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Variability for Phenological Traits and Fruit Yield Attributes in Bael (*Aegle marmelos* Correa) Cultivars under Semi-Arid Conditions

Mukesh KUMAR[1*] Sushil SHARMA[2] Manoj KUMAR[3] Amarjeet NIBHORIA[4] Bijender Singh YADAV[5]

[1] Department of Horticulture, CCS Haryana Agricultural University, COA, Bawal (Rewari)-123501
[2] Department of Horticulture, CCS Haryana Agricultural University, Hisar-125004
[3] Department of Plant Pathology, CCS Haryana Agricultural University, RRS, Bawal (Rewari)-123501
[4] Department of Agronomy, CCS Haryana Agricultural University, RRS, Bawal (Rewari)-123501
[5] Department of Fruit Science, Maharana Pratap Horticultural University (MHU), Karnal-132001

[*] Corresponding author e-mail: sabharwalmk@gmail.com

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ABSTRACT

The study on evaluation of bael cultivars for phenology, fruit set, fruit drop, fruit shape and fruit yield was conducted at Experimental Orchard, CCS HAU, Regional Research Station, Bawal (Rewari). Among phenological parameters, leaf bud burst was recorded earliest (30 April) in NB 16, while it was late (12 May) in NB 5. The initiation of flowering was recorded earliest (19 June) in NB 5, while it was late (12 July) in NB 17. Time taken for expansion of leaf in different genotypes ranged from 67 days (NB 5) to 85 days (NB 16). Flowering to fruit setting took less time (45 days) in CISHB 2, however, it took more time (63 days) in NB 9. Time taken from fruit setting to fruit maturity was observed least (224 days) in NB 16. It was at par with NB 17 (229 days) and Pant Aparna (229 days), while maximum time taken from fruit setting to fruit maturity (242 days) was recorded in NB 5. Time taken to complete leaf fall was recorded minimum (336 days) in CISHB 1. However, maximum time taken to complete leaf fall (345 days) was recorded in NB 5. The range of fruit set per cent varied from 11.48 % (Pant Sujata) to 18.35 % (NB 17). Fruit drop among different cultivars ranged from 88.33 to 92.67 %. It was lowest in NB 5 and highest in Pant Aparna. Fruit apex and base of cultivars varied as shallow, flattened and depressed, whereas shape varied as round, ovate, globose and elliptical.

Keywords: Bael (*Aegle marmelos*), fruit crack, fruit drop, fruit shape, germplasm, phenology, yield

Introduction

Bael (*Aegle marmelos* Correa) is one of the important underutilized medicinal, indigenous fruit crops of India. It can adapt a wide range of habitat therefore spread over different parts of the country. Plant shows enormous variability with respect to qualitative as well as quantitative characters. Apart from the tree morphological characters, wide variability exists in size and shape, bearing habit, flesh colour and texture of fruit (Misra et al., 2000). The wider genetic variability is priority of breeders to develop new variety(s) with better quality and higher production. The erosion of plant genetic resources results in a severe threat to the world's food security. In recent statistics the area under bael is 8320 ha and production 82260 MT (Anonymous, 2021).

Normally, the fruits are considered mature after litter fall at yellowish-green stage. Therefore, fruits are harvested after litter fall and kept for one week so that it loses green tint. A ripe bael fruit has great demand in market for therapeutic use. Beverages prepared from fruit pulp during summer give smothering and cooling effect. Besides, it is a good source of vitamins, minerals, alkaloids and steroids (Kumar et al., 2013). The bael fruit juice is useful to release the stomach problems and also provide cooling effect to brain (Arya et al., 2021).

Recently, few land races have been developed for commercial cultivation from NDUA&T, Faizabad; GBPUAT, Pantnagar; CISH, Lucknow; Regional Station, IARI, Samastipur, but their adaptability under different arid and semi-arid conditions has not been studied adequately. In order to identify distinct characters of various bael cultivars, the morphological characters are equally important. Bael gene pool with enormous variability with respect to qualitative as well as quantitative characters is spread over different parts of the country (Nagar et al., 2018). Identification of suitable genotypes for arid and semi-arid region is demand of time for better production, productivity and quality of the fruits. The evaluation of different cultivars will help the orchardist in selection of appropriate cultivar(s) of this neglected crop for large scale adoption. Unproductive land races of this region are being grown by orchardist due to their hardy nature. It holds promise for nutritional security and also helpful in curing various ailments.

