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Improved genotypes of harad (*Terminalia chebula*): a new potential crop for Jammu & Kashmir region of India

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ABSTRACT

Due to its multipurpose uses and market potential, interest in the domestication of Harad has received much impetus recently. The large-sized fruit of Harad fetches a higher price in national and international markets. The present study was conducted in farmers' fields in three villages of Jammu district. Trees were grouped into three categories: i. Improved (5-10 years old), ii improved (10-15 years old), and iii naturally growing (15-20 years old). By random sampling, ten trees were selected and analyzed for tree parameters (height, diameter, crown spread) and fruit parameters (fruit length, diameter, fresh fruit weight, fresh pulp weight and dry fruit weight, fruit yield per tree, and fruit productivity). Natural growing plants were 15-20 years old, whereas tree ages in the improved groups were 5-10 years and 10-15 years. Both groups of improved plants had significantly lower sizes (height, diameter and crown spread) than natural growing plants. Fruit parameters (fruit length, fruit diameter, fruit fresh weight, fresh pulp weight per fruit) of both the improved groups were statistically at par and like their mother tree due to precocity but significantly higher than the natural plants. Maximum fruit yield per plant and per hectare was observed in improved plants of 10-15 years age group, followed by improved trees of 5-10 years age-group. Minimum yield per tree was observed in naturally growing plants (15-20 years) despite their largest crown spread due to small-sized fruits. The price received by the farmers and net margins for pre-harvest contractors and forwarding agents were higher for improved Harad than natural Harad.

Keywords: *Terminalia chebula*, Grafted, Non-grafted, Fruit size, Medicinal, Yield

INTRODUCTION

There has been a wider interest in diversifying the horticultural production in India to improve the farmers' income. *Terminalia chebula*, is multipurpose remunerative fruit species growing in the wild has potential for such diversification through its domestication. Cultivation of *Terminalia chebula*, has been constrained by its poor regeneration, long gestation period, higher fruit set heights, unavailability of superior genotypes bearing large sized fruits and lack of standardization of agrotechnology. Due to large sized fruits, the plants of this mother tree are in high demand and have higher value in national and international market, specially for export to Pakistan and Gulf countries for pickles and murraba and preserves (Choudhary *et al*., 3). Therefore, Saleem *et al*. (8) in the Division of Agroforestry (SKUAST-Jammu) evaluated its germplasm across Jammu and Kashmir and Himachal Pradesh for fruit characteristic and identified more than 100 years old mother tree located at Mathwar village (Jammu District, Jammu and Kashmir) with most superior traits (fruit size, length and diameter, fruit weight, fruit pulp content) than others and standardised its propagation in nursery through grafting using scion wood of this mother tree. The annual demand for *harad* fruits is 6678.4 tonnnes which is growing @4.6% (Choudhary *et al*., 3).Farmers of of Jammu and Kashmir, Himachal, Punjab, Haryana, Uttarkhand are now preferring superior genotype this species as horticultural species over other fruits crops like mango, litchi andamblaetc due to longer shelf life of its fruits, salability of its fruits on the trees themselves and its suitability for rainfed areas. Although there are no estimates its production trade and area under its cultivation at Union Territory inlevel as a whole in Jammu and Kashmir, the annual production trade of fresh and dry fruits of this species even single block of Mathwar of Jammu and Kashmir has been estimated to the tune of 350 tonnes and 15-20 tonnes respectively (Choudhary *et al*., 3). The expected economic returns from this superior germplasms has been estimated to be much higher (Rs 593750 per ha) than many other horticultural crops (Choudhary *et al*., 3).

Terminalia chebula have a trade name of *chebulic myrobalan*, belongs to family Combretaceae and is found throughout South and Southeast Asia. In India, it is mainly found in Himachal Pradesh, Kerala, Karnataka, Maharashtra, Uttar Pradesh, Haryana,

