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## Evaluation of Low Chilling Strawberry (*Fragaria ananassa*) Varieties with Respect to Yield and Quality in Eastern Nepal

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### ABSTRACT

The experiment entitled “Evaluation of low chilling strawberry (*Fragaria ananassa*) varieties with respect yield and quality in eastern Nepal” was conducted in Dharan and Biratnagar of Nepal with five varieties ‘EMCO 33’, ‘EMCO 32’, ‘Florida Fortuna’, ‘Florida Beauty’ and ‘Sweet Sensation’. The experiment was laid out in Factorial RCBD where variety and location was considered as factors. From the experiment highest number of fruits per plant (13.22) and maximum fruit set (95.72%) was recorded with variety ‘EMCO 33’. However, maximum number of fruits per plot (444.25) with only 14.04 % of unmarketable fruit and highest yield of 9068.75 grams per plot with 7976.00 grams of marketable yield per plot was obtained with variety ‘EMCO 32’ in Dharan. Comparing the length and diameter of fruit variety ‘EMCO 32’ (49.00 cm×43.42 cm) and variety ‘EMCO 33’ (49.04 cm×38.41 cm) seems more appealing in form. pH, vitamin C and TA content was found higher in variety ‘EMCO 33’ (3.48, 71.89 mg/g and 0.90 % respectively) and higher TSS content (6.57 °Brix) was obtained with variety ‘EMCO 32’ with no interaction effect for quality traits. Thus among treatment combinations variety ‘EMCO 32’ followed by ‘EMCO 33’ in Dharan conditions is more preferable to other treatments and also both the varieties perform well compared to other varieties in Biratnagar conditions also. However still more studies are required to assess the varietal performance and it would be premature to recommend suitable variety for given locations.

### INTRODUCTION

The modern cultivated strawberry (*Fragaria ananassa* Duch.) is a hybrid of two largely dioecious, octoploid species, *Fragaria chelonensis* Duch and *Fragaria virginiana* Duch belonging to family Rosaceae. Basically, it is herbaceous perennial and short day plant. It grows predominantly in the temperate climate but worldwide it is the most widely distributed fruit crop due to its genetic diversity, highly heterozygous nature and broad range of environmental adaptation (Anderson and Guttridge, 1982; Dale et al., 2000).

Strawberry is cultivated in limited regions of Nepal in Nuwakot district and its periphery and choice of varieties is limited to Nyoho, Ohno, Eyeberry and Akhime. Productivity of strawberry in Nepal is only 9 mt/ha compared to world productivity 23.58 mt/ha (DADO, 2017; FAO, 2019). Because of limited research, strawberry cultivation is still in womb stage in Nepal. Only limited varieties are available. Previously, Nyoho variety was widely cultivated recently, Ankhime and Eyeberry varieties are also introduced. Cultivation of strawberry on other hand is concentrated in hilly areas of Nepal potential areas has not been identified no studies on strawberry in terai is conducted Strawberry once thought to be temperate fruit can be grown in tropical areas too. Since strawberry is high value fruit, more potential areas need to be identified and tropical low chilling requiring varieties need to be explored. So, 5 low chilling strawberry varieties ‘Florida Beauty’, ‘Sweet Sensation’, ‘Fortuna’, ‘EMCO 32’ and ‘EMCO 33’ were studied in two domains Biratnagar and Dharan in eastern Nepal to compare

their performance under different growing condition with following objectives:

- To study the comparative yield performance of low chilling required five strawberry varieties in two locations
- To assess the quality of fruit of different strawberry varieties under different growing location.

### LITERATURE REVIEW

World Production of strawberry is in increasing trend, it was 4.4 million tonnes in 2000 AD to 9.2 million tonnes in year 2017 (FAO, 2019) which is almost twice. China leads the world Production with 3.7 million tonnes in year 2017 A.D which is almost one third of world production while USA has highest productivity of 67 tonnes/ha. Here in Nepal strawberry production is concentrated in Nuwakot District covering area of 55 ha and the production is around 495 mt where 254 families are involved in strawberry cultivation (DADO, 2017). Nepal imports 10,826 Kg of strawberry annually which is worth NRs 2.1 million (TEPC, 2019). The Japanese first saw the potential for strawberry farming in Kakani 25 km to the north of Kathmandu, 25 years ago when agronomist Matsuura Hiroshi brought six sample plants which flourished and spread among farmers who till then had been growing radish for the Kathmandu market, in 1991. The variety of strawberries cultivated in Nepal Akhime, Nyoho, require an altitude of 1500 - 2500m with a temperature range of 4-25 degree Celsius and 3000-4000 ml of rainfall, making Kakani the ideal location (Nepali Times, 2017). Currently more than 700 households are involved in commercial farming,

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each producing approximately 1000kg of strawberries per season (MEDEP, 2010). Nuwakot district has been gaining prominence in strawberry cultivation as a summer fruit. Kakani and Okharpauwa VDCs are regarded as the pocket area for strawberry cultivation.