Materials and Methods

The experiment on evaluation of bael cultivars *viz.,* NB 5, NB 9, NB 16, NB 17 collected from NDUA&T, Faizabad; Pant Aparna, Pant Sujata collected from GBPUAT, Pantnagar; and CISHB 1, CISHB 2 collected from CISH, Lucknow was carried out at Experimental Orchard, CCS HAU, RRS, Bawal. The experiment was laid out in a randomized block design. Twelve years old, uniformly grown trees were selected randomly and maintained under uniform conditions of orchard management practices during the study period, where all the agronomic practices were carried out as per recommended package of practices. This location has a typical semi-arid climate with hot and dry summer and extremely cold winter. The mean monthly maximum temperature during summer months (June, July) ranged from 44 to 47ºC, while minimum temperatures as low as freezing point during winter months (December, January). About 65-70 per cent of total rainfall is received during July to September.

Different cultivars were observed for variability in dates of appearance of leaf. It was observed with naked eyes and the average of dates of leaf bud burst or sprout was calculated. Leaf expansion period was measured by counting the days from date of leaf bud bursts to the date of leaf becomes fully mature. Unpleasant smell produced from bruised leaf was considered as indication of mature leaf. Days taken to leaf fall were calculated as period from date of leaf bud burst to the date of complete leaf fall and its average was calculated.

The branches of plants were tagged in different directions to observe the date of initiation of flowering. Date of 50% flower opening on each tagged branch was considered as date of initiation of flowering and their average was considered as a date of initiation of flowering. The average of time taken to open 50 per cent flowers on each tagged branch to 50% fruit setting was taken as days to fruit setting. The period from 50 per cent fruit setting on each tagged branch to the date of complete leaf fall was considered as a time taken (days) from fruit setting to fruit maturity.

The fruit set per cent was calculated as fruits developed out of total number of flowers on tagged branches and average fruit set was calculated. Fruit drop was calculated as fruits dropped out of total fruits set. The fruits dropped from fruit setting to the harvesting were added at weekly interval. Splitting of fruit bark or formation of cracks on the outer surface of the fruit were counted in the fruit crack. The cracked fruits were also calculated by counting cracked fruits from fruit set to harvesting of fruits out of total fruit set on the plant. Some fruits dropped due to cracking were counted in cracked as well as dropped fruits. The fruit yield per plant was calculated by adding the weight of fruits harvested in each picking. Fruit shape *viz.,* fruit apex, fruit base and fruit shape of different bael cultivars were observed by matching with the standards figures available in the descriptors of bael crop.

In order to evaluate comparative performance of the various treatments, the data were analyzed by the techniques of analysis of variance described by Fisher (1958). The statistical method described by Panse and Sukatme (1967) was followed for analysis and interpretation of the experimental results. The test of significance was worked out at 5 per cent level of the significance and results were compared by critical difference (CD).

Results and Discussion

Phenological parameters: The data collected from various genotypes of bael planted at CCS HAU, RRS, Bawal during 2007 under semi-arid region of Haryana revealed that the genotypes varied in different life cycle events (Table 1). It was observed from the data, leaf bud burst was recorded earliest (30 April) in NB 16, followed by CISHB 1 (4 May) and Pant Aparna (5 May), however, it was recorded late (12 May) in NB 5. The initiation of flowering was recorded earliest (19 June) in NB 5; followed by NB 9 and CISHB 1, whereas it was observed late (12 July) in NB 17. The variation in duration of flowering might be due to variability in genetic make-up of the particular germplasm. Mazumdar et al., (2006) observed flowering in bael during May and June.

