Evaluation of Onion Genotypes for Bulb Yield and Storability at Dailekh, Karnali Province, Nepal

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Abstract

Bulb yield and its storability associate with genetic traits besides the agronomic, environmental and other biotic factors. Field experiments were conducted at Horticulture Research Station, Dailekh (28°13'6.18"N, 83°58'27.72"E, and 1255 meter above sea level) in the main cropping season (2018-2019 and 2019-2020) to investigate seven onion genotypes (AVON-1016, AVON-1028, AVON-1027, AVON-1052, AVON-1103, Light Red and Nasik Red) for their bulb yield and storage performance and compared them with Red Creole, a commercial variety. Experiments were laid-out in randomized complete block design with four replications. The analysis of data showed that genotypes had significantly different in neck diameter, individual bulb weight, total bulb weight and total bulb yield. Genotype AVON-1016 produced the highest bulb weight (5.4 kg/plot) and bulb yield (35.4 t/ha). Genotype AVON-1016 produced 33.6% higher bulb yield than Red Creole. The lowest bulb rotting percentage was recorded in Red Creole (17.1%) followed by AVON-1052 (20.6%) and AVON-1016 (24.4%) after 120 days of storage at room condition. The lowest bulb weight loss was recorded in Red Creole (34.5%) followed by AVON-1052 (36.0%) and AVON-1016 (36.5%). Thus, AVON-1016 can be selected as high yielding onion genotype with good storage potential to grow in commercial level at Mid-western Nepal.

Keywords: Bulb rotting percentage, genotypes, storage, weight loss, yield

Introduction

Onion (Allium cepa L.) is one of the important vegetable crops in the world which belongs to the family Liliaceae. The genus Allium is subdivided into three groups; Allium cepa, Allium aggregation, Allium prolilum which are all diploids (Boukary et al., 2012). Onion is the second most valuable vegetable crop worldwide, after tomato (FAOSTAT 2011, http://faostat.fao.org). In Nepal, it is one of important income generating crop for farmers and mid-hills are the leading regions of onion production in Nepal.

Onion is used as both the green and mature bulb stages as a salad vegetable and spices. It has a great demand due to its flavor, pungent taste, medicinal value and low profile containing rich carbohydrate, protein, vitamin A, thiamine, riboflavin, niacin and ascorbic acid (Kale and Ajjappalavara, 2015). Onion is also used for processing such as pickling, freezing, dehydration and oil extraction. Onion is also useful crop for medicinal purposes such as prevention and treatment of blood and heart diseases (Cheema et al., 2003).

In Nepal, onion is cultivated an area of 20,908 ha with a total production of 2, 91,538 and productivity 13.9 t/ha. In Karnali Province, it is cultivated an area of 718 ha with a total production of 7,942 and productivity 11.1 t/ha (MoALD, 2019). Onion productivity is lower in Karnali Province than the national average of 13.9. Despite its year round production potential, the yield of the crop is far below the world average (19.7 t/ha) (FAO, 2012). Low yielding with limited number of varieties, unavailability of quality seed at planting time, pre-mature bolting, bulb splitting, poor adaptation of cultivars to low input management conditions etc. are the reasons of low productivity of onion in Nepal (Gautam et al., 2019). Improved seed varieties would contribute to crop yield up to 30% (Muhammad et al., 2016). Asian Vegetable Research and Development Centre (AVRDC) has been developed new genotypes that have yield potentiality of more than 45 t/ha. Varieties grown so far in Nepal are mostly imported hybrids with low storability. Most of the farmers have not accessed to these hybrids due to its high price as well as high inputs costs. Red Creole, is an open pollinated variety, very adaptive in mid hills and it has good storability (personal observation). However, there is a need to develop other onion varieties better than Red Creole for yield as well as storability.

Introduction, testing, and selection of high yielding open pollinated varieties are the best option for increasing the yield and productivity (Gautam et al., 2019). In addition, storage is an important aspect for postharvest management and it determines the period of availability in the market. But onion storability is affected by environmental, pathogenic and genetic factors (Ko et al, 2002). In the tropics and sub-tropics, onions are produced during cool-dry season and stored by farmers in hot-wet season. Onion is less perishable commodity than other vegetables and storages loss in the tropics can be as high as 50% (Musa et al., 1973). Farmers generally store onion in shelters at ambient conditions in mid-hills of Nepal. Selection of high yielding with good storability and well-adapted onion variety will help for smallholder producers to achieve potential yields as well as to increase their income and improve livelihood. Therefore, this research was aimed to identify high yielding onion genotype with good storage potential at room conditions at mid-hills of Nepal.

