Nepalese Horticulture 18 : 86-95, 2024
ISSN : 2092-1122 | Print : 2542-2936 (Online)
DOI: https://doi.org/10.3126/nh.v18i1.72809

Research Article

OPEN ACCESS

Performance and Post-Harvest Evaluation of Sweet Pepper Genotypes

Ranjana Rawal[1*], Bikash Bhusal[2], Sujata Poudel[3], and Ishwori Prasad Gautam[1]

[1]*National Horticulture Research Center, Khumaltar, Lalitpur, Bagmati, Nepal*

[2]*National Agriculture Genetic Resources Center, Khumaltar, Bagmati, Nepal*

[3]*Agriculture and Forestry University, Rampur, Chitwan, Bagmati, Nepal*

[*]Corresponding Author's Email: ranjanarawal.narc@gmail.com

Orcid IDs:

Ranjana Rawal: https://orcid.org/0000-0003-4229-2139

Bikash Bhusal: https://orchid.org/0000-0002-0721-324X

Sujata Poudel: https://orcid.org/0000-0002-4003-1333

Ishwori Prasad Gautam: https://orcid.org/0000-0003-0682-9306

Received on: 6 July, 2024 **Revised on:** 6 November, 2024 **Accepted on:** 12 November, 2024

Abstract

The study evaluated the novel six open-pollinated sweet pepper genotypes for yield, quality, and self-life at Khumaltar conditions during 2078–2079. The experiment was laid out in RCB design with six treatments and four replications. Each plot was mulched with 25-micron plastic, and 43-day-old seedlings were planted by making a hole at a distance of 60 cm x 45 cm. The result showed that sweet pepper genotypes had a significant effect on yield attributing and quality parameters. HRDCAP004 (575.1) and HRDCAP003 (527.9) recorded the highest number of fruits per plot. However, the highest yield was recorded in genotype HRDCAP001 (37.8 t/ha). The lower yield in genotype 'HRDCAP003' (24.7 t/ha), even though it had the highest number of fruits per plot, was due to the smaller fruit size of this genotype. There was a significant effect of the sweet pepper genotype on the quality attributing characters. The content of titratable acidity (0.6 %), Ascorbic acid content (21.1 mg/100g), and fruit firmness (4.1 kg/cm2) was found to be significantly higher in 'HRDCAP001' compared to other genotypes. In addition, fruits were wrapped in 25 μ low-density polyethylene bags and stored under Coolbot conditions at 8^0 C and 95% relative humidity. The result indicates a significant effect of packaging and storage conditions on the storage life of the tested genotypes. Hence, the genotype HRDCAP001 will be further recommended for farmers' field trials and a variety registration processes.

Keywords : Capsicum, fruit quality, low energy storage, post-harvest.

Introduction:

Sweet pepper **(***Capsicum annuum* L. var. grossum) is commonly known as bell pepper, capsicum, or green pepper and belongs to the Solanaceae family. This crop is cultivated worldwide and used as a cooked vegetable, salad, and processing purposes. From a nutritional perspective, it is an excellent source of Ascorbic acid content (63–243 mg), Vitamin A (carotenoids, 8493 IU), Potassium (263.7 mg), Calcium (13.4 mg), Phosphorous (28.3 mg) and Magnesium (14.9 mg) per 100 g of fresh weight (Howard et al., 1994). It is also rich in other health-promoting metabolites such as capsaicin, capsantin, phenolic compounds, and antioxidants (Aminifard et al., 2012). The fruits of sweet peppers are different colours; green is the most favoured colour, while red and yellow are also preferred because of their quality and higher price in the market. The global consumption of sweet pepper has increased in the last two decades, with production ranging from about 19 to 40 million tons (Faostat, 2018).

In recent years, it has attained the status of a high-value crop and occupies a proud place among vegetables in Nepalese cuisine because of its delicacy and pleasant flavor. Due to excessive demand from urban consumers as well as from star hotels, it fetches a high market price. In Nepal, this crop occupies an area of 1,779 hectares (ha), with an annual production of about 18,748 tons and a productivity of 10.54 tons per hectare (t/ha) (MoALD, 2020/21). The major sweet pepper-producing districts of Nepal are Kavrepalanchok, Chitwan, Lalitpur, and Dhading. In Kavrepalanchok, sweet pepper covers an area of 168 ha with an annual production of 2,748 mt and a productivity of 16.06 mt/ha (MoALD, 2020/21). Despite this crop's huge demand and high retail price, most of the sweet pepper is imported from India. This may be due to lower productivity and a lack of superior varieties that are resistant to diseases and have been adapted to the different agroclimatic domains of Nepal.

In Nepal, sweet pepper is grown as a summer crop in the mid-hills and as a winter crop in the Terai region. Hence, to obtain good-quality produce and fulfill the demand for sweet peppers throughout the year, there is a need to identify the varieties suitable for different agroecological zones of Nepal. In our context, the available sweet pepper varieties are less productive and highly susceptible to diseases like bacterial wilt, fusarium wilt, and phytophthora blight. While inside the protected structures, the farmers prefer to grow an indeterminate hybrid cultivar of sweet pepper. Till now, only three varieties have been registered in Nepal, and these varieties are determinate and not preferred by the farmers (SQCC, 2023). So, farmers are using varieties that are not released or registered in Nepal. In addition to this, the demand for this vegetable is throughout the year, but due to its perishable nature, it can not be stored for a long time in ambient conditions. So, developing suitable postharvest handling technology is essential to ensuring crop availability in the market during the lean period. Considering its economic importance as a high-value crop and potential off-season vegetable, there is a need for the identification of new varieties and technologies that meet the demand of commercial sweet pepper growers and increase overall productivity to reduce the negative balance of trade.