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Punjab, Uttrakhand, North-eastern states, Gujarat, Assam and Jammu and Kashmir (Chander and Chauhan, 2). In Jammu and Kashmir, it is found in sub-tropical forests ranging from 300 to 1630 m (Sharma *et al*., 9). This is most suited fruit plant for rainfed and kandi areas where it is difficult to grow many other horticultural trees due to scarcity of water. The edible part of the fruit possesses 10.3 times more Vitamic C, 15.4% more proteins and three times more energy value than apple (Barthakur and Arnold, 1). The fruits are rich in tannin and used in leather industry for tanning. The fruits also possess medicinal value. The fruits are an important constituent of 'Triphala' (a medicinal digestive stew) and used in many Ayurvedic medicine to treat flatulence, dyspepsia, liver and spleen disorders, constipation, cancer, and cardio-vascular diseases like ulcers, leprosy, arthritis, gout and epilepsy (Suryaprakash*et al*., 10). It has been reported as antioxidant, antidiabetic, antibacterial, antiviral, antifungal, anticancerous, antiulcer and antimutagenic (Kannan *et al*., 4). This species also plays an important role in our export earnings due to its export to Pakistan and other foreign countries for murraba (Choudhary *et al*., 3). Unlike many other horticultural species, this tree not only provide fruits but also lopped as fodder for livestock during winter when other green fodder is very scarce in this region. Major advantage of this species is that fruits after drying have longer shelf life (usually more than one year) than the fruits of many contemporary species. Thus farmers have more flexibility in storing its fruits till the reasonable prices are obtained.

Notwithstanding the importance of the above-said superior genotype of this species, the studies its performance with respect to tree and yield attributes at farmers' field level are non-existent. Inspite of its considerable export from Jammu and Kashmir to Pakistan and Gulf countries, the knowledge of marketing potential of both its grafted (improved) *vis-a vis* naturally grown (non-grafted) plants is non-existent. Thusto encourage its large scale cultivation, field performance investigations to compare the tree and yield attributes, and marketing avenues of improved and that growing natural (non-grafted) *harad* were undertaken.

MATERIALS AND METHODS

The present study was conducted in Jammu district of Jammu and Kashmir as the maximum numbers of *harad* growers were present in this district. The average annual rainfall at the site is about 1000-1200 mm, 75-80 percent of which is received during July to September and rest 20-25 per cent during winter months of December to January. The maximum temperature rises upto 45°C in May and June and minimum falls to 1°C during winter. Three villages of Jammu district namely Manwal, Ranjan and Mathwar were purposely selected as the farmers in these villages grew both improved (grafted) and and non-grafted (naturally growing) *harad* (Plate 1).

In case of improved plants, the scion was taken from superior mother tree as selected by Salim et. al. (8). In the present investigation grafted plants were compared with non-grafted (naturally growing) to estimate the growth and yield parameters. Trees were grouped into different categories: i. Improved (5-10 years old) and ii. Improved (10-15 years old) and iii naturally growing (15-20 years old). Trees in each group were marked and from each group ten trees using simple random sampling were selected and analyzed for different parameters: tree parameters (height, diameter, crown spread) and fruit parameters (fruit length, fruit diameter, fresh fruit weight, fresh pulp weight and dry fruit weight, fruit yield per tree, fruit productivity). The fruit parameters were measured in the laboratory of Division of Agroforestry of Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu at Chatha of Jammu. The pulp and seeds (left after removing the pulp) of 10 fruits per tree were dried separately in oven at 80°C for 48 hours. The dry pulp and seed weight for each sample was determined by weighing these dried samples using digital balance. The dry pulp weight and dry seed weight of each

Plate 1. *Harad* plantations in a study village

sample was added to get the average dry fruit weight of the respective sample. The data, generated from the present investigations were analysed statistically using OPSTAT statistical software. The dbh is the diameter of trees measured as breast height (1.37 m above ground level).

The data regarding marketing of *harad* fruits were collected by by interviewing the farmers as well as different market functionaries directly. Relevant primary data were collected with the help of a pre-tested, well designed interview schedule. This was supplemented with secondary data. Marketing cost, marketing margin and price spread was calculated on per quintal basis. Producer's share (PS) in consumer rupee and marketing efficiency was calculated by using following formula: PS= Price received by producer/Price paid by consumer ×100.

RESULTS AND DISCUSSION

Cultivation of *Harad* has received impetus due to various nutrient contents in fruits (Table 1). The characteristics of present genotype of *harad* with longer fruit length and diameter as well as high pulp content makes it ideal for preparation of preserves and pickles.

