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Performance Evaluation of Apple Varieties at Wadla District, North Wollo, Ethiopia

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Abstract. Apple is one of the most important fruit crops in the highland areas of Ethiopia. This fruit tree is the only producible fruit tree in the highlands of North Wollo. However, its productivity is very low compared to other countries, particularly temperate regions. This is partly attributed to lack of adaptable, high yielding and better quality apple varieties to farmers. To solve this problem apple variety trial was carried out at Wadela District from 2012-2019. The trial was laid out in randomized complete block design with three replications. Low to medium chill grafted apple seedlings were planted at a spacing of 3.0 m between rows and 3.0m between plants. Each plot was planted with three seedlings. On average irrigation water was applied on 7 days interval. Necessary plant protection and agronomic practices like training and pruning were applied as required. Scion diameter, rootstock diameter, girth ratio, canopy diameter, plant height, mean fruit weight and fruit yield data were collected for two consecutive years. Yield data was collected two times within a year. The Anna variety gave significantly the highest fruit yield (9.52 t. ha^{-1}) followed by Gransmith (8.92 t $.ha^{-1}$). On the other hand, Crispin gave the lowest fruit yield (7.77 t $.ha^{-1}$). Fruit yield obtained by Anna and Gransmith were higher by 23% and 15%, respectively, compared to the lowest yielding variety, Crispin. Similarly, Anna and Gransmith also gave significantly the highest mean fruit weights of 85.98 and 62.34 g, respectively, as compared to the variety Crispin, which gave a mean fruit weight of 41.01 g. Farmers also select Anna variety by their criteria setted. Therefore, Anna and Gransmith are recommended for producers at Gashena conditions and similar agro-ecologies.

Keywords: chill apple varieties; girth; fruit; yield

INTRODUCTION

Apple (*Malus domestica)* is a woody plant belonging to the family, *Rosaceae* and sub-family *Maloideae* or formerly *Pomoideae* (Brown, 1992). Under normal growing conditions an apple will develop into a small to medium-sized tree, of 5–10 m height, freely branching with long shoots and various types of short spurs. When growing unattended in the tropics it will revert to a stiff, overcrowded upright bush of 2–4 m in height (Griesbach, 2007). The exact origin of the plant is not clearly known. However, it is the most ubiquitous of temperate fruits and has been cultivated in Europe and Asia. There are suggestions that it originates from central Asia, where its wild ancestor is still found today (Janick *et al*., 1996). Apple is the most important fruit and it is the leading table fruit served, because of its attractive appearance, easily cultivable and can be stored at normal temperature for every month.

Apple requires an elevation of 1600-2700 m.a.s.l. Apple is a very nutritious, aromatic and delicious fruit and very rich in vitamins A, B and C. It contains about 11% sugar besides essential minerals in appreciable amounts. It has color appeal, stimulates appetite and is most refreshing (Anonymous, 2001). Apple fruits are alkaline because they contain pectin with alkaline pH. They are also important to prevent constipation for ease defecation of solid waste, because pectin from the apple takes in excess water in the intestines, making a soft bulk that creates a mild, non-irritating stimulant. Apple can be used in many different forms; cooked, made into preserves, jellies, canned, candied, as fresh apple juice and made into cider or vinegar. Moreover, the peal is used for making pectin (Anonymous, 2001). The proverb “an apple a day keeps the doctor away” strengthens the idea that apple fruit is an excellent source of very important food nutrient.

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Apple accounts for 50% of the world's deciduous fruit tree production. The leading apple growing country is China, producing about 41% of the world's apple; followed by the United States, India, and Turkey. In Africa, the leading producer is South Africa, followed by Egypt and Kenya (USDA, 2013). In 2017, from 4933841 hectares of land 83139326 tons of apples with a productivity of 16.85 t ha^{-1} were produced in the world (FAOSTAT, 2017).

In Ethiopia, fruit production has been dominated by tropical and sub-tropical fruit types which include banana, citrus, papaya, mango, avocado, lemon, etc. these are mainly grown in the lowland areas of the country (CSA, 2016). While Ethiopian highlands are endowed with climate of low temperature (having diverse topography and agro-ecological zones covering about 50% area of highland with 2000-4500 m.a.s.l. altitudes), lands with mosaic of soils, and ample water resources suitablefor the production of highland fruits like apple. Apple is a moderate climatic zone fruit tree and thus regarded as an exogenous crop to Ethiopia. It is introduced by Missionaries from abroad some 65 years ago (Hayesso,2008; Ashebir *et al*.,2010; Girmay *et al*., 2014).