Materials and Methods:

Experimental site and experimental design

An experiment was conducted at the National Horticulture Research Center, Khumaltar, Lalitpur, Nepal. Six open-pollinated sweet pepper genotypes 'HRDCAO001', 'HRDCAP003', 'HRDCAP004', 'HRDCAP005' and 'HRDCAP006' were used as a treatment and compared with 'California Wonder' as a standard check in an open field conditions during 2078/79. The experiment was laid out in a Randomized Complete Block Design with six treatments and four replications. The plot size was 5.4 m2 (2.4 m x 2.25 m) with four rows and five plants per row. Each plot was mulched with 25-micron plastic (silver upside and black inside), and the seedlings were planted by making a hole at a distance of 60 cm x 45 cm.

Raising seedlings and transplanting

The seeds were sown in 72-cell plastic plug trays. The growing substrate for seed germination was prepared using a mix of sandy soil, vermicompost, and peat (2:1:1). The seeds were sown on Falgun 3rd, 2078, and transplanted on Chaitra 16th, 2078. The standard recommended dose of fertilizers (30-ton FYM + 100:100:60 kg NPK/ha) was applied. A half dose of nitrogen was applied at the time of transplanting, and another half dose was top-dressed 35 days after transplanting.

The first pinching-off of flower buds and small fruits at the first and second nodes was done on Jestha 6th, 2079. All the unnecessary leaves and branches below the first and second nodes were removed on a regular basis.

Growth and fruit quality Parameters

Since the sweet pepper genotypes were determinate type, the plant height was measured when 50% of the plants were at the flowering stage (Gotame et al., 2019). The plant canopy width was measured immediately after the first harvest, at its widest point. The leaf area was measured using a portable leaf area meter (SYSTRONICS, Leaf Area Meter-211). The average fruit length, fruit diameter (at the widest point), and pericarp thickness of 10 ripe fruits per treatment of the second harvest were measured using the Vernier caliper. The average fruit weight of 10 ripe fruits from the second harvest was also measured. Disease incidence (I) was calculated by using the following formula: (I = X/N), which is the proportion of diseased plants, which consisted of the number of diseased plants (X) divided by the total number evaluated (N).

Quality attributing characters

The quality attributing characteristics such as Total Soluble Solid (TSS), fruit firmness, Titratable acidity and ascorbic acid content were measured after harvesting of fruits. The TSS of the sweet pepper fruit (average of five samples) was measured using the Portable Digital Brix Refractometer (Atago Co., Tokyo, Japan). The average fruit firmness was measured using a handheld FR-5120 Digital Penetrometer (QA Supplies, VA, USA) with a cylindrical stainless-steel probe of 5.84 mm in diameter. Puncture tests were taken from the three equatorial sides of the same fruit. Three fruits were used in each treatment. Titratable acidity was determined by titrating 5 g of homogenized sweet pepper pulp in 100 ml of distilled water against 0.1 N NaOH, using phenolphthalein as an indicator, and expressed as a percentage of citric acid, as described by Corrêa et al. (2018).

The amount of ascorbic acid was measured by the

volumetric method according to the protocol of Sadasivsm and Manickam (1991). The ascorbic acid content was calculated by using the following formula:

$$\text{The amount of ascorbic acid (mg/100 g sample)} = \frac{0.5 \text{ mg x V2mL x 12mL x 100}}{\text{V1mL x 5mL x wt. of the sample}}$$

V1mL x 5mL x wt. of the sample

Where, V1= amount of dye consumed during the titration

V2 = amount of dye consumed when the supernatant was titrated with 4% oxalic weight of fruit, which was considered total weight loss during the storage interval and expressed as a percentage.

Post-harvest evaluation

The best-performing genotype 'HRDCAP001' was evaluated for post-harvest analysis and compared with genotype California Wonder. The experiment was carried out inside the Coolbot storage (9.8° Celsius and 86% relative humidity) installed at the laboratory of the NHRC, Khumaltar and compared with the fruits placed at ambient conditions or room conditions. For modified atmosphere packaging (MAP) material, the 25 µ Low-Density Polyethylene (LDPE) was used. The six pinhole-sized perforations were used for fruit packaging and compared with the fruits without MAP materials. The research was carried out in a Factorial Completely Randomized Design with four replications. The treatments and levels were as follows:

Variety: HRDCAP001 and California Wonder

MAP: with MAP and without MAP

Storage conditions: Coolbot storage and ambient conditions

The physiological weight loss, spoilage loss, shrinkage loss, ascorbic acid, and firmness were recorded at 7-day intervals up to 21 days.

Physiological weight loss: The weight of seven non-destructive samples of sweet pepper fruits was recorded on the first day and on every 7-day interval up to 21 days. The difference between the initial and final weight of the fruit was considered a physiological weight loss during storage and expressed as a percentage on a fresh weight basis as per the standard method of AOAC (1994).

$$\text{Physiological Weight Loss (PLW \%)} = \frac{\text{Initial weight - Final weight x 100}}{\text{Initial weight}}$$

Spoilage loss: Fruits were visually evaluated for symptoms of decay and damage at the end of each storage interval.

$$\text{Spoilage loss (SL \%)} = \frac{\text{No. of decayed fruits x 100}}{\text{Number of total fruits}}$$

Fruit Shrinkage Loss: Fruits were visually evaluated for symptoms of shrinkage at the end of each storage interval.

$$\text{Fruit Shrinkage Loss (FSL \%)} = \frac{\text{No. of wrinkled fruits x 100}}{\text{Number of total fruits}}$$

Statistical analysis

All statistical analyses were done using R software 3.3.3 (R Core Team, 2017). The normality of the data was assessed using the Shapiro-Wilk test followed by the Bartlett test to check the homogeneity of variance before performing an analysis of variance (ANOVA) using the function shapiro.test and bartlett.test in R (Kassambara 2020). Pairwise comparisons between the treatments were performed with Fisher tests of least significant difference (LSD) (P=0.05) by utilizing the agricolae package (1.3-3) in R (Mendiburu 2015).