Once suitable temperature and day length conditions are met, strawberry flower buds are initiated. Initially, the apical meristem broadens, then the sepal, petal, stamen and carpel primordia develop in sequence and start to enlarge (Darrow, 1966; Darnell, 2003).

The primary flower emerges first, followed by the secondary, tertiary and quaternary flowers (Hancock, 1999). Typically the inflorescence includes one primary flower and two or three, or sometimes four, secondary flowers terminally on individual branches of the main stem (Darnell, 2003). At least 30% of the carpels need to be fertilized for fruit to develop good shape (Day, 1993), although Guttridge (1979) reported 70-80% were needed. Strawberry fruit development can be divided into several stages: small green, large green, white, pink and red. The weight and size of the fruit is largest at the red stage (Darrow, 1966; Abeles and Takeda, 1990).

When fruits take about 30 days to develop from bloom to ripening, cell division occurs first and ends 10-15 days after anthesis (Cheng & Breen, 1992). Then the cells enlarge and expand towards the inside of the fruit. However, although the cells divide and expand, the main factor which causes the variation in fruit size is the number of cells at anthesis (Cheng & Breen, 1992). Cell division contributes between 15-20% of the total growth. The remaining growth comes from cell enlargement by cells expanding towards inside of the fruit (Hancock, 1999).

Many day-neutral strawberry cultivars require a dormancy period of between 675 and 1000 hours in a conditions of -1 to 10° C (Stewart & Folta, 2010). Studies show day/night temperatures of 18/14° C as the ideal for fruit production (Hancock, 1999).

Heat stress is a challenge in strawberry production that has been reported all over the world. In general, strawberry plants under heat stress grow more slowly, and produce fewer and smaller fruit (Renquist et al., 1982; Hellman and Travis, 1988).

Temperature and photoperiod are the two major factors which influence the transition from vegetative to floral growth. Flower bud initiation is inhibited when temperatures are above 12 to 28°C depending on day length and flowering type (Chabot, 1978; Okimura and Igarashi, 1997; Dale et al., 2009).

One recent study showed that the developmental stages of flower buds in 'Akihime' strawberry were significantly larger at 22°C than those of the untreated plants (Kim et al., 2009).

Fruit number per plant decreases as temperature increases. In 'Nyoho' and 'Toyonoka' the numbers of fruit were greatly reduced at 30/25°C when compared to 23/18°C (Ledesma et al., 2008). When the day-time and night-time effects were investigated, fruit size was smaller under day-

time temperatures over 15-17°C and largest at 12°C night temperature. (Went, 1957; Sato & Hiraoka, 1971)

'Sweet Sensation' is a new strawberry cultivar released from the University of Florida in 2013, commonly known as 'Florida 127' in US and Canada originally evaluated as breeding selection FL 09-127. 'Florida127' originated from a 2009 cross between WinterStar™ 'FL 05-107' (female parent) and unreleased breeding selection FL 02-58 (male parent) (Whitaker et al., 2017).

'Florida Fortuna' a strawberry variety released by US is known as 'Florida Radiance' in US and Canada released from UF/IFAS in 2008 (Chandler et al. 2009) originated from a 2001 cross between 'Winter Dawn' (female parent), a 2005 release from the UF/IFAS breeding program, and FL 99-35 (male parent) (Whitaker et al., 2019).

'Florida Beauty' (PPAF) is a new strawberry cultivar released by the University of Florida and commercialized in 2017. This cultivar was originally evaluated as breeding selection FL 12.121-5. 'Florida Beauty' originated from a 2012 cross between Queensland Australia selection 2010-119 (female parent) and 'Florida Radiance' (male parent) (Whitaker et al., 2017a).

'Florida127' is a short-day plant adapted to annual, winter plasticulture growing systems. The plant is moderately compact, robust, and upright with long pedicels, making the fruit easy to harvest producing conic to broad-conic fruit that are uniform in shape throughout the season, resulting in few non-marketable fruit (Whitaker et al., 2017).

"Florida Fortuna" produces conic to long-conic fruit that are very large, uniform, glossy, and evenly coloured. 'Florida Fortuna' has a weak plant habit and can benefit from extra chilling hours in the nursery. While it requires little chilling to initiate flower buds compared to typical short-day cultivars, increased chilling may be important to increase production (Whitaker et al., 2019).