The results obtained after analysis of variance for various tree parameters in different age groups have been presented in Table 2. There were significant differences between dbh, height and crown spread of different type of plants. Diameter of natural growing trees was 17.3 cm which was significantly higher than 15.7 cm in improved (10-15 years) and 11.5 cm in improved (5-10 years) respectively. Within improved, 10-15 years had significantly higher dbh than 5-10 years group. The diameter of natural plants was 10.2% higher than improved (10-15 years) and 39.5% higher than improved (5-10 years). The age of natural growing *harad* was higher as minimum bearing period in this case was 15 years. The height of improved plants 4.6 m and 5.6 m in 5-10 years and 10-15 years group respectively was significantly

Table 1. Characteristics of *Harad* fruits

Characteristics	Value
Moisture content (%)	49.88
Fresh pulp content (%)	75.21
Dry pulp content (%)	24.65
Protein content (%)	2.81
K (%)	1.17
P (%)	0.29
Ca (%)	0.78
Mg (%)	0.22

Table 2. Tree parameters as affected by type of plants

Type of plants	Diameter (dbh) (cm)	Height (m)	Crown spread (m)
Improved (5-10 years)	11.5	4.6	4.8
Improved (10-15 years)	15.7	5.6	6.1
Natural (15-20 years)	17.3	7.5	7.3
$CD_{0.05}$	1.5	0.4	0.4
±SE(m)	0.5	0.1	0.1

lower than that of naturally growing (Table 2). This shows that height of natural plants was 33.9% higher than improved (10-15 years) and 63.0% higher than improved (5-10 years). Within the improved group, 10-15 years had significantly higher height than 5-10 years group. The crown spread of naturally growing plants was 7.3 m which was significantly higher than 6.1m in improved (10-15 years) and 4.8 m in improved (5-10 years) respectively (Table 2). This implies that naturally growing plants had 19.8% and 52.1% crown spread than improved (10-15 years) and improved (5-10 years) respectively. Natural growing plants bearing fruits were older (15-20 years) than both the improved groups (5-10 years and 10-15 years). This was because the bearing in the naturally growing plants fruit bearing started at the age of 15 than improved where bearing took place at an early age of 5 years. This could be due to precocity effect in case improved *harad*. The early bearing is desirable characteristics of any horticultural tree. Both groups of improved plants had significantly lower size (height, dbh and crown spread) than natural growing plants. Hence owing to smaller crown spread and lower height the picking up of fruits of these plants was easy and hence farmers preferred them over the natural. This implies that improved *harad* fulfils the second desirable characteristics of a horticultural tree i.e. lower harvesting height. This all is in consonance with Mng'omba*et al*. (6) who reported that grafting helps in early fruiting and tree dwarfing but in contrast to Khah (5) who reported that grafted plants of aubergine were taller than the non-grafted.

All the studied fruit parameters, yield per tree per year and productivity of different types of plants varied significantly (Table 3). The fruit length of improved (5-10 years) was highest (77.92 mm) and statistically at par with improved 10-15 years (77.77 mm) but both of these were significantly higher than natural (42.83 mm). This shows that fruit length of improved (5-10 years) and improved (10-15 years) were respectively 81.92% and 81.57% higher than the natural (10-15 years). The fruit diameter of improved (5-10 years) was also highest (32.77 mm)

Table 3. Fruit parameters of improved and natural plants

Type of plants	Fruit size (mm)		Fruit weight (g)		Fresh pulp weight (g)	Fruit yield (kg tree^{-1})	Current year productivity (kg ha^{-1}yr^{-1})
	Length	Diameter	Fresh	Dry			
Improved (5-10 years)	77.92	32.77	42.82	21.08	33.38	14.14	1414
Improved (10-15 years)	77.77	32.45	42.57	20.93	33.14	16.76	1676
Natural (15-20 years)	42.83	24.75	17.02	8.14	12.44	11.52	1152
$CD_{0.05}$	1.29	0.83	0.94	0.43	1.22	0.95	95.0
±SE (m)	0.43	0.28	0.31	0.14	0.41	0.32	74.93