Result:

Effect of sweet pepper genotypes on growth and yield attributing parameters

The result showed that sweet pepper genotypes significantly affected the different growth and yield attributing parameters. The maximum fruit length was observed in genotypes 'California Wonder' (63.1 cm), 'HRDCAP001' (62.8 cm), and 'HRDCAP005' (60.4 cm), which was followed by 'HRDCAP006' (55.3 cm), whereas the shortest fruit length was observed in genotypes 'HRDCAP004' (41.8 cm) and 'HRDCAP003' (46.7 cm). The largest fruit width was observed in genotypes 'HRDCAP006' (55.3 cm), 'HRDCAP001' (76.4 cm), 'HRDCAP005' (76.3 cm), and 'California Wonder' (73.4 cm), whereas the smallest fruit width was observed in genotypes 'HRDCAP003' (56.2 cm) and 'HRDCAP004' (52.8 cm). A similar result was observed in the case of fruit weight (Table 1). The lowest number of seeds per fruit was observed in genotype 'HRDCAP006' (116.3), while there was no significant difference in the number of seeds per fruit in other genotypes of sweet pepper (Table 1).

The highest plant height and canopy diameter were recorded in 'HRDCAP004' (75.2 cm and 62.8 cm) and 'HRDCAP003' (73.8 cm and 62.9 cm). In contrast, the lowest plant height and canopy diameter were recorded in 'HRDCAP005' (48.2 cm) and 'California Wonder' (55.3 cm), respectively. Sweet pepper genotype significantly affected the total number of fruits per plant and plot and yield per hectare. The highest number of fruits per plot was recorded in 'HRDCAP004' (575.1) and 'HRDCAP003' (527.9), while the lowest number of fruits per plot was recorded in the other four genotypes of sweet pepper: 'HRDCAP006' (255.3), 'California Wonder' (262.9), 'HRDCAP005' (286.9), and 'HRDCAP001' (324.7). However, the highest yield was recorded in genotype 'HRDCAP001' (37.8 t/ha), which was followed by 'HRDCAP005' (32.3 t/ha), 'HRDCAP004' (31.4 t/ha), 'HRDCAP006' (30.5), and 'California Wonder' (29.9 t/ha). The lowest yield was recorded in genotype 'HRDCAP003' (24.7 t/ha). The lower yield in genotype 'HRDCAP003', even though it had the highest number of fruits per plot, was due to the smaller fruit size of this genotype (Table 1 and 2).

Effect of sweet pepper genotypes on disease incidence

The sweet pepper genotypes had a significant effect on the incidence of disease. The genotype 'HRDCAP001' was highly susceptible to Phytophthora blight (59% disease incidence); however, it was moderately resistant to virus incidence (15%). While genotypes 'HRDCAP003' and 'HRDCAP004' were highly resistant to Phytophthora blight (0% disease incidence), they were susceptible to virus incidence (47.5%) and (17.5%), respectively. The sweet pepper genotypes had no significant effect on the incidence of bacterial wilt disease (Table 3).

Effect of sweet pepper genotypes on quality attributing characters

The result showed that there was a significant effect of sweet pepper genotype on the quality-attributing characters (Table 4). The content of TA was found to be significantly highest in 'HRDCAP001' (0.6 %) followed by 'HRDCAP005', 'HRDCAP006' and 'California Wonder' (0.5 % each), while the lowest TA was recorded in 'HRDCAP003' and 'HRDCAP004' (0.4% each) (Table 4). In the case of Ascorbic acid content, the highest amount was recorded in genotype HRDCAP001 (4.1 mg/100g) and 'California Wonder' (21.8 mg/100 g), while the lowest amount was found in the rest of the other genotypes of sweet pepper, ranging from 8.5 to 11.8 mg/100g. Sweet pepper genotypes had no significant effect on the TSS content. The sweet pepper genotype has a significant impact on the fruit's firmness. The maximum fruit firmness was recorded in genotypes 'HRDCAP001' (4.1 kg/cm2) and 'California Wonder' (3.9 kg/cm2), while the lowest fruit firmness was recorded in genotypes 'HRDCAP003' (2.2 kg/cm2), 'HRDCAP004' (2.6 kg/cm2), and 'HRDCAP006' (2.8 kg/cm2) (Table 4).

Table 1: Fruit characters of sweet pepper genotypes at NHRC, Khumaltar, 2021/22

Genotypes	Fruit length (mm)	Fruit width (mm)	Pericarp thickness (mm)	Fruit weight (g)	No. of seeds per fruit	1000 seed weight (g)
HRDCAP001	62.8 ± 4.8a	76.4 ± 3.8a	4.8 ± 0.35	69.9 ± 12a	212 ± 28a	6.5 ± 0.3abc
HRDCAP003	46.7 ± 2.6c	56.2 ± 2.3b	3.7 ± 0.47	32.3 ± 3.4b	216 ± 39a	5.6 ± 0.3d
HRDCAP004	41.8 ± 2.7c	52.8 ± 2.3b	3.8 ± 0.48	32.2 ± 3.2b	237 ± 46a	6.2 ± 0.5c
HRDCAP005	60.4 ± 0.9a	76.3 ± 7.5a	4.3 ± 0.39	65.3 ± 7.8a	227 ± 66a	6.3 ± 0.1bc
HRDCAP006	55.3 ± 4.6b	77.3 ± 5.6a	3.9 ± 0.87	64.8 ± 1.3a	116 ± 24b	6.8 ± 0.1ab
California Wonder (ch)	63.1 ± 3.1a	73.4 ± 3.9a	4.6 ± 0.68	69.9 ± 7.5a	219± 70a	6.9 ± 0.5a
p value	<0.001	<0.001	>0.05	<0.001	<0.05	<0.05

Values are means ± SD of one experimental trial with four replicates. Means in a column followed by different letters are significantly different according to Fisher LSD test (P < 0.05).

