mature in 170-230 days, green leaf color, fresh bulb yield 40000-50000 kg/ha and 500-600 kg/ha seed production, recommended for mid hills, lower hills and inner terai. This variety is proposed by registration by CEAPED with collaboration with NARC.

## 2.3.2 Kangkong

**Thai Palungo:** leaf length 15-20 cm, length width 6-7 immature in 5-6 weeks from days of transplanting, yield: 3000-4000 kg/ropani

## 2.4 Promising lines

## 2.4.1 Radish

**HRDRAD002:** Yield 63.7 t/ha, number of leaves/ plant: 23.8, root length: 24 cm, root diameter: 4.7 cm average root weight: 286.9 g, found promising both in mid hill and terai conditions.

**HRDRAD005:** Yield 60.9 t/ha, number of leaves/ plant: 23.8, root length: 24 cm, root diameter: 5 cm, average root weight: 274.1 g, found promising both in mid hill and terai conditions.

## 2.4.2 Onion

**AVON 1027:** Yield 38.83 t/ha, leaf length 38.48 cm, number of leaves:9.88, plant height: 44.37cm, neck diameter: 14.04 mm, Bulb diameter: 73.54 mm, Weight of individual bulb:180.3 gram, green foliage color, found promising in mid hills conditions.

## 2.4.3 Capsicum

**HRDCAP004:** Fruit length: 50.93 mm, fruit width: 42.49 mm, fruit weight 29.4 gram, number of fruit per plant: 49.60, pericarp thickness: 3.47 mm, Yield: 40.3 t/ha, found promising in mid hills condition.

**HRDCAP001:** Fruit length: 75.06 mm, fruit width: 69.11 mm, fruit weight: 125.2 gram, number of fruit per plant: 19.60, pericarp thickness: 6.43 mm, yield: 68.3 t/ha, found promising in mid hills condition.

# CONCLUSION

- Well decomposed goat manure mixed with 2 gram trichoderma per kg manure is found more effective against coco-pit and other media for year round production of high value vegetable seedlings in tray under protected condition.
- Vegetable School Gardening are more effective in influencing food knowledge and preferences than actual food choices. This technology is effective to increase the nutrition of rural school children and suggested government to disseminate this technology in whole Nepal.
- Post-harvest losses in vegetables could be minimized through development and dissemination of appropriate postharvest handling technologies on harvesting, packaging, transportation and storage. The low cost storage technology as pot in pot, coolbot are more convenient for small scale vegetable storage without deterioration of quality.

- The way out for regular exchange of germplasms, experts and technology especially in the field of breeding, biotechnology and hybrid seed production to reduce the huge import of hybrid vegetables seeds from other countries. MoALD and NARC should manage sufficient land and infrastructures for hybrid vegetable breeding. A multidisciplinary team need to be formed to run the hybrid seed production technology in major vegetables.
- The other burning areas needing attention are: micro-irrigation, hydroponic, aero-ponic and wild and/or under-exploited plants used as vegetables, etc. Some of these works are going to initiate in the division.

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