Generally, apples are becoming an income-generating crop for rural communities. Thus it plays an important role in poverty alleviation. However, the performance of apple varieties in Ethiopia particularly Eastern Amhara sub region is poor and farmers grow low yielding as well as poor quality apple varieties. Therefore, the objective of this study was initiated to identify well adaptable and high yielding apple varieties for Gashena and similar areas.

METHODS

The experiment was conducted at Wadla District Gashena trail site of Sirinka agricultural research centre during July 2012 to December, 2019. Gashena is situated at $11^0 46'$ N latitude and $38^0 45'$ E longitude, at 2865 meters above sea level (Figure 1).

The average annual minimum and maximum temperatures were 12 and 24 ^{0}C, respectively (SARC, 2018). It receives a mean annual rainfall of 1127.80 mm. The soil type of the trial site is clay loam that has good drainage property. Eight low and medium chill apple varieties namely: Anna, CP-92, Princisa, Bond Red, Golden delicious, Crispin, Jona Gold & Gransmith were used as experimental material. Appropriate type of grafted seedlings were planted in a well prepared hole with a depth, diameter and width of 50, 50 and 50 cm, respectively on July 10, 2012 in randomized complete block design with three replications at a spacing of 3.0 and 3mx3m with a population density of 1111 plants ha^{-1}. There were 3 plants per plot. Irrigation water was applied on weakly.

Necessary plant protection and agronomic practices like training and pruning were applied as required. Data like scion diameter, rootstock diameter, girth ratio, canopy diameter, plant height, mean fruit weight and fruit yield were collected for two consecutive years. Farmers' opinion was collected once at fruiting stage and set their criteria to evaluate apple varieties. After setting their criteria they evaluate apple varieties and gave rank on the setted criteria. Vegetative data was collected after dormancy while yield data was collected two times within a year. Data were analysed using SAS 9.0 software (SAS, 2002). Least Significant Difference (LSD) at 5% probability level was carried out for mean separation.

RESULTS AND DISCUSSION

The combined Analysis of variance (ANOVA) showed that scion diameter was highly variable among the cultivars studied; the highest values were being recorded for cultivars Anna (5.20 cm) and Golden delicious (4.16 cm), whereas the lowest value was found in Jona Gold (Table 1). The

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result is in line with (Abayneh and Masresha, 2014; Petri and Leite, 2004; Andrii *et al*., 2023). Moreover, it was observed that the longest rootstock diameter of (6.17 cm) was recorded by the cultivar Anna, whereas the smallest diameter (3.29 cm) was scored by Jona Gold. Similar result was observed (Dereje *et al*., 2010; EIAR, 2002).