Table 2: Yield attributing characters of sweet pepper genotypes at NHRC, Khumaltar, 2021/22

Genotypes	Plant height (cm)	Plant canopy diameter (cm)	No. of secondary branches/ plant	No. of fruits/ plant	Yield/ plant (g)	Total No. of fruits/plot
HRDCAP001	50.1 ± 6.3cd	58.2 ± 2.5ab	10 ± 1b	19 ± 2b	1.4 ± 0.2a	325 ± 24b
HRDCAP003	73.8 ± 4.2a	62.9 ± 3.1a	18 ± 1a	29 ± 6a	0.9 ± 0.3b	528 ± 64a
HRDCAP004	75.2 ± 3.3a	62.8 ± 5.2a	17 ± a	32 ± 4a	1.1 ± 0.2ab	575 ± 89a
HRDCAP005	48.2 ± 3.2d	54.2 ± 3.5b	11 ± 1b	19 ± 2b	1.2 ± 0.5ab	287 ± 80b
HRDCAP006	54.7 ± 3.3bc	58.0 ± 1.9ab	12 ± 1b	17 ±2b	1.1 ± 0.4ab	255 ± 49b
California Wonder (ch)	59.8 ± 4.1b	55.3 ± 3.7b	12 ± 3b	18 ± 2b	1.3± 0.2a	263 ± 29b
p value	<0.001	<0.05	<0.001	<0.001	<0.05	<0.001

Values are means ± SD of one experimental trial with four replicates. Means in a column followed by different letters are significantly different according to Fisher LSD test (P < 0.05).

Table 3: Effect of sweet pepper genotypes on yield and disease incidence at NHRC, Khumaltar, 2021/22

Genotypes	Yield per plot (kg)	Yield (t/ha)	Phytophthora Blight incidence (%)	Bacterial Wilt incidence (%)	Virus incidence (%)
HRDCAP001	20.40 ± 2.5 a	37.8 ± 4.7 a	59.3 ± 34 a	10.1 ± 10.8	15.5 ± 11.2 b
HRDCAP003	13.36 ± 2.9 c	24.7 ± 5.4 c	0 c	2.7 ± 3.1	47.4 ± 13.1 a
HRDCAP004	16.93 ± 4.3 b	31.4 ± 8.1 b	0 c	5.0 ± 5.8	17.5 ± 12.5 b
HRDCAP005	17.41 ± 1.7 b	32.3± 10.8 b	26.5 ± 5.9 b	6.9 ± 5.5	5.8 ± 6.7 c
HRDCAP006	16.46 ± 3.3 b	30.5 ± 6.2 b	21.1 ± 9.0 bc	4.1 ± 2.7	17.3 ± 9.9 b
California Wonder (ch)	16.19 ± 1.9 b	29.9 ± 3.6 b	40.0 ± 15.9 ab	1.4 ± 2.7	11.4 ± 8.1 b
p value	<0.05	<0.05	<0.001	>0.05	<0.001

Values are means ± SD of one experimental trial each with four replicates. Means in a column followed by different letters are significantly different according to Fisher LSD test (P < 0.05).

Table 4: Quality attributing characters of sweet pepper genotypes at NHRC, Khumaltar, 2021/22

Genotypes	TA (% citric acid)	Ascorbic acid content (mg/100g)	TSS (o Brix)	Firmness (kg/cm^2)	Leaf area (cm^2)
HRDCAP001	0.6 ± 0.1a	126.5 ± 30a	4.1 ± 0.2	4.1 ± 0.3 a	7.08 ± 0.6b
HRDCAP003	0.4 ± 0.1b	71.0 ± 14 b	4.0 ± 0.4	2.2 ± 0.3 b	3.84 ± 0.7c
HRDCAP004	0.4 ± 0.1b	51.2 ± 8 b	4.3 ± 0.2	2.6 ± 0.5 b	4.07 ± 0.1c
HRDCAP005	0.5 ± 0.1ab	70.5 ± 25 b	3.93 ± 0.1	3.1 ± 1.2 ab	8.49 ± 0.8ab
HRDCAP006	0.5 ± 0.1ab	51.8 ± 29 b	4.1 ± 0.6	2.8 ± 0.3 b	9.39 ± 0.1a
California Wonder (ch)	0.5 ± 0.0b	130.8 ± 36 a	4.5 ± 0.6	3.9 ± 0.3 a	80.2 ± 0.8ab
p value	<0.05	<0.01	>0.05	<0.05	<0.001

Values are means ± SD of one experimental trial with four replicates. Means in a column followed by different letters are significantly different according to Fisher LSD test (P < 0.05). TA indicates Titratable Acidity and TSS indicates Total Soluble Solid.`

Effect of sweet pepper genotypes, modified atmosphere packaging and storage conditions on the post-harvest life of sweet pepper

The result showed that there was a significant effect of modified atmosphere packaging and storage conditions on different physiochemical properties of sweet pepper; however, there was no significant effect of tested genotypes of sweet pepper on different physiochemical properties during the storage period (Table 5, Figures 1–3). Storing the fruit using MAP at the Coolbot storage condition resulted in a higher Ascorbic acid content (50 mg/100 g) compared to sweet pepper stored at ambient conditions after 7 DAS. However, there was no significant effect of packaging and storage conditions on the Ascorbic acid content of fruit at 14 DAS and 21 DAS (Table 5).