Whitaker et al. (2017) stated that Florida Fortuna' fruit size is larger than the other cultivars late in the season. The fruit has a moderate acid content with a balanced flavor and is generally the juiciest of the UF/IFAS cultivars. Both early season and late-season yields of 'Florida Fortuna' in Florida have been higher than any other UF/IFAS cultivar in most seasons. In an experiment conducted in Queensland to compare varieties

'Florida Beauty' cultivar has excellent fruit quality, with flavour often similar to 'Sweet Sensation' and sufficient quality to be marketed at retail under the 'Sweet Sensation'® brand. Early and total season yields of 'Florida Beauty' have been very similar to 'Florida Fortuna' for early planting dates around Sept 25. When planted early in the planting period, no overly elongated fruit have been observed in contrast to 'Florida Fortuna', which can produce elongated fruit in the early season. When planted at later dates around Oct 10, 'Florida Beauty' has had lower yields than 'Florida Fortuna' due to its more compact plant size (Whitaker et al., 2017a).

Whitaker et al. (2017) stated that Fruit size of 'Sweet Sensation' is very large, exceeding that of 'Florida

Fortuna' on average over the course of the season. Fruit firmness is slightly greater than that of 'Florida Fortuna', with excellent shelf life. Average fruit weight of 'Sweet Sensation' Florida Fortuna and 'Florida Beauty' is 35-45 gm, 30-40 gm and 27-37 gm respectively as recorded in U.S. Plant Patent (United States Patent No. USOOPP20363P2, 2009; United States Patent No. US 20140359905P1, 2014; United States Patent No. USOOPP30385P3, 2019)

In an experiment conducted to compare 3 varieties of strawberry average marketable yield of 803.6 gm per plant was recorded with 'Sweet Sensation' being at par with 'Florida Fortuna' i.e. 749.7 gm per plant and lowest yield was recorded with 'Florida Beauty' i.e. 601.3 gm per plant with average weight per fruit being 30.8 gm, 25.0 gm and 22.3 gm respectively (Whitaker et al., 2015).

In an experiment in university of Florida it was recorded the pH of Florida Fortuna was 3.6 and that of 'Sweet Sensation' was 3.7. But 'Sweet Sensation' was superior for sweetness compared to 'Florida Fortuna' with total soluble solid content 7.5 % and 5.3 % respectively (Whitaker et al., 2015). It is estimated that the picking interval should be one day longer for 'Sweet Sensation' than for 'Florida Fortuna' at most points during the season. The ripe fruit of 'Florida127' have excellent flavour and aroma. Soluble solids contents of 'Sweet Sensation' fruit were significantly higher than those of 'Florida Fortuna' on six of seven harvest dates tested. Titratable acidity was not significantly different from 'Florida Fortuna. Significant

difference in TSS/TA ratio was observed in variety 'Sweet Sensation' and 'Florida Fortuna' with ratio being 10.8 and 6.4 respectively (Whitaker et al., 2015).

## METHODS

### Treatment details

Different low chilling strawberry varieties and two locations were considered as factors in combination. Therefore, there were two different factors in this research which are shown below.

#### Factor 1: Location

The experiment was conducted in two locations to evaluate the performance of strawberry in different ecological zones. Two ecological regions Biratnagar and Dharan were selected to conduct the varietal research trial on strawberry.

#### Biratnagar

The city is located in the Morang District of province 1 has a total area of 77.5 km<sup>2</sup>. The geographical location is 26°28'60"N 87°16'60"E. In Biratnagar, the average annual temperature is 24.3 °C. The rainfall here averages 1898 mm.

#### Dharan

The city is located in the Sunsari District of province 1 has a total area of 192.61 km<sup>2</sup>. The geographical location is 26°49'0"N 87°17'0"E. The city experiences sub-tropical climate situated at altitude of 349 masl. In Dharan, the average annual temperature is 23.2 °C. The rainfall here averages 1799 mm.

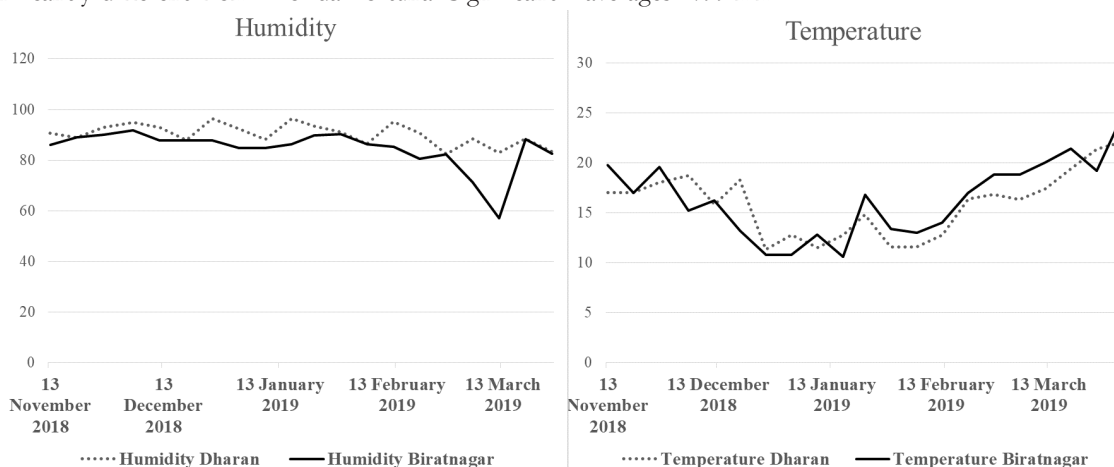


Figure 1. Average weather data of Biratnagar and Dharan from November 2018 to May 2019