Materials and methods

Experimental site and climate

The experiment was conducted at Horticulture Research Station (HRS), Kimugaon, Dailekh. This is situated at 28˚13' 6.18" N longitudes and 83˚58'27.72" E latitude with an elevation of 1, 255m asl. This station represents mid-western hills of Karnali Province and falls under sub-tropical climatic region. The dominant soil at the station was clay loam type with slightly acidic. Average maximum temperature was higher in January in the year 2018-2019 but from February onwards, average maximum and minimum temperature increased steadily in both years (Fig. 1). Plants were received more rainfall in January in 2019-2020. In contrast, more precipitation was recorded in February in 2018-2019. The pattern of precipitation from March to May in 2019-2020 was evenly distributed but it was consistently increased in 2019-2019.

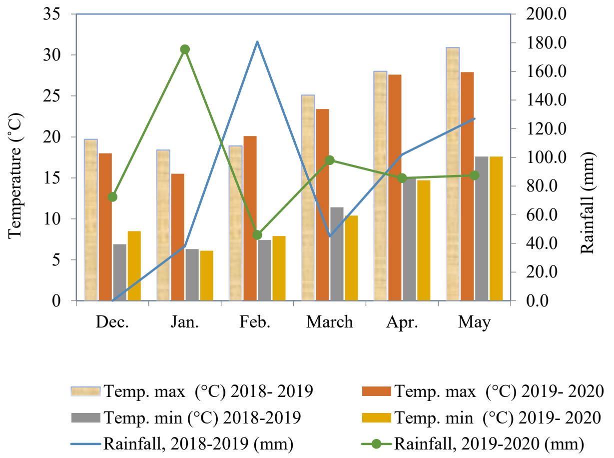

Fig. 1. Temperature and rainfall pattern of HRS, Dailekh during the experimentation of onion from 2018-2019 to 2019-2020

Plant materials, cultivation and storage

A total of five long-day onion genotypes (AVON-1016, AVON-1028, AVON-1027, AVON-1052 and AVON-1103) were received from National Horticulture Research Centre (NHRC), Khumaltar. NHRC was received these materials from AVRDC, Taiwan. In 2018-2019, five onion genotypes were studied and compared with standard variety Red Creole. But in 2019-2020, seeds of two additional varieties namely Light Red and Nasik Red were collected from different sources and evaluated, and compared with Red Creole. The nursery was placed on 28th Oct. in 2018 and 42-days old seedlings were transplanted on 29th Dec. 2018. In 2018, seedlings were transplanted at the spacing of 20 cm x 15 cm with plot size was maintained at 1 m2. Each replication had 30 plants/genotype. A randomized complete block design (RCBD) with four replications was used. In 2019, seeds were sown in nursery in 20th Oct. and seedlings were transplanted on 6th Dec. in 2019. A total of 100 seedlings for each genotype were transplanted where plants were spaced 20 cm between rows and 10 cm between plants within rows. The plot size of each replication was 2 m^2. The fertilizer was used as 100:80:60 kg NP2O5K2O/hectare along with 20 ton FYM/hectare as per the recommendation (Chalise and Pun, 2012). The full amount of phosphorous and potassium and half amount of nitrogen and FYM were mixed in the soil at the time of land preparation. Remaining half amount of nitrogen was top-dressed at 25 days after transplanting and the half at 50 days after transplanting. Intercultural operations like weeding and irrigation were carried out as desired during crop growing period.