A change in weight loss in sweet peppers was positively related to storage conditions (temperature) and storage time. The sweet pepper genotypes packed inside the modified atmosphere packaging and stored under Coolbot conditions resulted in lower physiological weight loss percentages (1.8–0.94% at 7 DAS, 17.38–1.05% at 14 DAS, and 20–21% at 21 DAS) compared to the genotypes stored at ambient conditions (9.7 % at 7 DAS, 49.33-53.73% at 14 DAS) (Figure 1). Sweet pepper can be stored only for up to 14 days in ambient conditions irrespective of packing conditions and genotypes.

Modified atmosphere packaging and storage conditions had a significant effect on the firmness of sweet pepper fruit. The result reported that up to 7 days, MAP and storage conditions had no significant effect on the sweet pepper fruit firmness (Figure 2 A). The sweet pepper genotypes packed inside the 25 µ Low-Density Polyethylene and stored inside the Coolbot condition recorded the highest fruit firmness at 14 days and 21 days after storage (Figure 2). The maximum spoilage loss was recorded in the sweet pepper genotypes packed inside the MAP and stored at ambient conditions. While, there was no significant difference among other treatments (Figure 3, A).

Table 5: Effect of modified atmosphere packaging (LDPE) and storage conditions on Ascorbic acid content (mg/100g) of sweet pepper genotypes, recorded at 7 days intervals up 21 days at NHRC, Khumaltar, 2021/22.

Treatments	Ascorbic acid content (mg/100 g)		
	7 DAS	14 DAS	21 DAS
California Wonder + Ambient	40.9 ± 0.4 ab	33.39 ± 21	discard
California Wonder + Coolbot	40 ± 0.0 ab	72.42 ± 50	82.22 ± 17.2
California Wonder + LDPE + Ambient	31.49 ± 8.1 b	41.26 ± 21	discard
California Wonder + LDPE + Coolbot	50 ± 0.0 a	62.73 ±36	46.03 ± 40
HRDCAP001 + Ambient	33.88 ± 10.1 ab	74.05 ± 48	discard
HRDCAP001 + Coolbot	40 ± 14.1 ab	64.09 ±26	33.34 ± 18
HRDCAP001 + LDPE + Ambient	41.20 ± 14.3 ab	75.18 ± 21	discard
HRDCAP001 + LDPE + Cootbot	50 ± 10.0 a	70.72 ± 27.6	60.36 ± 24
p value	p<0.05	p>0.05	p>0.05

Values are means±SD of one experimental trial with four replicates. Means in a column followed by different letters are significantly different according to Fisher LSD test (P<0.05).

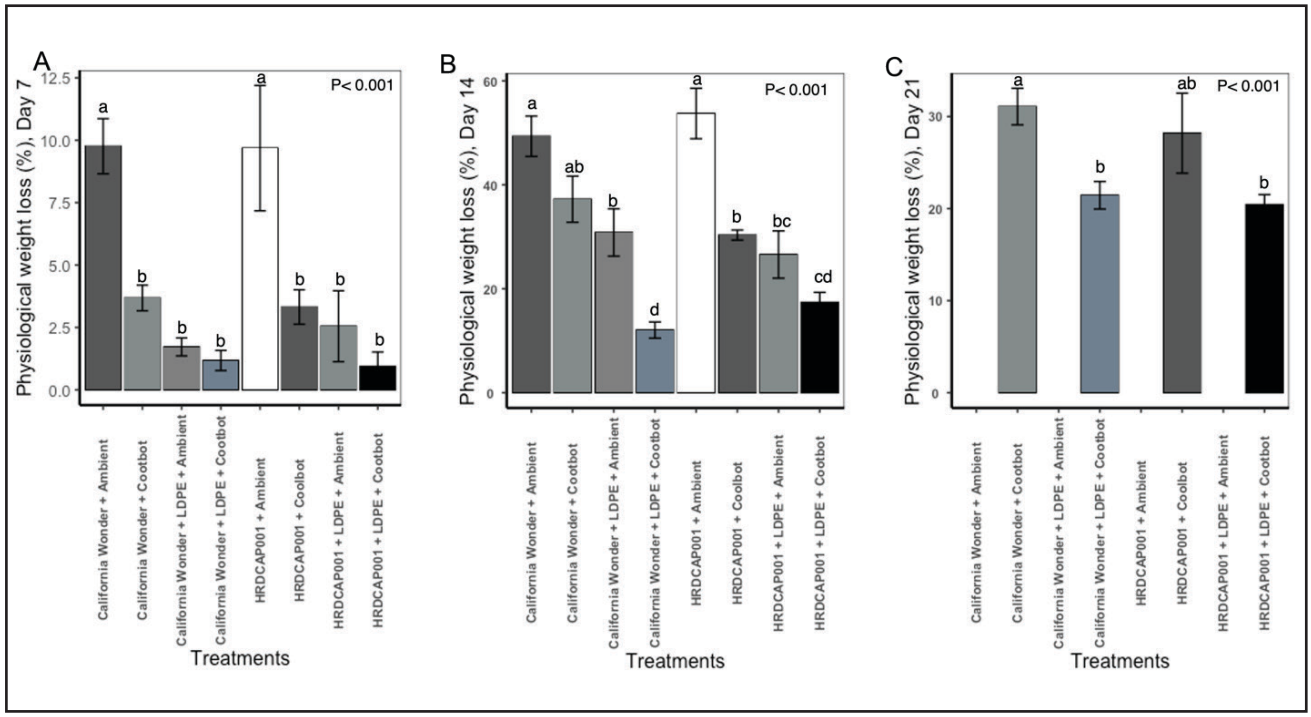

Figure 1: Effect of modified atmosphere packaging (LDPE) and storage conditions on Physiological Weight Loss % of sweet pepper genotypes, recorded at 7 days (A), 14 days (B) and 21 days (C) at NHRC, Khumaltar, 2021/22. Treatments with different superscripts are significantly different according to Fisher LSD test (P < 0.05). Bar colors represent the different treatment combinations.

