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Agromorphological characterization of almond in North-Western Himalayan region of Kashmir

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Abstract
Almond (*Prunus dulcis*) is among the most popular nut trees. The present study was carried out on 214 almond trees of seedling origin to check the variation in tree characteristics by UPOV (International union for protection of new varieties of plants) and PPV & FRA (Protection of Plant Varieties and Farmer's Rights Authority) guidelines. Significant variability was observed in different genotypes with respect to tree characteristics. The most of the genotypes were strong (92) or intermediate (91) with respect to tree vigor, the higher percentage being that of strong (42.99%) followed by intermediate (42.52%). Out of 214 studied genotypes 87 genotypes were "upright to spreading" in their growth habit behavior this number was followed by the genotypes having spreading (62) type of growth habit. The branching behavior was mostly intermediate (41.12%) or dense (40.65%). This variation suggests the presence of great genetic pool of almond in Kashmir and suggesting the use of this pool for future breeding programme.

Keywords: Agromorphological characterization, almond, *Prunus dulcis*

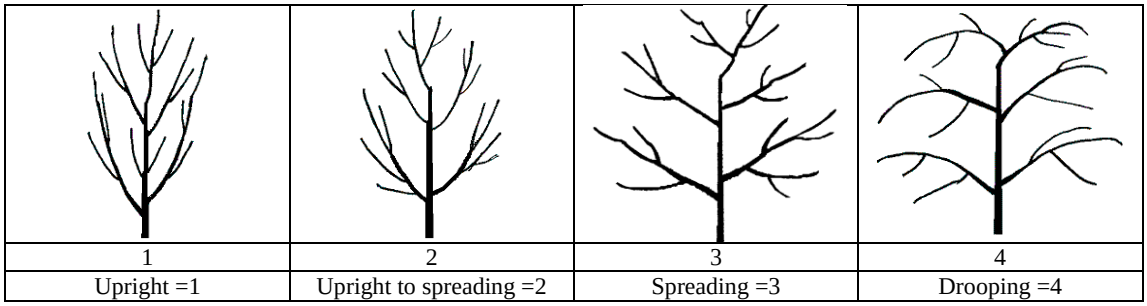
Introduction
Almond (*Prunus dulcis* Miller [D.A. Webb] syn *Prunus amygdalus* Batsch) vernacularly '*Badam'* is a deciduous nut fruit really savored around the world. It has the privilege of being the choicest dry fruit not only due to taste and nutritional benefits but also due to its magnificent phenotypic character like tree serenity, nut/kernel shape and the beautiful flowers, leaves etc. It is an edible seeded nut belonging to family Rosaceae with its origin Southwestern Asia. The Rosaceae family is one of the most important plant families in the temperate regions and contains several important commercial species, such as apple, apricot, plum, sweet cherry, sour cherry, almond, and strawberries. It is a valuable nut native to temperate and sub-tropical regions of the world (Kester *et al.*, 1993) [5]. Almonds receive great attention around the globe due to their wide food, medicinal, and cosmetic applications (Ozcan *et al.*, 2020) [6]. Cultivated almonds (*Prunus dulcis*) are one of the most important perennial fruit trees. According to FOA statistics 2020 the top 10 almond producing countries are United States of America (2370021 tonnes), Spain (416950 tonnes), Australia (221886 tonnes), Iran (Islamic Republic of) (164348 tonnes), Turkey (159187 tonnes), Morocco (134436 tonnes), Syrian Arab Republic (123017 tonnes), Italy (80520 tonnes), Tunisia (62000 tonnes) and Algeria (60832 tonnes). In India, almond agriculture is concentrated in the hilly regions of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh, but Kashmir retains the distinction of being the country's almond heartland. The Kashmir valley's dry fruits, particularly almond and walnut, are world-renowned and exported to different parts of the world. The goal of this study was to assess, identify, and characterise historic almond genotypes in the North-western Himalayan region of Kashmir from an agromorphological standpoint in order to prevent their extinction and to incorporate them in future almond breeding projects.