#### Factor 2: Variety (V)

Five low chilling strawberry varieties were used to evaluate their relative performance. The varieties used were

- V1 = Florida Beauty
- V2 = Sweet Sensation
- V3 = Fortuna
- V4 = EMCO 32
- V5 = EMCO 33

### Experimental design

The field was laid out in Randomised Block Design (RCBD) with 4 replications in both locations.

#### Layout of field

The field was laid out in Randomized complete block design (RCBD) design with 4 replications and 5 varietal treatment in each location. The area of experimental field was 297 m<sup>2</sup> with length and breadth of main field 45 m × 6.6 m respectively. Distance between replications was maintained at 1 m and treatments were laid 50 cm apart. With spacing of 38 cm × 28 cm (RR × PP), 52 plants per plot were maintained.

### Planting techniques

Strawberries were planted in a raised bed with double row system. Following schematic diagram was followed for raised bed system.

### Planting material and Planting

Bare root strawberry transplants were used as planting

material. The bare root strawberry transplants were transplanted in raised plastic- mulched beds at spacing of 38 cm ×28 cm. Planting was done on Nov 13, 2018. One week of overhead sprinkler irrigation was provided for one week to ensure plant establishment.

#### Parameters studied

Various yield and quality parameters of randomly selected and properly tagged sample plants were evaluated

#### Fruit yield parameters

Fruit set percentage (%), Number of fruit per plant, Number of fruits per plot, Number of marketable plot, Marketable yield per plot (grams) and Fruit yield per plot

(grams) were recorded

#### Fruit quality parameters

Total Soluble Solids (TSS), pH of strawberry, Titrable acidity (%), Ascorbic acid (Vitamin C) content (mg/100g)

#### Data analysis

All data recorded were processed using Microsoft Excel. Statistical analysis and relation among treatments was established for the selected parameters with reference to Gomez and Gomez, 1984. Different statistical tools as R and EXCEL were used for the analysis of variance, DMRT test and other data analysis as required.

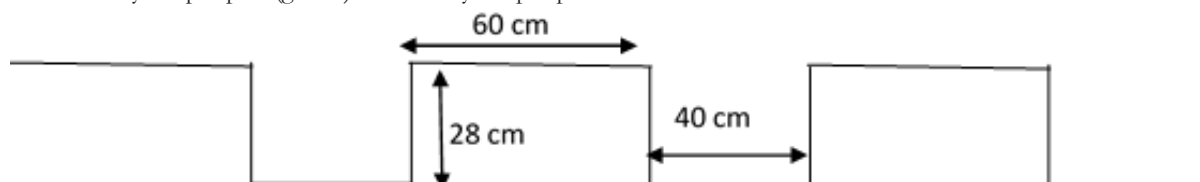


Figure 2. Double row system of strawberry planting

## RESULTS AND DISCUSSION

### Phenological characters

Table 1. Phenological characters of strawberry (*Fragaria ananassa*) as influenced by varieties and different locations of Nepal in 2018/2019.

#### Effect of location on phenological characters

Phenological characters of different varieties of strawberry as influenced by location is presented in table 1. Days to First flowering, Number of flowers per plant,

fruit set % and number of fruits per plant are found significantly different statistically at different locations.

Earlier flowering (14.52 DAT), higher number of flowers per plant (13.79) was observed in Biratnagar being statistically different to days to first flowering (16.11 DAT) and number of flowers per plant in Dharan (10.76). However fruit set percentage is found significantly higher in Dharan (89.48 %) compared to Biratnagar (70.82 %).

No significant effect was seen regarding number of fruits per plant which might be due to low fruit set % in Biratnagar though higher number of flowers were

**Table 1:** Phenological characters of strawberry (*Fragaria ananassa*) as influenced by varieties and different locations of Nepal in 2018/2019.