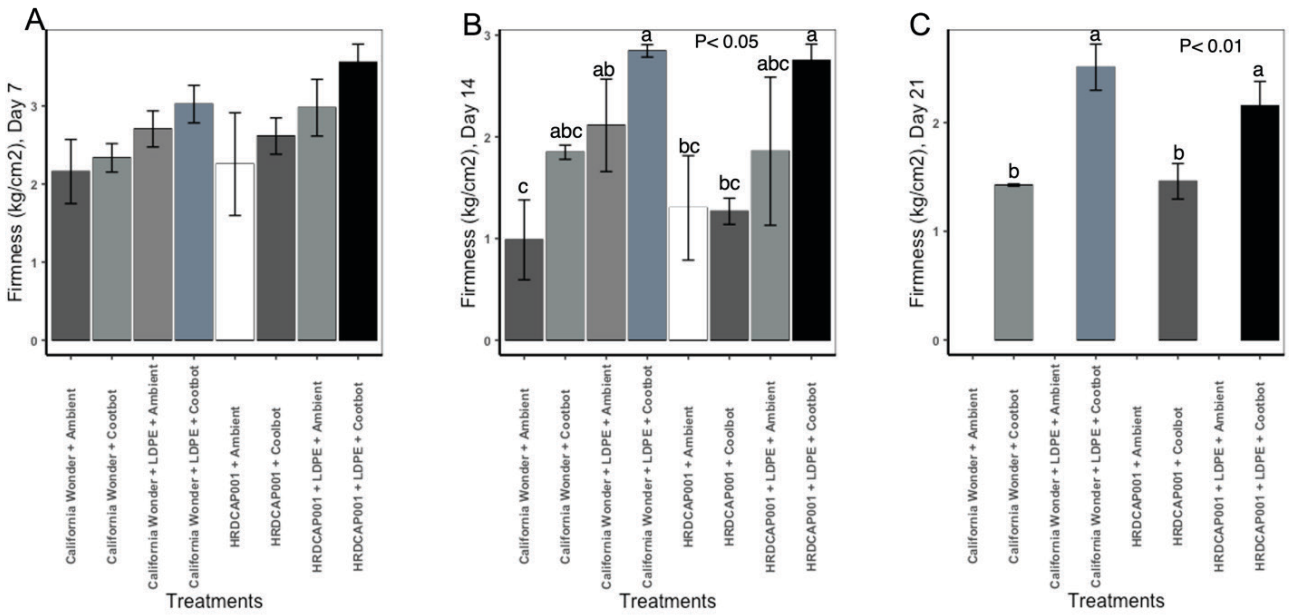

Figure 2: Effect of modified atmosphere packaging (LDPE) and storage conditions on Fruit firmness (kg/cm2) of sweet pepper genotypes, recorded at 7 days (A), 14 days (B) and 21 days (C) at NHRC, Khumaltar, 2021/22. Treatments with different superscripts are significantly different according to Fisher LSD test (P < 0.05). Bar colors represent the different treatment combinations.

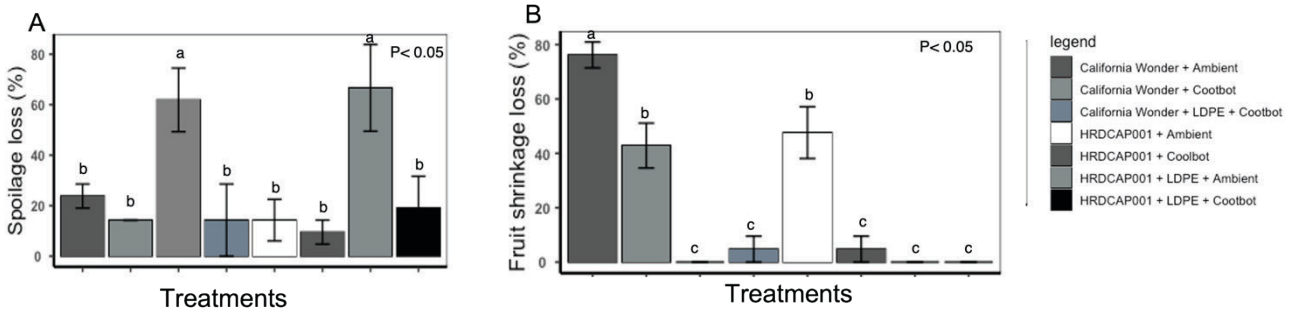

Figure 3: Effect of modified atmosphere packaging (LDPE) and storage conditions on A) spoilage loss % and B) fruit shrinkage loss % of sweet pepper genotypes, recorded at 21 days after storage at NHRC, Khumaltar, 2021/22. Treatments with different superscripts are significantly different according to Fisher LSD test (P < 0.05). Bar colors represent the different treatment combinations.

Discussion:

The difference between growth and yield could be influenced by the genetic make-up of the cultivars. Sweet peppers exhibit high genetic variation in terms of size, shape, colours, and biochemical composition (Lee, Howard, & Villalon, 1995). According to Chitarra and Chitarra (2005), variations can occur in the same species because of different cultivars, climate conditions, soil types, and cultural practices. Srinivas et al. (2017) and Nagaraju et al. (2018) also reported the variation in the fruit yield in different genotypes of chili pepper. The results of our research correlate with their research findings.

The range of pathogens afflicting pepper is very broad, and in our experiment, we observed the incidence of diseases such as Phytophthora blight, bacterial wilt, and viruses (Table 3). The diseases caused by *Phytophthora capsici, Ralstonia solanacearum* and potyviruses are some of the most destructive pathogens of pepper (Parisi et al., 2020). Dunn et al. (2013) reported that the three sweet pepper varieties, 'Paladin', 'Intruder', and 'Aristotle', yield well in fields with a history of severe phytophthora blight compared to other tested varieties of pepper. Parisi et al. (2020) reported that only selected accessions/lines/genotypes of Capsicum have the resistance gene in their genome against different fungal, bacterial, and viral pathogens. So, the identification of these genotypes is very important for the introduction of resistance in commercial varieties.