Bulbs were harvested at the last week of May in 2019 and 2020. For the storage trial in 2020, seventy bulbs of each cultivar were placed plastic crates (42 cm long x 34 cm wide x 12 cm high). Four kilograms of bulbs each cultivar with no visible disease symptoms were selected and placed in individual plastic crates. The experiment was conducted using a completely randomized design (CRD) with three replications. The plastic crate with bulbs was placed on a concrete storage room (10 m long, x 6 m wide x 5 m high). Single layer plastic crate was installed in the room. Windows were opened for air circulation and bulbs were stored for four months at 32.0 ± 1.5ºC and a RH of 70±3.5 %. After four months, number of rotting bulbs was counted, and weight of sound bulbs was measured. Number of rotting bulb for each cultivar and bulb weight loss (%) was recorded. The number of rotting bulb was determined as number of rotting bulb/total number of bulb x 100. Likewise, weight loss of bulb in each cultivar was determined as weight loss of bulb/initial total bulb weight x100.

Observations and data analysis

The data collected included final leaf length (cm), neck diameter (mm), equatorial bulb diameter (mm), individual bulb weight (g), total bulb weight/plot (kg) and total bulb yield (t/ha). Leaf length (cm) was measured on the longest leaves in randomly selected five plants and it was measured from the base of leaf to tip using meter scale. Neck diameter (mm) was measured using vernier caliper on randomly selected five plants. Individual bulb weight (g) was measured on randomly selected five sample bulbs using digital balance after removing leaves. After removal of leaves, total weight of bulb/plot was measured using electronic weighing balance (H-HondaTM) and total bulb yield (t/ha) was calculated. The quantitative data were analyzed using GenStat Release 10.3 DE Software (VSN International Ltd. UK). Pearson correlation coefficient among the quantitative traits was computed with genotypes mean using IBM SPSS Statistics 20. The qualitative data including foliage color, bolting degree, bulb shape and uniformity, bulb and skin color, and flesh and neck color were assessed using IPGRI descriptors (IPGRI, ECP/GR, AVRDC, 2001). Foliage color was assessed by visually at fully developed plants. Bolting degree was assessed as low, medium and high at fully developed plant or flowering stage. Bulb shape was recorded at mature dry stage after four weeks of storage. Bulb skin color was recorded at harvested bulb with dry skin stage. Bulb flesh color was assessed after cutting the transverse section of bulb.

Results

Leaf length and bulb characters

The results of leaf length, neck diameter and bulb diameter of studied genotypes are presented in Table 1. The genotypes showed non-significant effect on leaf length. The highest average leaf length (37.50 cm) was measured in 2019. Genotype AVON-1028 produced the highest (43.0 cm) leaf length but the lowest (32.0 cm) leaf length was produced in AVON-1052 and Nasik Red. Highly significant (p≤0.01) differences in neck diameter were observed among the genotypes. The neck diameter was measured the highest (15.9 mm) in AVON-1016 but it was statistically similar with the genotype AVON-1028 (14.5 mm) and AVON-1103 (14.1 mm) but the lowest (11.8 mm) was measured in AVON-1052. In 2019, genotypes showed significant (p≤0.05) difference in bulb diameter. The highest (59.7 mm) bulb diameter was measured in AVON-1028 but it was statistically similar with AVON-1052 (57.0 mm), AVON-1103 (56.3 mm), and AVON-1027 (53.0 mm) but the lowest (52.2 mm) was measured in AVON-1016 followed by Light Red (52.7 mm). The pooled mean over the years showed the non-significant effect on bulb diameter among the genotypes.

Table 1. Leaf length and bulb characters of onion genotypes evaluated at HRS, Dailekh during 2018 and 2019

Genotypes	Leaf length (cm)		Mean	Neck diam. (mm)		Mean	Bulb dia. (mm)		Mean
	2018	2019		2018	2019		2018	2019	
AVON-1016	40.6	37.0	38.8	16.8	15.0	15.9	76.7	52.2	64.5
AVON-1028	34.6	43.0	38.5	13.2	15.9	14.5	74.0	59.7	66.8
AVON-1027	39.5	40.0	39.5	11.6	14.7	13.2	78.8	53.0	65.9
AVON-1052	36.4	32.0	34.1	11.4	12.2	11.8	72.4	57.0	64.7
AVON-1103	37.7	38.0	37.8	15.1	13.1	14.1	72.5	56.3	64.4
Red Creole (Ch)	30.0	38.0	34.0	10.5	14.6	12.5	72.3	53.5	62.9
Light Red	-	39.0	-	-	17.3	-	-	52.7	-
Nasik Red	-	32.0	-	-	13.4	-	-	56.30	-
Mean	36.4	37.50	37.62	13.1	14.55	13.88	74.78	55.11	64.66
F-Test	*	*	NS	**	*	**	NS	*	NS
LSD (0.05)	5.82	5.30	5.7	2.847	2.78	2.35	7.12	5.43	6.9
CV (%)	10.6	12.7	12.7	14.5	10.9	14.2	6.4	8.7	8.9

NS, * and ** indicate non-significant, significant and highly significant at 0.05 and 0.01 levels, respectively. '-' not tested in particular year.