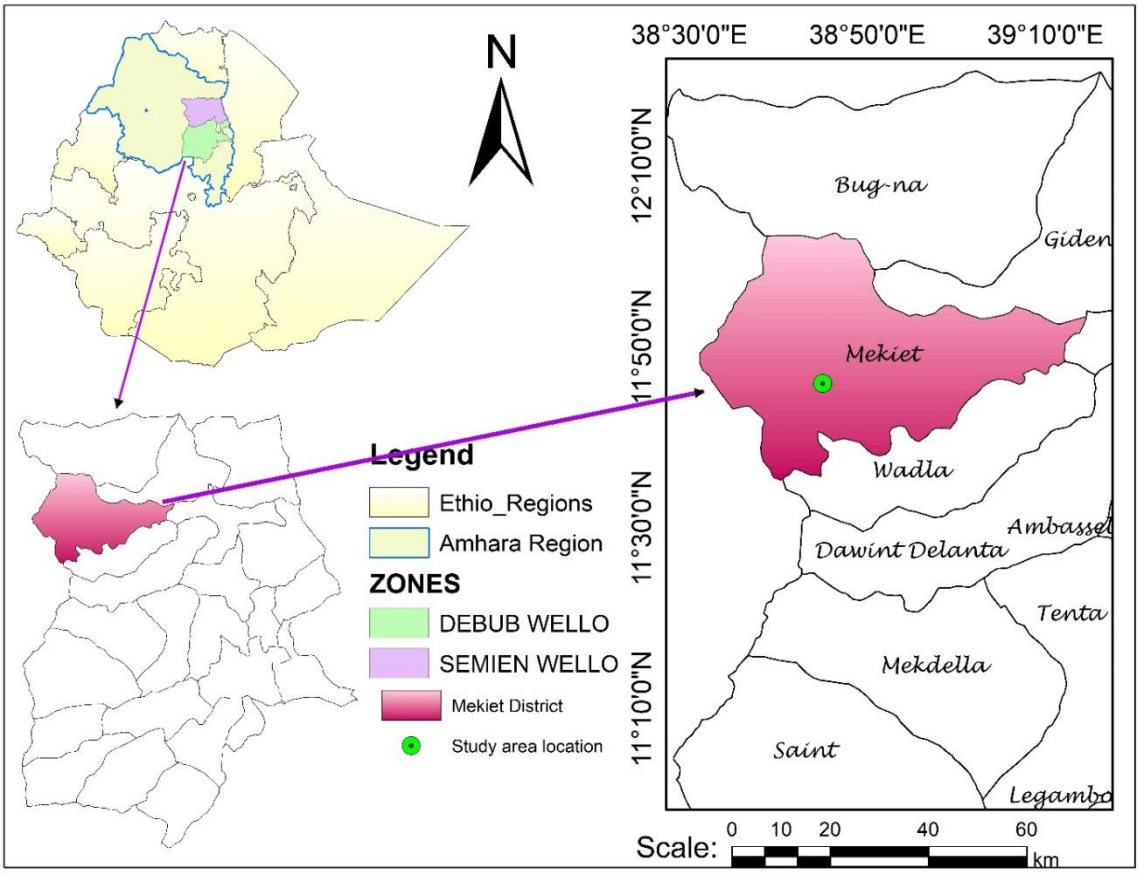

Figure 1. Gashena highland fruit (apple) orchard site location map

Cultivars showed significant (P<0.05) difference in girth ratio. Significantly, the highest ratio was obtained from cultivar CP-92 and Golden delicious with an average value of 87.80 and 85.46 %, respectively (Table 1). while the lowest was recorded for Princisa, with 63.96 %.Similar result was reported by Kebede and Masresha (2005). Least Significant Difference (LSD) at 5% probability level was carried out for mean separation. Varieties showed significant variation in terms of plant height. Significantly, tallest plants were recorded by Anna followed by Bond red variety with plant height value of 3.09 and 2.72m, respectively (Table 1). Whereas, the shortest plant height value was recorded by Crispin (2.19 m). In addition, cultivars showed significant variation in canopy diameter. Anna scored the highest canopy diameter value (1.84 m). On the other hand, CP-92 scored the shortest canopy diameter with value (1.08 m) (Table 1). The result is in line with (Abayneh and Masresha, 2014; Petri and Leite, 2004). On the contrary (Gheorghe et al. 2010), a maximum canopy diameter of 4.6 m was recorded. Canopy spreading depends on intensity of pruning in any plant.

The cultivars studied differed significantly in mean fruit weight, the highest weight being reported for Anna followed by Gransmith with an average value of 85.98 and 62.34 g, respectively.

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The lowest were found for Crispin and Jona Gold with 41.01 and 51.97g, respectively (Table 1). Similar result is reported by Gizaw *et al*. (2023). Fruits from cultivar Anna gave relatively the highest total yield 9.52 t .ha^{-1}. In contrast, Crispin gave the lowest yield of 7.77t.ha^{-1}. The result is in line with Abayneh and Masresha (2014); Petri and Leite (2004). But Getenesh *et.al* (2023) reported lower yield from summer unpruned and trained apple trees. This yield is equal to most countries of the world (FAO, 2011). But there are countries whose productivity of the crop reaches up to 40.5 ton ha^{-1} (M. K. Verma, 2014). Generally temperate fruit productivity is low in tropical areas due to biotic and abiotic stress (pest, chilling, flower physiology, field management, etc).