There is a genotypic diversity of sweet pepper, specifically in the physicochemical properties. Corrêa et al. (2018), identified the differences in quality attributes such as pH, TSS, titratable acidity, and ascorbic acid content in hybrids and lineages of sweet peppers. Bicikliski et

al., (2018) also reported the variance in the thickness of the pericarp in different genotypes of Capsicum. During the storage period, temperature management is the most effective parameter for maintaining the quality and extending the shelf life of fresh vegetable crops such as sweet peppers (Leon et al., 2013). Sattar et al. (2019) also reported that the maximum Ascorbic acid content was recorded in the sweet pepper fruit packed inside the perforated poly bag compared to the unpacked fruits at the end of the storage period. According to Znidarcic et al. (2010), physiological weight loss in vegetable crops during storage conditions is normally due to transpiration loss of water. In addition, high temperatures increase respiration rates and other metabolic processes that cause the depletion of compounds like sugars and proteins, resulting in weight loss (Nyanjage et al., 2005). Storage of fruit inside the MAP reduces the normal transpiration rate and decreases fruit weight loss, thereby increasing the postharvest life of the fruit. Lower physiological weight loss that coincided with a decrease in storage temperature and MAP is in agreement with the findings of De Castro et al. (2006), Rao et al. (2011), and Poudel et al. (2021). Our result is consistent with (Sattar et al., 2019), which showed that capsicum fruit in the perforated polythene bags at reduced temperature reported the minimum change in firmness. It was also found that the firmness of the fruit decreased during ripening because the polymers present in the cell wall, such as pectin, cellulose, and hemicellulose, are degraded by enzymes such as pectin methyl esterase, cellulase and polygalacturonase (Pose et al., 2013; Atkinson et al., 2012; Paniagua et al., 2014). However, the enzymatic activity of these compounds was reduced when sweet pepper was stored under cool atmospheric conditions. As compared to fruits stored at 25 °C, the fruits stored at 10 °C exhibit less enzyme activity in the sweet pepper fruits (Rao et al., 2011).

Our results do not recommend the storage of the MAP-packed fruits at ambient conditions. The accumulation of a high level of CO_2 inside the LDPE packaging led to the maximum spoilage loss of the fruit (Poudel et al., 2021). Kaur et al. (2013) reported that the fruit spoilage percentage was found to be higher in LDPE-lined crates, and this could be due to the permeability difference of polyethylene films. In addition to this, the sweet pepper fruits stored at lower temperatures and relative humidity inside the Coolbot might prevent spoilage percentage in compared to the control treatment (NHRC, 2020). The packaging of fruits inside the LDPE also reduces the fruit shrinkage % even under ambient conditions (Figure 3, B). This is due to the low transpiration rate of the fruits packed inside the MAP (Sharma et al., 2018).

Conclusion:

Among the tested genotypes of sweet pepper, the genotype 'HRDCAP001' was found to be superior in relation to growth and yield attributing characters compared to other genotypes (HRDCAP003', 'HRDCAP004', 'HRDCAP005' and 'HRDCAP006') and the commercial variety 'California Wonder.' In addition to this, the fruit of genotype 'HRDCAP001' had better physiological parameters such as TA, ascorbic acid content, and firmness compared to other genotypes. The shape and size of this genotype are beautiful, and it is yellow in colour which is preferred for commercial purposes. So, this genotype will be further recommended for farmers' field trials and a variety registration process. Though the genotypes 'HRDCAP003' and 'HRDCAP004' had small fruit sizes and were not preferred for commercial production, these genotypes are highly resistant to Phytophthora blight. So, these varieties could be used for breeding purposes for the introduction of disease resistance in susceptible commercial varieties. In the post-harvest experiment, the use of modified atmosphere packaging (25-micron LDPE) maintained the good quality of sweet pepper genotypes during storage under the Coolbot condition.

Acknowledgment:

We would like to acknowledge the National Horticulture Research Center, Khumaltar for providing facilities and for providing financial support for the conducting of this research experiment.

Declaration of conflict of interest and ethical approval:

R Rawal was involved in designing the experiment, recording data, analyzing the data and writing the manuscript. S Poudel and B Bhusal helped to conduct the experiment and record data. IP Gautam edited the manuscript. The authors declare no conflict of interest regarding the publication of this manuscript.

References:

Aminifard, M. H., Aroiee, H., Ameri, A., & Fatemi. H. (2012) Effect of plant density and nitrogen fertilizer on growth, yield and fruit quality of sweet pepper (Capsicum annuum L.). Afr J Agric Res. 7(6): 859-866.

Atkinson, R.G., Sutherland, P.W., & Johnston, S.L. (2013). Down-regulation of polygalacturonase1 alters firmness, tensile strength and water loss in apple (Malus x domestica) fruit. BMC Plant Biol., 12(1), 129. DOI:https://doi.org/10.1186/1471-2229-12-129.

Chitarra, M. I. F., & Chitarra, A. B. (1990). Pós-colheita de frutos e hortaliças: fisiologia e manuseio (p. 320). Lavras: Esal/Faepe.