Treatments	Phenological Characters			
	Days to first flowering	Number of flowers per plant	Number of fruits per plant	Fruit set %
Location (Factor A)				
Dharan	16.11 <sup>a</sup>	10.76 <sup>b</sup>	10.06	89.48 <sup>a</sup>
Biratnagar	14.52 <sup>b</sup>	13.79 <sup>a</sup>	9.64	70.82 <sup>b</sup>
Grand Mean	15.31	12.28	9.85	80.15
SEM	1.53 <sup>**</sup>	2.46 <sup>***</sup>	1.12 <sup>ns</sup>	8.60 <sup>***</sup>
LSD	1.28	2.24	1.02	7.78
CV	29.87	28.49	16.12	15.17
Variety (Factor B)				
EMCO33	10.83 <sup>c</sup>	16.90 <sup>a</sup>	11.60 <sup>ab</sup>	88.37 <sup>a</sup>
Sensation	22.62 <sup>a</sup>	8.43 <sup>d</sup>	6.10 <sup>d</sup>	64.46 <sup>c</sup>
Florida Beauty	13.61 <sup>b</sup>	12.09 <sup>bc</sup>	10.39 <sup>b</sup>	73.63 <sup>bc</sup>
EMCO32	7.91 <sup>d</sup>	14.10 <sup>b</sup>	12.60 <sup>a</sup>	88.92 <sup>a</sup>
Fortuna	21.6 <sup>a</sup>	9.85 <sup>cd</sup>	8.57 <sup>c</sup>	85.39 <sup>ab</sup>
Grand Mean	15.31	12.28	9.85	80.15
SEM	1.78 <sup>***</sup>	1.66 <sup>***</sup>	1.12 <sup>***</sup>	8.80 <sup>***</sup>
LSD	2.56	2.38	1.61	12.62
CV	16.47	19.15	16.12	15.51

Means with same letter within column do not differ significantly at  $p=0.05$  by DMRT. NS- Non –significant, SEM- Standard error of mean, LSD- Least significant difference, CV- Coefficient of variance, DAT- Days After Transplanting

obtained in Biratnagar.

### Effect of varieties on phenological characters

Effect of variety on phenological characters of strawberry plants is presented in table 1. Days to First flowering, Number of flowers per plant, fruit set % and number of fruits per plant are found significantly different statistically among different varieties.

Earlier flowering (7.91 DAT), higher fruit set (88.92 %) and higher number of fruits per plant (12.55) was

obtained in variety 'EMCO 32' whereas late flowering (22.62 DAT), least fruit set percentage (64.46 %) and least number of fruits per plant (6.10) was obtained in variety 'Sweet Sensation'.

However highest number of flowers per plant (16.90) were recorded in variety 'EMCO 33' whereas least number of flowers per plant (8.43) was obtained in variety 'Sweet Sensation' being statistically similar to variety 'Florida Fortuna' (9.85).

**Table 2.** Interaction effect on phenological characters of strawberry (*Fragaria ananassa*) varieties at different locations of Nepal in 2018/2019.

Treatments	Phenological characters			
	Days to first flowering	Number of flowers per plant	Number of fruits per plant	Fruit set %
Location × variety interaction				
Dharan.EMCO33	12.12 <sup>f</sup>	14.31 <sup>bc</sup>	13.22 <sup>a</sup>	95.72 <sup>a</sup>
Dharan.Sensation	26.65 <sup>a</sup>	7.25 <sup>f</sup>	6.9 <sup>de</sup>	73.75 <sup>d</sup>
Dharan.Beauty	11.97 <sup>f</sup>	10.36 <sup>dc</sup>	9.43 <sup>bc</sup>	93.89 <sup>a</sup>
Dharan.EMCO32	6.60 <sup>h</sup>	15.57 <sup>b</sup>	12.01 <sup>a</sup>	94.68 <sup>a</sup>
Dharan.Fortuna	23.20 <sup>b</sup>	9.24 <sup>ef</sup>	8.67 <sup>cd</sup>	89.37 <sup>b</sup>
Biratnagar.EMCO33	9.55 <sup>g</sup>	19.5 <sup>a</sup>	9.99 <sup>bc</sup>	51.54 <sup>f</sup>
Biratnagar.Sensation	18.6 <sup>d</sup>	9.62 <sup>ef</sup>	5.29 <sup>e</sup>	55.17 <sup>e</sup>
Biratnagar.Beauty	15.25 <sup>e</sup>	13.82 <sup>bc</sup>	11.35 <sup>ab</sup>	82.05 <sup>c</sup>
Biratnagar.EMCO32	9.22 <sup>g</sup>	16.27 <sup>b</sup>	13.10 <sup>a</sup>	83.95 <sup>c</sup>
Biratnagar.Fortuna	20.00 <sup>c</sup>	10.46 <sup>dc</sup>	8.48 <sup>cd</sup>	81.40 <sup>c</sup>
Grand Mean	15.31	12.28	9.85	80.15
SEM	0.64 <sup>***</sup>	1.18 <sup>**</sup>	0.94 <sup>***</sup>	1.73 <sup>***</sup>
LSD	1.30	2.42	1.90	3.53
CV	5.88	13.67	13.42	3.05

Means with same letter within column do not differ significantly at  $p=0.05$  by DMRT. NS- Non –significant, SEM- Standard error of mean, LSD- Least significant difference, CV- Coefficient of variance, DAT- Days After Transplanting

### Interaction effect of location and variety for phenological characters

Interaction effect of location and variety on phenological characters of strawberry plants is presented in Table 2. Days to First flowering, Number of flowers per plant, fruit set % and number of fruits per plant are found significantly different statistically among different varieties at different locations.