Materials and Methods
Study Area and plant material selection
A preliminary survey was carried in two major almond producing districts of Kashmir (*i.e*, Pulwama; 33°37′to 34°06′ N and Budgam; 74°33′to 75°14′ E) made in the selected districts wherein the data for the good yielding types was collected. Based on this preliminary survey; the screening of 268 high yielding and expected late booming diverse genotypes was made during 2018. After on-spot rejection only 214 (including three checks) promising genotypes were marked out for further studies.

Agromorphological characterization

The characterization of the genotypes for diversity analysis at phenotypic level was carried out as per the UPOV (International union for protection of new varieties of plants) and PPV & FRA (Protection of Plant Varieties and Farmer's Rights Authority) guidelines published in 2011 and 2012 respectively and recently modified in 2019 as follows:

Tree characteristics like tree vigour, tree habit and ramification (method of branching) were made during dormancy. Tree vigour was checked during the November and December months. It was characterized as weak, medium, strong and very strong and was rated as per descriptor as, Weak = 3, Intermediate = 5 and Strong = 7. Similarly during November and December, tree growth habit was measured in terms of extent of the canopy in two different directions i.e. East-West and North- South and was graded accordingly as Upright =1, Upright to spreading =2, Spreading =3 and Drooping =4.



1	2	3	4
Upright =1	Upright to spreading =2	Spreading =3	Drooping =4

Method of branching (ramification) from sparse to dense was graded according to the classification of the descriptor mentioned as sparse = 3, intermediate = 5 and dense = 7.

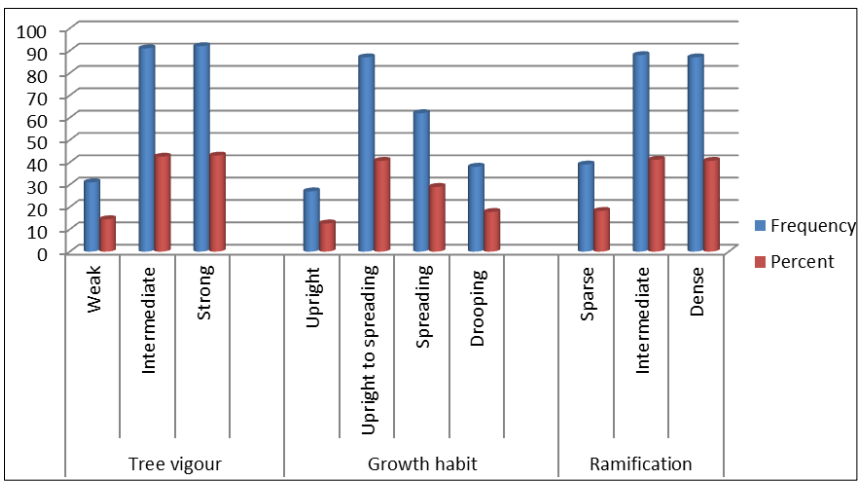
The hull which covers the nut splits along the suture in the month of August/September in the valley. Harvested date from the reference date for harvest (RDH = 1st August) was recorded when 50% splitting of the hull. The nuts harvested before 10th of August were considered as very early. Accordingly the harvested dates between; 11-20 August, 21-30 August, 31 August - 9 September and over 10 September were considered early, mid, late and very late respectively. The notes for these descriptors are; (a) before 10th Aug (Very Early) = 1, (b) 11th to 20th Aug (Early) = 3, (c) 21st to 30th Aug (Medium) =5, (d) 31st Aug to 9th Sept (Late) =7 and (e) after 10th Sept (Very Late) =9. Based on the personal scores the frequencies of different values were calculated.