Bulb weight and bulb yield

The analyzed data of bulb weight, total bulb weight and bulb yield in onion genotypes are given in Table 2. In 2018, genotypes showed significantly higher (105.7 g) bulb weight than in 2019 (81.1 g). The pooled analysis showed significant (p≤0.05) effect on bulb weight in onion genotypes. Genotype AVON-1027 produced the highest (104.5 g) bulb weight followed by AVON-1016 (101.2 g) but the lowest (89.0 g) was in AVON-1052. Genotypes showed the significant (p≤0.05) effect on total bulb weight. Total bulb weight/plot produced the highest (5.4 kg) in AVON-1016 followed by AVON-1027 (4.9 kg) and AVON-1028 (4.4 kg) but the lowest (4.0 kg/plot) was recorded in AVON-1103. As compared to the year 2018, the total bulb weight/plot produced was higher (5.66 kg) in 2019. Similarly, pooled analysis over the years showed the significant (p≤0.05) differences in total bulb yield among the genotypes. Genotype AVON-1016 produced the highest (35.4 t/ha) bulb yield followed by AVON-1027 (34.9 t/ha) and the lowest (26.5 t/ha) was in Red Creole. In 2019, AVON-1016 produced the highest (36.8 t/ha) but it was statistically similar with AVON-1027 (29.9 t/ha), and AVON-1028 (29.1 t/ha) but the lowest (23.8 t/ha) was produced in Nasik Red.

Table 2. Bulb weight and yield of onion genotypes evaluated at HRS, Dailekh during 2018 and 2019

Genotypes	Individual bulb wt. (g)		Mean	Total bulb wt. (kg)		Mean	Bulb yield (t/ha)		Mean
	2018	2019		2018	2019		2018	2019	
AVON-1016	105.8	97.4	101.2	3.4	7.4	5.4	34.1	36.8	35.4
AVON-1028	100.3	90.3	97.0	3.0	5.8	4.4	30.1	29.1	29.6
AVON-1027	134.4	75.8	104.5	4.0	5.9	4.9	40.0	29.9	34.9
AVON-1052	91.4	87.4	89.0	2.8	5.6	4.2	30.1	27.8	28.7
AVON-1103	88.7	92.1	90.0	2.7	5.5	4.0	27.4	27.3	27.3
Red Creole (Ch)	113.7	69.1	92.0	3.0	5.3	4.1	26.6	26.4	26.5
Light Red	-	61.7	-	-	4.9	-	-	24.8	-
Nasik Red	-	74.7	-	-	4.8	-	-	23.8	-
Mean	105.7	81.1	95.5	3.17	5.66	4.6	31.7	28.29	30.40
F-Test	*	*	*	*	*	*	*	*	*
LSD (0.05)	24.7	20.1	10.1	0.743	1.46	0.854	7.42	7.30	5.76
CV (%)	15.5	19.1	18.7	16.5	15.5	18.8	16.8	14.7	15.8

* indicate significant at 0.05 level.. '-' not tested in particular year.

Foliage and bulb characters

Foliage color was varied from green, light green to dark green in the studied genotypes (Table 3). Genotype AVON-1028 and Red Creole was characterized as dark green foliage. Nasik Red was noted as high bolting genotype whereas Red Creole was observed as medium bolting variety. Variation in bulb shape was observed in the genotypes and it was varied from Spanish, globe to flattened globe. Bulb of AVON-1027 was remarked as non-uniform but remaining genotypes produced the uniform bulb. Bulb color was varied from red, yellow to light red type. Likewise, skin color was also varied from violet, dark violet, light violet, yellow, light yellow to yellowish white. Bulb morphology of studied onion genotypes are given in Figure 2. Genotype AVON-1016 contained violet creamy flesh but AVON-1028, AVON-1027 and AVON-1052 had creamy white flesh and remaining genotypes had violet flesh. Pink, light green, whitish pink and pink neck color was observed in the genotypes.