Earlier flowering (6.60 DAT) was obtained in Dharan with variety 'EMCO 32' followed by variety 'EMCO 32' in Biratnagar (9.22 DAT) whereas late flowering (26.65 DAT) was obtained in Dharan with variety 'Sweet Sensation'.

The result reveals that although in overall performance there is late flowering in Dharan but still from interaction effect it is evident that earlier flowering variety 'EMCO 32' performs better in Dharan.

Significantly higher number of flowers per plant (19.50) was recorded in Biratnagar with variety 'EMCO 33' followed by variety 'EMCO 32' in Biratnagar (16.27) whereas least number of flowers (7.25) were obtained in

Dharan with variety 'Sweet Sensation' being statistically similar to variety 'Florida Fortuna' in Dharan (9.24).

Significantly higher fruit set (95.72 %) was recorded in Dharan with variety 'EMCO 33' being statistically at par with variety 'EMCO 32' in Dharan (94.68 %) and also with variety 'Florida Beauty' in Dharan (93.89 %) whereas least fruit set (51.54 %) percentage was recorded in variety 'EMCO 33' in Biratnagar followed by variety 'Sweet Sensation' in Biratnagar (55.17 %).

Significantly higher number of fruits per plant (13.22) was recorded in Dharan with variety 'EMCO 33' being statistically at par with variety 'EMCO 32' in Biratnagar (13.10) whereas least number of fruits per plant (5.29) was recorded in Biratnagar with variety 'Sweet Sensation' followed by variety 'Sweet Sensation' in Dharan (6.9).

From results presented in table 1 and table 2 we can conclude that larger number of flowers are obtained in Biratnagar with variety 'EMCO 33' but variety 'EMCO 32' performed better than variety 'EMCO 33' in Dharan Interaction effect shows that for phenological characters variety 'EMCO 33' is more suitable for Dharan and



Variety ‘EMCO 32’ is more suitable for Biratnagar. Earlier flowering in Biratnagar conditions contradicts with findings of Kurian (2015), that earlier flowering was observed in high altitude. The favourable temperature and day condition, prevailing in Biratnagar may have influence on early flowering in Biratnagar. Earlier flowering in variety ‘EMCO 32’ might be attributed to its day neutral behaviour. Variability in flowering period in different varieties might also be due to differences in their chilling requirement as suggested by Joolka and Badiyala (1983) Number of leaves per plant, leaf area and number of crowns per plant are positively correlated with number

of flowers per plant (Girijalba et al., 2015) which might be reason for higher number of flowers in Dharan and in variety ‘EMCO 32’ and ‘EMCO 33’.

Variation in number of fruits per plant might be due to differential fruitset % among varieties in different location. Lower fruit set % but higher number of flowers in Biratnagar conditions resulted in insignificant difference in number of fruits per plant among locations. The variation in fruit set % may be due to genetic makeup of the cultivars and adaptation to climatic condition (Jami et al., 2015).

#### Yield per plot

**Table 3:** Yield per plot of strawberry (*Fragaria ananassa*) varieties as influenced by different locations of Nepal in 2018/2019.

Treatments	Yield per plot of strawberry	
	Marketable Yield per plot (gm)	Total Yield per plot (gm)
Location (Factor A)		
Dharan	4101.20	4720.75 <sup>a</sup>
Biratnagar	2794.33	3244.81 <sup>b</sup>
Grand Mean	3447.76	3982.78
SEM	935.47 <sup>ns</sup>	1066.73 <sup>***</sup>
LSD	1693.84	1931.50
CV	26.74	25.75
Variety (Factor B)		
EMCO33	6034.68 <sup>a</sup>	6932.97 <sup>a</sup>
Sensation	1558.25 <sup>b</sup>	1848.25 <sup>b</sup>
Florida Beauty	1541.25 <sup>b</sup>	1831.12 <sup>b</sup>
EMCO32	6844.64 <sup>a</sup>	7828.32 <sup>a</sup>
Fortuna	1260.00 <sup>b</sup>	1473.25 <sup>b</sup>
Grand Mean	3447.76	3982.78
SEM	384.23 <sup>***</sup>	446.85 <sup>***</sup>
LSD	1103.12	1282.91
CV	31.52	31.73

#### Effect of location on Yield per plot

Yield per plot of different varieties of strawberry as influenced by location is presented in Table 3. Marketable yield per plot and in relation to location was found statistically insignificant whereas weight of total yield per plot was found statistically significant.

Significantly higher total yield was obtained in Dharan (4720.75 gm) compared to Biratnagar (3244.81 gm).

#### Effect of Variety on yield per plot

Effect of variety number of fruits per plot of strawberry plants is presented in Table 3. Marketable yield per plot and yield per plot in relation to location are found significantly different statistically among different varieties.