Results

The mean descriptive data of various tree characters *viz*., tree vigour, growth habit and ramification are presented in table 1. It is evident from table 1and graph 1, that most of the genotypes were either intermediate (91) or strong (92) with respect to tree vigor, the higher percentage being that of strong (42.99%) followed by intermediate (42.52%) and the lowest being of weak (14.49%). It was also found that out of 214 studied genotypes 87 genotypes were "upright to spreading" in their growth habit behavior this number was followed by the genotypes having spreading (62) type of growth habit and then drooping (38) and lowest (27) were the upright type of plants. The branching behavior was mostly intermediate or dense; the two types constituted 41.12% and 40.65% respectively of the total studied genotypes the meager rest 18.22% of the genotypes studied possess sparse type branching behavior.

Table 1: Frequency distribution of tree characteristics of various almond (*Prunus dulcis*) genotypes

Parameter	Tree vigour			Total	Growth habit				Total	Ramification			Total
Responses	Weak (3)	Intermediate (5)	Strong (7)		Upright (1)	Upright to spreading (2)	Spreading (3)	Drooping (4)		Sparse (3)	Intermediate (5)	Dense (7)	
Frequency	31	91	92	214	27	87	62	38	214	39	88	87	214
Percent	14.49	42.52	42.99	100.0%	12.62	40.65	28.97	17.76	100.0%	18.22	41.12	40.65	100.0%
Cumulative Frequency	31	122	214		27	114	176	214		39	127	214	



Graph 1: Tree parameters

Discussion

The almond is a popular fruit tree grown for its commercial value in temperate climates around the world. One of the richest and most diverse gene pools of cultivated almonds is found in the Northwestern Himalayan region. Jammu and Kashmir also possesses genetically rich almond germplasm locations. Because almost all almond trees in these places were historically propagated by seed, the almond population in these areas has a wide range of morphological and genetic variety. The current study took place in Pulwama and Budgam, two of the Kashmir's most prominent almond-growing districts.

Tree size is a relative term that is affected by factors such as tree age, site (climate and soil), management (irrigation, fertiliser, and pruning) and in particular the genotypic strength. Early bearing and productivity can have an impact on vigor. Kester and Gradziel (1996) [4] and Vargas *et al*. (2008) [9] found that trees like the 'Merced' or 'Tarraco' slow down with age, partially due to precocious production, whilst trees like the 'Nonpareil' or 'Vairo' keep their vitality, resulting in larger and more prolific trees. Gradziel and Lampinen (2011) [3] found that large almond trees with open branch architecture offer a clear yield advantage especially in young trees. Sarvisé and Socias I Company (2005) [7] found a link between tree growth and bearing habit and vegetative growth and flower bud development. These finding are in accordance with Vargas and Romero (1994) [10] as were studied for Spanish cultivars. The variation in the tree architecture is significant because the natural tree habit is genetically controlled (Wit-I-de *et al*. 2000) [11] and tree habit is considered critical to choose the right parents for a breeding programme. This variation observed in the tree vigour and growth habit could be due to genetic makeup, age, soil fertility and environmental conditions. Wit-I-de *et al*. (2000) [11] speculated that the degree of acrotony is influenced by the progeny as well as the development habit. Vargas and Romero (1994) [10] found that majority of the types had great vigour, medium to medium upright tree habit, and medium branching density. Similarly Sharma (1999) [8] in a variability study on seedling origin of walnut found semierect (20%), semi spreading (25%) and spreading (47.50%). Giordani *et al*. (2016) [2] also found similar results were working on almond accessions in Afghanistan.

Conclusion

The agromorphological characteristics of vast number of 214 selections (selected based on past performances) of almond genotypes growing in the north-western Himalayan region of Kashmir, all of which are clearly in decline or on the verge of extinction, were studied. Genotypes studied were found diverse in tree characteristics. The diversity among the almond genotypes in the Kashmir therefore suggested that these promising seedling almond genotypes can be used for further breeding programmes in Jammu and Kashmir in order to increase production and productivity of better quality almond nuts.

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