Table 3. Foliage and bulb characters of onion genotypes evaluated at HRS, Dailekh during 2018 and 2019

Genotypes	Foliage color	Bolting degree	Bulb shape	Bulb uniformity	Bulb color	Skin color	Flesh color	Neck color
AVON-1016	G	L	S	U	R	DV	VC	P
AVON-1028	DG	L	G	U	Y	Y	CW	LG
AVON-1027	G	L	S	NU	Y	LY	CW	LG
AVON-1052	LG	L	G	U	Y	YW	CW	LG
AVON-1103	LG	L	G	U	R	V	V	WP
Red Creole (Ch)	DG	M	G	U	R	LV	V	P
Light Red	G	L	G	U	LR	V	V	WP
Nasik Red	G	H	FG	U	R	V	V	P

Foliage color, G = Green, DG = Dark green, and LG = Light green, Bolting degree; L = Low, M = Medium, and H = High, Bulb shape; S = Spanish, G = Globe, and FG = Flattened globe, Bulb uniformity; U = Uniform, and NU = Non-uniform; Bulb color; R = Red, Y = Yellow, and LR = Light red, Skin color; DV = Dark violet, Y = Yellow, LY = Light yellow, YW = Yellowish White, V = Violet, and LV = Light Violet, Flesh color; VC= Violet Cream, V = Violet, CW = Creamy White, and Neck color; P = Pink, LG = Light green, and WP = Whitish pink

Fig. 2. Bulb morphology of onion genotypes evaluated at HRS, Dailekh during 2018-2019. A = AVON-1016; B = AVON-1028; C= AVON-1027; D = AVON-1052; E = AVON -1103; F = Red Creole; G = Light Red; and H = Nasik Red

Correlation among the phenotypic traits

The relationship among the phenotypic traits of onion genotypes is presented in Table 4. Leaf length was positively correlated with neck diameter, individual bulb weight and total bulb yield. Bulb diameter had significantly positively correlated with total bulb weight and total bulb yield. Individual bulb weight was positively correlated with total bulb weight and total bulb yield. Likewise, relationship of total bulb weight with total bulb yield was positive.

Table 4. Pearson's correlation coefficient analysis among phenotypic traits of onion genotypes at HRS, Dailekh during 2018 and 2019

Genotypes	LL	ND	BD	IBWT	TBWT	TBYLD
LL	1.0	0.43**	0.07	0.53**	0.29	0.36**
ND		1.0	-0.01	0.10	0.18	0.04
BD			1.0	0.19	0.58**	0.39**
IBWT				1.0	0.47**	0.71**
TBWT					1.0	0.48**
TBYLD						1.0

LL = Leaf length (cm), ND = Neck diameter (mm), BD = Bulb diameter (mm), IBWT = Individual bulb weight (g), TBWT = Total bulb weight (kg/plot) and TBYLD = Total bulb yield (t/ha)

Rotting (%) and weight loss (%)

Onion bulbs in the storage were observed the rotting and weight loss for four months (Figure 3). Variation in rotting percentage was observed among the stored onion genotypes. The highest (52.1%) rotting was recorded in Nasik Red followed by AVON-1027 (40.8%) and AVON-1028 (30.8%) whereas Red Creole (17.1%) showed the lowest rotting bulb followed by AVON-1052 (20.6%) and AVON-1016 (24.4%). Red Creole is adapted to storage conditions in Dailekh and bulbs are more uniform size than the other genotypes. Likewise, Nasik red exhibited the highest (68.6%) weight loss followed by AVON-1027 (54.3%) whereas the lowest weight loss was observed in Red Creole (34.5%) followed by AVON-1052 (36.0%) and AVON-1016 (36.5%). Red Creole was adaptive variety in mid-hill and as compared to introduced genotypes, this variety was less rotting and weight loss percentage.