Highest marketable yield per plot (6844.64 gm) and highest total yield per plot (7828.32 gm) was recorded in variety ‘EMCO 32’ being statistically at par with variety ‘EMCO 33’ for marketable yield (6034.68 gm) and total yield (6932.97 gm) per plot whereas least marketable yield per plot (1260.00 gm) and least total yield per plot (1473.25 gm) was obtained in variety ‘Florida Fortuna’ being statistically at par with variety ‘Sweet Sensation’

(1558.25 gm)

Differences in survivability and yield per plant of different varieties may be reason behind difference in number of fruits per plot of strawberry.

#### Interaction effect of location and variety on yield per plot

Interaction effect of location and variety on number of fruits per plot of strawberry plants is presented in Table 4. Marketable yield per plot and total yield per plot are found significantly different statistically among different varieties at different locations.

Higher marketable yield per plot (7976.00 gm) was recorded in Dharan with variety ‘EMCO 32’ being statistically at par with variety ‘EMCO 33’ (7116.75 gm) in Dharan. Similarly in Biratnagar conditions also variety ‘EMCO 32’ had highest marketable yield per plot (5713.28 gm). Whereas least marketable yield per plot (682.00 gm) was obtained in Biratnagar with variety ‘Florida Fortuna’. Lowest unmarketable yield per plot (192.00 gm) was recorded in Biratnagar with variety ‘Florida Fortuna’ being statistically at par with variety ‘Florida Fortuna’



(222.00 gm) in Dharan being statistically at par with variety 'Sweet sensation' (264.00 gm) in Dharan. Whereas highest unmarketable yield per plot (1243.25 gm) was obtained in Dharan with variety 'EMCO 33'.

Higher total yield per plot (9068.75 gm) was recorded in Dharan with variety 'EMCO 32' being statistically at par with variety 'EMCO 33' (8360.00 gm) in Dharan. Similarly in Biratnagar conditions also variety 'EMCO 32' had highest total yield per plot (6587.90 gm). Whereas lowest total yield per plot (874.00 gm) was obtained in

Biratnagar with variety 'Florida Fortuna'.

The result presented in table 16 and table 17 reveals that variety 'EMCO 32' followed by variety 'EMCO 33' performed best in both locations and Dharan conditions was more favourable for yield per plot. Also higher unmarketable yield per plot were related with higher total yield of fruits. The differences for total yield per plot may be attributed to difference in plant survivability and number of fruits per plot.

#### Effect of location on fruit quality parameter

**Table 4:** Interaction effect on yield per plot of strawberry (*Fragaria ananassa*) varieties at different locations of Nepal in 2018/2019.

Treatments	Yield per plot of strawberry	
	Marketable Yield per plot (gm)	Total Yield per plot (gm)
Location × variety interaction		
Dharan.EMCO33	7116.75a	8360.00 <sup>a</sup>
Dharan.Sensation	1786.50c	2050.50 <sup>c</sup>
Dharan.Beauty	1788.75 <sup>c</sup>	2052 <sup>c</sup>
Dharan.EMCO32	7976.00a	9068.75 <sup>a</sup>
Dharan.Fortuna	1838.00c	2072.50 <sup>c</sup>
Biratnagar.EMCO33	4952.62b	5505.94 <sup>b</sup>
Biratnagar.Sensation	1330.00 <sup>c</sup>	1646.00 <sup>c</sup>
Biratnagar.Beauty	1293.75 <sup>c</sup>	1610.25 <sup>c</sup>
Biratnagar.EMCO32	5713.28 <sup>b</sup>	6587.90 <sup>b</sup>
Biratnagar.Fortuna	682.00 <sup>c</sup>	874.00 <sup>c</sup>
Grand Mean	3447.76	3982.78
SEM	275.01*	314.36*
LSD	1123.28	1284.04
CV	22.56	22.32
CV	31.52	31.73

Means with same letter within column do not differ significantly at  $p=0.05$  by DMRT. NS- Non –significant, SEM- Standard error of mean, LSD- Least significant difference, CV- Coefficient of variance, DAT- Days After Transplanting

Significant difference between locations was recorded for quality parameters TA, pH and Vit-C content of fruits and no significant difference between locations for TSS was recorded, fruit quality parameter of different varieties of strawberry as influenced by location are presented in Table 5.

Significantly higher pH value (3.28) and TA content (0.85 % citric acid) of fruit was observed in Biratnagar compared to pH (3.17) and TA content (0.80 % citric acid) in Dharan

Higher vitamin C content (68.22 mg/100gm) was recorded in Dharan being significantly different to Biratnagar (64.47 mg/100gm).

#### Effect of varieties on fruit quality parameters

Significant difference among varieties were recorded for quality parameters TSS content, pH, Vit- C content and TA of fruits as presented in Table 5.