Table 1. Combined yield and vegetative data of apple varieties at Wadla District, North Wollo, Ethiopia, 2018/19

Variety	DAU(cm)	DBU(cm)	GR(%)	PH(m)	CD (m)	MFW (g)	FY(t ha^{-1})
Anna	5.20	6.17	84.94	3.09	1.84	85.98	9.52
CP-92	3.43	3.92	87.80	2.35	1.08	53.50	8.05
Princisa	2.94	4.62	63.96	2.35	1.30	57.06	7.88
Bond Red	3.44	4.11	84.25	2.72	1.31	61.98	8.73
Gs.deliciou	4.16	4.84	85.46	2.79	1.36	56.08	8.43
Crispin	2.99	3.52	81.98	2.19	1.15	41.01	7.77
Jona Gold	2.33	3.29	73.45	2.46	1.14	51.97	7.88
Gransmith	3.36	4.14	82.00	2.51	1.45	62.34	8.92
LSD (5%)	0.48	0.62	9.49	0.23	0.28	13.48	0.71
CV (%)	14.41	15.04	12.42	9.59	21.85	19.45	7.22

Note: DAU= diameter above union, DBU= diameter below union, GR= girth ratio, PH= plant height, CD= canopy diameter, MFW= marketable fruit weight and FY= fruit yield

Farmers were invited to set their criteria and select their favorite varieties. High yielding, fruit shape, fruit size fruit, color and taste were the main farmer's criteria stetted. Based on the value models results, Anna was identified at the first choice of farmers due to its best performance in all criteria's setted. Gransmith was selected as a second choice because of its good in yield, fruit shape and fruit size. The third and fourth choice of the farmers was CP-92 and Bond Red due to its better in fruit shape and its yield advantage (Table 2).

Table 2. Value model result (points system) for ranking varieties at Wadla District, North Wollo, Ethiopia, 2018/19

Variety	Framers' criteria and point values for each attribute						Mean	Rank
	Fruit Shape	Fruit size	Taste	Fruit color	Yield	TPV		
Anna	25	20	25	18	25	113	22.6	1st
CP-92	20	15	17	15	19	86	17.2	3rd
Princisa	14	18	13	10	20	75	15	5th
Bond Red	21	21	11	12	17	82	16.4	4th
Gs.deliciou	18	14	19	10	14	75	15	5th
Crispin	16	12	13	7	18	66	13.2	7th
Jona Gold	12	10	15	5	8	50	10	8th
Gransmith	23	20	21	16	25	105	21	2nd

Note: TPV= total point values

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During selection farmers had a better understanding towards identifying the criteria for selection. Finally the rank sum method was used to identify the promising varieties to Gashena and similar areas. According to the rank sum method variety Anna selected first followed by Gransmith (Table 3).

Table 3. Overall score of farmer's preference and combined rank sum at Wadla District, North Wollo, Ethiopia, 2018/19

Variety	FY(t. ha^{-1})	Yield rank	Farmers rank	Rank sum
Anna	9.52	1st	1st	1st
CP-92	8.05	5th	3rd	4rd
Princisa	7.88	6th	5th	6th
Bond Red	8.73	3rd	4th	3th
Gs.deliciou	8.43	4th	5th	5th
Crispin	7.77	8th	7th	7th
Jona Gold	7.88	7th	8th	7th
Gransmith	8.92	2nd	2nd	2nd

CONCLUSION

Production of apples is very important in the highland areas of Ethiopia for nutritional and economic purposes. Even if its importance, limitation inappropriate variety, management operation, soil fertility, etc., reduce apple productivity in the highland areas. Introducing medium and low chilly varieties from abroad is necessary to increase the productivity of apples in our country. From the adaptation trial, Anna and Gransmith varieties were found outstanding in terms of physical quality parameters like (shape, color and size) and marketable yield. Disseminating these apple varieties is vital to the area to exploit the crop's full potential. MM-106 rootstock variety is adapted and recommended for woolly aphid protection. Therefore, Anna and Gransmith varieties were recommended for production at Gashena, as well as similar agroecologies. Finally, scions of the recommended varieties will grafted with the best rootstock variety MM-106 and distributed to farmers.

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