which was statically at par with 32.45 mm in improved (10-15 years). The fruit diameters of the both the improved groups were significantly higher than the natural (Table 3). The diameter of improved (5-10 years) and improved (10-15 years) were respectively 32.40% and 31.1% higher than the natural. The fruit fresh and dry weight of both the improved groups were significantly higher than the respective values of the natural group (Table 3). However, there were non-significant differences between between both improved groups for the respective values of fresh and dry weight (Table 3). The fresh fruit weight of improved (5-10 years) and improved (10-15 years) was respectively 151.6% and 150.1% higher than natural. The dry fruit weight of improved (5-10 years) and improved (10-15 years) was respectively 159% and 157% higher than the natural. The fresh pulp weight per fruit of improved (5-10 years) was maximum (33.38 g) which was statistically at par with improved-10-15 years (33.14 g) but both of these were significantly superior to natural (8.14g). The fresh pulp weight of impoved (5-10 years) and improved (10-15 years) was respectively 168.3% and 166.4 higher than the natural. Yield of improved group (10-15 years) was highest (16.76 kg per tree) which was significantly higher than 14.14 kg in improved (5-10 years) and 11.52 kg in the natural trees (Table 3). The fruit productivity (100 trees/ha/ year) follwed the same pattern. The yield (per tree) of the improved (10-15 years) was 45.4% higher than the natural and the yield of improved (5-10 years) was 22.0% higher than the natural. Fruit parameters (fruit length, fruit diameter, fruit fresh weight, fresh pulp weight per fruit) of both the grafted types were statistically at par. This could be attributed to reason that genotype of both the improved groups was the same. Further the fruit parameters both the groups were similar to the superior mother tree selected by Saleem *et al*. (8) from which the scion wood for the present improved plants was obtained. This shows that progeny retained the characteristics of the mother tree being true to type obtained vegetatively through grafting. Lavah*et al*. (1995) also did not find different between traits of grafted plants of Avocado and Mango and their respective mother trees. In current study, the maximum fruit yield per plant and productivity per hectare was observed in grafted plants of 10-15 years age-group followed by grafted trees of 5-10 years age-group. Higher yield in former group could be due to its higher crown spread owing to older plants. Minimum yield and productivity was observed in non-grafted plants of 15-20 years age-group in spite of the largest crown spread in this group. This could be attributed to significantly smaller sized fruits in this group than both the grafted groups leading to lower yield (quantity) per tree. Khah (5) also reported an increase in fruit yield in grafted Aubergine plants compared to non-grafted. Improvement in fruit productivity and fruit yield by grafting in different rootstock has also been reported by Lavah *et al*. (1995) in Avocado and Mango.

Harad being a forest species, had many restrictions in its harvesting, transport and marketing consequently a lot of intermediaries were involved in its marketing who were specialised in fulfilling the legal formalities to ease out marketing. This marketing channel was: producer - pre-harvesting contractor - forwarding agent - wholeseller/ market (Fig 1). In this channel *Terminalia chebula* grower sold his produce to the pre-harvesting contractor who acted as a bridge between producer and forwarding agent.

The price received by the farmers for improved *harad* was Rs. 4500 per/q which was nine times higher than price of Rs. 500/q received for fruits from naturally growing *harad* plants (Table 4). The expenses incurred by the farmers were nil for both the improved and natural as the pre-harvested contractors themselves harvested the fruits on their own cost and paid to farmers on the basis of weight of harvested fruits.

The price for improved *harad* received by farmers in current study was much higher than price of Rs. 1200/q to Rs. 3500/q reported by Chander and Chauhan (2). This could be attributed large sized

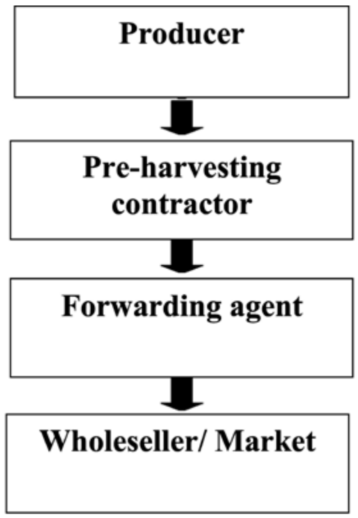

Fig. 1. Marketing Channels of *Terminalia chebula* fruits

fruits in improved *harad* fruits in the current study. The net margins for the pre-harvest contractors were Rs 2354.0/q for improved which was 9.3 times higher than Rs. 254/q received for fruits of naturally growing *harad* trees. The net margins of forwarding agent was 6.0 times in improved group than the natural *harad* (Table 4). Overall total net margin was Rs 4754.00/q for improved than 654.0/q in natural *harad* (Table 4). This implies that overall net margins for improved *harad* were 7.3 times higher than the natural ones. The price spread was also higher (Rs 14000/q) in improved than the natural (Rs. 800). In case improved hard and natural *harad* trees, the share of income received by the producer was highest than forwarding agent and pre-harvest contactors respectively (Fig. 2-3). The share of the farmers was highest (48.36%) in case of improved

Table 4. Price spread and marketing efficiency improved and natural *harad* fruits