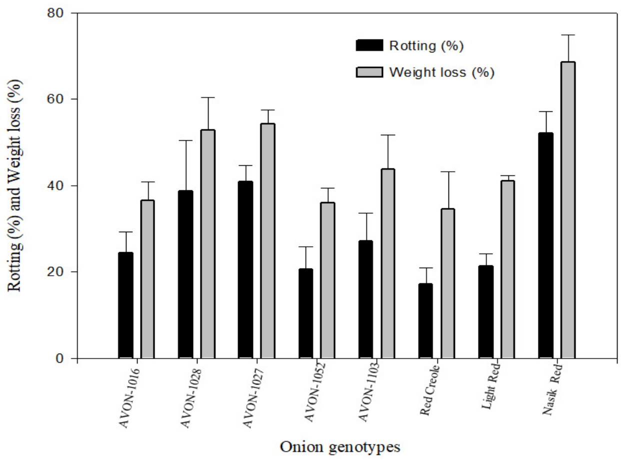

Fig. 3. Rotting (%) and weight loss (%) of eight onion genotypes under room condition after 120 days of storage at HRS, Dailekh, 2020. Values are the mean ± SE (Standard error) from three determinations.

Discussion

Significant variation in leaf length observed in onion genotypes and the difference in leaf length is mainly genetically related to cultivar (Nilufar, 2009). The significant differences in leaf length in onion genotypes were also reported by previous researchers (Azoom et al., 2014; Attri et al., 2015; Roy et al., 2016). Large variation was observed in neck diameter and genetic differences between varieties might be created the differences neck diameter. Significant differences in neck diameter among the onion genotypes were also reported by many researchers (Gautam et al. 2006; Azoom et al., 2014). In 2018, larger individual bulb weight was observed than in 2019 and this might be due to wider plant spacing which influenced on water availability, light and nutrients and the effect of plant spacing on bulb size had been reported by many workers (Kahsay et al., 2013; Khokhar, 2017; Peerzade and Harish Babu, 2017). In this study, onion genotypes contributed significantly different in total bulb yield and this might be due to variation in bulb weight and genetic potential of the variety. This result is similar with the findings of Som (2014), Ddamulira et al. (2019) and Gautam et al. (2019). Simon et al. (2014) had reported that yield differences in onion varieties due to interaction of genetic and environmental conditions. Onion genotypes showed the variation in qualitative characters and the variation in skin color in onion genotypes was also reported by Currah and Proctor (1990). Gautam et al. (2019) also reported the variation in qualitative characters in onion genotypes. Our results showed the significant positive correlation of bulb diameter and bulb weight with bulb yield which confirmed the previous findings of previous researchers (Rahman et al., 2002; Aliya et al., 2007). Leaf length, bulb diameter, and bulb weight could be important traits for indirect selection and enhance the yield potential of onion genotypes.

Onion bulb is the widely consumed part of the plants and its storability is affected by environmental, pathogenic and genetic factors (Ko et al., 2002). In our study, Red Creole, check variety showed the lowest (17.1%) rotting after 120 days of storage, but in the study of Ddamulira et al. (2016), they reported that the local check had the lowest (below 50%) rot after 113 days of storage. In our study, storage condition for all genotypes were same at room temperature and variation in the weight loss and dormancy were due to genotypic differences rather than storage condition and similar results were reported by Ddamulira et al. (2016). White bulb onions were reported very poor storability (Schwartz and Mohan, 1995). In contrast, in this study, red skin variety had very poor storability. However, bulb skin color did not associate with storage losses (Ko et al., 2002).

Conclusion

In this study, AVON-1016 found a high yielding onion genotype whereas Red Creole, a check variety was found low yielding type. As compared to Red Creole, genotype AVON-1016 gave 33.5% higher bulb yield. In contrast, variety Red Creole showed less rotting percentage of bulb followed by genotype AVON-1016. Long storability was recorded in Red Creole followed by genotype AVON-1016. Besides, qualitative characters including foliage color, bolting degree, bulb shape, bulb and skin color, and flesh and neck color affects the consumer preferences' for a particular variety and these distinctive morphological characters can be used to differentiate onion genotype from each other. Based on yield, storage and quality attributes, genotype AVON-1016 is selected and recommended to grow for commercial scale in mid-hills of Nepal.

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