Corrêa, C. V., Mendonça, V. Z. de, Mendes de

Sousa Gouveia, A., Gonçalves Carpanetti, M., Barbosa Tavares, A. E., de Brito Lima Lanna, N., Evangelista, R. M., & Inácio Cardoso, A. I. (2018). Physicochemical and biochemical traits of sweet pepper hybrids as a function of harvest times. *Food Chemistry, 257, 265–270. htpp://: doi.org/10.1016/j. foodchem.2018.03.002*

de Castro, L. R., Cortez, L. A., & Vigneault, C. (2006). Effect of sorting, refrigeration and packaging on tomato shelf life. Journal of Food Agriculture and Environment, 4(1), 70.

Dunn, A. R., Wyatt, L. E., Mazourek, M., Reiners, S., & Smart, C. D. (2013). Performance and tolerance to Phytophthora Blight of bell pepper varieties. HortTechnology, *23(3), 382–390. https://doi. org/10.21273/HORTTECH.23.3.382*

Faostat 2018. Available online: http://www.fao.org/

Gotame, TP., IP. Gautam, SL. Shrestha and NG Pradhan. 2019. A field guide for vegetable germplasm testing, evaluation and variety registration/release. Nepal Agricultural Research Council (NARC), National Agricultural Research Institute (NARI), Horticulture Research Division (HRD) Khumaltar, Lalitpur.

Howard, L.R., Smith, R.T., Wasner, A.B., Villalon, B., & Burns, E.E. (1994). Provitamin A and ascorbic acid content of fresh pepper cultivars (Capsicum annuum) and processed jalapenos. J Food Sci. 59: 362-365.

Lee, Y., Howard, L. R., & Villalon, B. (1995). Flavonoids and antioxidant activity of fresh pepper (*Capsicum annuum) cultivars. Journal of Food Science, 60(3), 473-476.*

Leon, J.J., Elias, J.L., Huez Lopez, M.A., Garcia Lopez, A.M., Ortiz, R.S., & Escoboza Garcia, L.F. (2013). Postharvest quality and shelf life of green pepper (Capsicum annuum L.) grown under open-field and greenhouse conditions. IDESIA (Chile) 3(4): 35-41.

MoALD. (2021). Statistical Information on Nepalese Agriculture 2078/79 (2020/21)

Nagaraju, M. M., Reddy, R.V.S.K., Reddy, K. M., Naidu, L. N., Rani A. S. & Krishna, K. U. (2018). Performance of Chilli (*Capsicum annuum L.) Genotypes for yield and yield attributing traits. Int. J. Curr. Microbiol. App. Sci., 7(12), 2252-2260. DOI: https://doi.org/10.20546/ijcmas.2018.712.256.*

Nyanjage, M. O., Nyalala, S. P. O., Absalom, I., Limbe, E., & Vulimu, E. M. (2005). Extending post-harvest life of sweet pepper with modified atmosphere packaging and storage temperature. Physiology of vegetables (ed): CAB International, *38*(2), 2834.

Paniagua, C., Pose, S., Morris, V.J., Kirby, A.R., Quesada, M.A., & Mercado, J.A. (2014). Fruit softening and pectin disassembly: an overview of nanostructural pectin modifications assessed by atomic force microscopy. Annals of Botany, 114(6), 1375– 1383. DOI: https://doi.org/10.1093/aob/ mcu149, PMCID:PMC4195560

Parisi, M., Alioto, D., & Tripodi, P. (2020). Overview of Biotic Stresses in Pepper (Capsicum spp.): Sources of Genetic Resistance, Molecular Breeding and Genomics. *International Journal of Molecular Sciences, 21(7), 2587. https://doi.org/10.3390/ijms21072587.*

Pose, S., Paniagua, C., Cifuentes, M., Blanco-Portales, R., Quesada, M.A., & Mercado, J.A. (2013). Insights into the effects of polygalacturonase FaPG1 gene silencing on pectin matrix disassembly, enhanced tissue integrity, and firmness in ripe strawberry fruits. Journal of Experimental Botany,64, 3803–3815. DOI: 10.1093/jxb/ert210

Poudel, S., Gautam, I. P., Ghimire, D., Pandey, S., Dhakal, M., & Regmi, R. (2021). Modified atmosphere packaging of capsicum for extending shelf life under coolbot condition. *Journal of Agriculture and Natural Resources, 4(1), Article 1. https://doi. org/10.3126/janr.v4i1.33233*

Rao, T. V. R., Gol, N. B., & Shah, K. K. (2011). Effect of postharvest treatments and storage temperatures on the quality and shelf life of sweet pepper (Capsicum annum L.). *Scientia Horticulturae, 132, 18–26. https://doi.org/10.1016/j.scienta.2011.09.032*

Sattar, M.A., Quddus, M.A., Rahman, M.H., Hossain, M.A., Sarker, M.H., & Islam, M.R. (2019). Effect of postharvest temperatures and packaging materials on shelf life and fruit quality of selected hybrid of sweet pepper. Journal of Energy and Natural Resources, 8(4), 137-145, doi: 10.11648/j.jenr.20190804.12.

Sharma, K.D., Cardona, J.A., & Sibomana, M.S. (2018). Quality attributes of modified atmosphere packaged bell pepper (*Capsicum annuum* L.) during storage. Journal of Nutrition FoodResearch and Technology., 1(2), 56–62. DOI: https://doi.

org/10.30881/jnfrt.00012

Srinivas, J., Reddy, K. R., Saidaiah, P., Anitha, K. & Pandravada, S. R. (2017). Performance of Chilli genotypes for yield and yield attributes of fruit quality in Southern Telangana. Int. J. Pure App. Biosci. 5(4), 1163-1170 (2017). DOI: http://dx.doi.org/10.18782/2320-7051.5690

SQCC. (2023). Notified and denotified varieties till 2080-01-18

Žnidarčič, D., Ban, D., Oplanić, M., Karić, L., & Požrl, T. (2010). Influence of postharvest temperatures on physicochemical quality of tomatoes (*Lycopersicon esculentum* Mill.). *J* Food Agric Environ, *8*(1), 21-25.