Particulars	Cost (Rs./q)		Percentage to consumers rupee	
	Non-grafted	Grafted	Non-grafted	Grafted
Farmers level				
Price received	500.00	4500.00	38.46	24.32
Expenses incurred	00	00	-------	-------
Net price received	500.00	4500.00	38.46	24.32
Pre-harvesting contractor level				
Purchase price	500.00	4500.00	38.46	24.32
Picking cost	20.00	20.00	1.54	0.11
Gunny bag cost	10.00	10.00	0.77	0.05
Transportation cost	11.00	11.00	0.85	0.06
Loading and unloading cost	5.00	5.00	0.38	0.03
Reduced weight cost	-	9000.00	-	48.65
Labour charges	-	100.00	-	0.54
Total expenses	46.00	9146.00	3.54	49.44
Net margins	254.00	2354.00	19.54	12.72
Forwarding agent level				
Purchase price	800.00	16000.00	61.54	86.45
Transportation cost	50.00	50.00	3.85	0.27
Total expenses	50.00	50.00	3.85	0.27
Net margins	400.00	2400.00	30.76	10.80
Wholesalers level				
Purchase price	1300.00	18500.00	100	100
Total marketing cost	96.00	9196.00	7.38	
Total marketing margins	654.00	4754.00	50.30	25.70
Price spread	800.00	14000.00	61.54	75.67
Producer share in consumers rupee	38.46	24.32	-	-

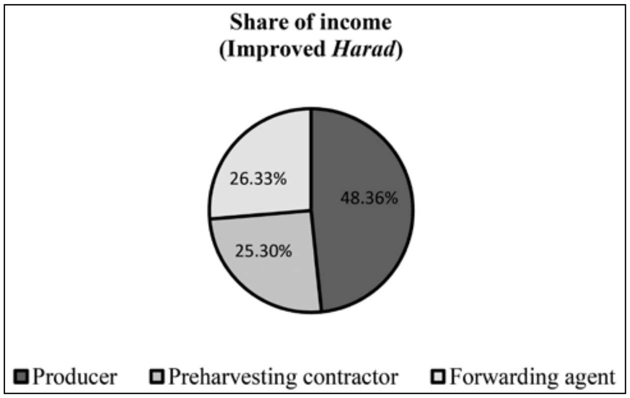

Fig. 2. Share of income of different stakeholder in marketing of improved *harad*

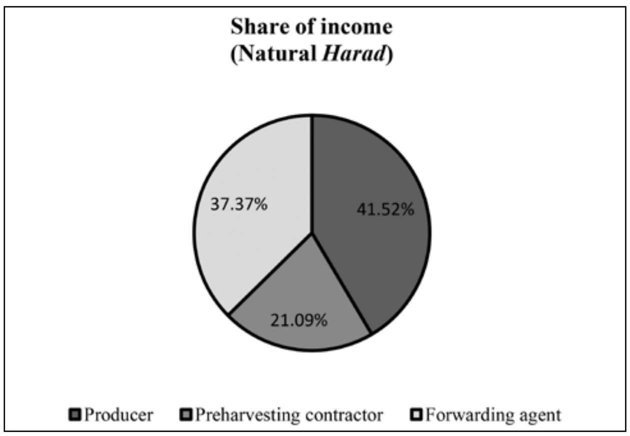

Fig. 3. Share of income of different stakeholder in marketing of improved *and* natural *harad*

than natural (41.52%) harad. Producer share in consumer's rupee was higher (38.46%) in fruits of naturally growing *harad* than that of improved harad (32.24%). Similar results were reported in pomegranate in middle Gujarat by Pundir and Patel (7). The price received by the farmers, net margins for pre-harvest contractors and forwarding agents were higher for improved *harad* than natural. Notwithstanding a considerable portion of the total margins was eked out by these intermediateries which reduced farmers share in consumers' rupee.

The improved plants had early fruiting period, lower fruit set heights and crowns, larger sized fruits, higher yield per tree, higher market price and higher margins for all intermediaries and hence suitable for domestication as horticultural tree. The intermediaries involved in marketing of *harad* fruits have eked out farmer's share in consumer rupee. Thus government should lift the restrictive legal regimes on this species so as to remove the intermediaries and increase farmers' share in consumers' rupee. This will help ultilising farmers' enthusiam to cultivate and domesticate this species to increase their income.

AUTHORS' CONTRIBUTION

Conceptualization of research (VS, KKS, NSR); Experimental layout and sampling design (NS, KKS, SS); Sampling, measurements of parameters and collection of field data (VS, SS); Data tabulation and analysis and interpretation (SS, VS, NSR); Preparation of manuscript (KKS, NSR, SS).

DECLARATION

No potential conflict of interest was reported by the author.

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