Highest pH value (3.48), highest TA content (0.90% citric acid), higher vitamin C content (71.89 mg/100 gm) was recorded in variety 'EMCO 33' whereas least pH value (3.07), least TA content (0.77 % citric acid) and least

Vit-C content (59.75 mg/100gm) was recorded in variety 'Sweet Sensation',

Highest TSS content (6.57 0B) was recorded in variety 'EMCO 32' whereas least TSS content (5.6 0B) was recorded in variety 'EMCO 33'. Variety 'Sweet Sensation' (6.12 0B) was found statistically at par with Variety 'Florida Beauty' (6.150B) and 'Florida Fortuna' (6.12 0B).

#### Interaction effect of location and variety on Fruit quality parameters

No significant effect of interaction of location and variety were recorded for quality parameters TSS content, pH, Vitamin - C content and TA of fruits.

Above results reveal that variety 'EMCO 32' and 'EMCO 33' were superior to other varieties as sweetness of fruit is related with TSS and TA content of fruit and variety 'EMCO 33' had higher vitamin-C content. Thus variety 'EMCO 33' is more preferable. Whitaker et al. (2015) and Kelly et al. (2016) also obtained similar results with physiochemical characters of strawberry fruits.

Higher TSS and ascorbic acid content of fruit may be attributed to higher vegetative growth as enough

**Table 5:** Fruit quality parameters of strawberry (*Fragaria ananassa*) varieties as influenced by different locations of Nepal in 2018/2019.

Treatments	Fruit quality parameters			
	pH	TSS	TA	Vit-C
Location (Factor A)				
Dharan	3.17 <sup>b</sup>	6.04	0.80 <sup>b</sup>	68.22 <sup>a</sup>
Biratnagar	3.28 <sup>a</sup>	6.19	0.85 <sup>a</sup>	64.47 <sup>b</sup>
Grand Mean	3.22	6.11	0.82	66.35
SEM	0.11 <sup>***</sup>	0.24 <sup>ns</sup>	0.04 <sup>***</sup>	4.69 <sup>**</sup>
LSD	0.10	0.21	0.03	4.1
CV	4.94	5.51	6.89	9.99
Variety (Factor B)				
EMCO33	3.48 <sup>a</sup>	5.6 <sup>c</sup>	0.90 <sup>a</sup>	71.89 <sup>a</sup>
Sensation	3.07 <sup>c</sup>	6.12 <sup>b</sup>	0.77 <sup>b</sup>	59.75 <sup>b</sup>
Florida Beauty	3.24 <sup>b</sup>	6.15 <sup>b</sup>	0.83 <sup>b</sup>	67.22 <sup>a</sup>
EMCO32	3.08 <sup>c</sup>	6.57 <sup>a</sup>	0.85 <sup>b</sup>	60.99 <sup>b</sup>
Fortuna	3.25 <sup>b</sup>	6.12 <sup>b</sup>	0.78 <sup>c</sup>	71.89 <sup>a</sup>
Grand Mean	3.22	6.11	0.82	66.35
SEM	0.06 <sup>***</sup>	0.10 <sup>***</sup>	0.03 <sup>***</sup>	3.25 <sup>***</sup>
LSD	0.08	0.14	0.04	4.66
CV	2.44	2.35	4.89	6.91

photosynthate was available for sugar and acid accumulation (Singh et al., 2007). TSS content was observed by the treatment which may be due to favorable temperature and humidity especially in night during fruit growth and ripening period. The soluble solids content was more dependent on environmental condition during growth and development than genetic inheritance in strawberry (Shaw, 1990).

The possible explanation for lower acidity in Dharan may be due to difference between day and night temperature which are very narrow, whereas cooler nights and warmer days are helpful in synthesizing more acidity noticed by Wani et al. (2007).

The oxygen concentration which is more in the lower altitude of the earth caused oxidation of more ascorbic acid, consequently fruits showed decreased ascorbic acid content in comparison to the fruits obtained and analyzed at higher altitude. In this support Klimczak and Stropiek (1988) reported that strawberries grown at higher altitude have higher ascorbic acid content.

## CONCLUSION

The experiment brought some important information on effect of location and variety on Yield and fruit quality parameters of strawberry.

For flowering and yield characters, variety 'EMCO 32' followed by 'EMCO 33' were superior both in Dharan and Biratnagar. But considering the overall production performance Dharan conditions were favourable than Biratnagar for given varieties. Fruit quality parameters are not of major importance in Nepal but Considering fruit quality variety 'EMCO 33' was more preferable with higher TSS, TA, Vitamin C and pH content while variety

'EMCO 32' had poor quality parameters and better quality fruits were obtained in Biratnagar.

Thus we can conclude that among the varieties under study, variety 'EMCO 33' and 'EMCO 32' can successfully be cultivated in both locations and taking fruit quality parameters into consideration variety 'EMCO 33' is more preferable. However still more studies are required to assess the varietal performance and it would be premature to recommend suitable variety for given locations.

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