Time taken for expansion of leaf in different cultivars ranged from 67 days to 85 days. Minimum time taken for expansion of leaf (67 days) was observed in NB 5, it was at par with Pant Sujata (73 days), however, highest leaf expansion period was observed (85 days) in NB 16, which was at par with NB 17 (83 days) and Pant Aparna (80 days). Minimum time taken from flowering to fruit setting (45 days) was recorded in CISHB 2, which was at par with NB 17, however, the highest time taken from flowering to fruit setting (63 days) was observed in NB 9, which was at par with NB 5. The variability in time taken from flowering to fruit setting may be due to variation in flowering behavior of the germplasm. The variation in different characters of germplasm may vary with genotypes and agro-climatic conditions also (Singh et al., 2011). The variation in these parameters shows the performance of these cultivars under semi-arid conditions. The reason of the variation may be due to genetic make-up, adaption of germplasm, variability in agro-climatic conditions. More or less similar results have been obtained with respect to variation in phenology of various bael genotypes (Singh et al., 2006). Flower bud emergence, flowering duration, time of anthesis, dehiscence of anther, stigma receptivity and pollen viability vary with variety and locality (Srivastava and Singh, 2000). Generally, flower bud emergence takes place in the month of April and flowering in full bloom stage appears in the month of May under hot semi-arid ecosystem of western India (Singh et al., 2008). Among different bael genotypes *viz*., CISH Bael-1, CISH Bael-2, NB 5, NB 7, NB 9, Pant Aparna, Pant Sujata, Pant Urvashi, Pant Siwani, Dhara Road and PB 1 under Gujarat conditions the earliest flower bud emergence was observed in CISHB 2 (30 April), whereas it was delayed in CISHB 1 and PB 1 (6 May), however, the flower bud emergence continued till last week of June. Similar findings have also been reported in other fruit crops like jamun (Singh and Singh, 2005).

Time taken from fruit setting to maturity was least (224 days) in NB 16, it was at par with NB 17 as well as Pant Aparna (229 days), while maximum time taken from fruit setting to fruit maturity (242 days) was recorded in NB 5. Time taken to complete leaf fall ranged from 336 days to 345 days (Table 1). Maximum time taken to complete leaf fall (345 days) was observed in NB 5, however, minimum time taken to complete leaf fall (336 days) was recorded in CISHB 1 and it was statistically at par with NB 16 and Pant Aparna. The maturity of the fruits may vary with the ripening behavior of the germplasm.

Fruit set, drop, cracks and yield: There was significant variation in fruit set per cent among different genotypes (Table 2). The range of fruit set per cent was varied from 11.48 per cent to 18.35 per cent (Table 2). The highest fruit set percent (18.35 %) was recorded in NB 17, it was statistically at par with CISHB 1 (17.58 %), while lower fruit set per cent (11.48 %) was observed in Pant Sujata. This variation in fruit set per cent among various germplasm of bael might be due to their inherent characters. Sometimes fruit set per cent may vary due to agronomic practices and local environmental conditions. However, Uniyal and Misra (2013) reported maximum fruit set in Pant Aparna and minimum fruit set in Pant Shivani.

This study showed a significant variation in fruit drop per cent among different cultivars. It ranged from 80.33 per cent 92.67 per cent. Least fruit drop (80.33%) was observed in NB 5. Fruit drop per cent was significantly higher (92.67%) in Pant Aparna, these values were statistically at par with NB 17 (90.33%), CISHB 1 (91.0%), NB 16 (91.67%) and Pant Sujata (90.33%). However, Uniyal and Misra (2013) reported the maximum fruit drop in Pant Sujata, followed by Pant Uravshi, while minimum fruit drop was observed in Pant Shivani and they reported that fruit drop may be due to embryo abortion. Dropping of fruits due to embryo abortion after fertilization was reported in Litchi by Ray et al., (2002). One of the reasons might be due to deficiency of nutrient especially Ca, Zn, B and K (Choi et al., 2020). The fruit drop may be due to competition among fruit lets for carbohydrates, water, nutrients, hormones and other metabolites (Uniyal and Misra, 2013). Fruit cracking in bael germplasm is also one of the reasons for fruit drop.

Fruit cracking in all the genotypes showed significant variation. Fruit cracking per cent was significantly higher (40.67%) in NB 16 and lowest (5.67%) in NB 5 (Table 2). In young plants, fruit cracking may occur due to boron deficiency but in fully grown tree, it may be due to dry conditions or soil moisture imbalances (Choi et al., 2020). Dhaker et al., (2013) reported that the fruit cracking reduced to 2.14 per cent with spraying of 0.6 per cent of borax. They also reported that the boron is helpful in improving the appropriate growth of bael tree and it is constituent of cell membrane and essential for cell division, which reduces disorders like cracking in fruits. Uniyal and Misra (2013) reported maximum fruit cracking in Pant Sujata, followed by Pant Urvashi, while minimum in Pant Aparna. Wani et al., (2015) reported that fruit cracking in different pomegranate cultivars varying from 6.31% to 31.40% under Kashmir valley conditions. Mean fruit yield was observed highest (63.2 kg/ plant) in NB 9 among different cultivars during the study period, which was at par with NB 5 and NB 17.

However, mean fruit yield was observed lowest (39.8 kg/ plant) in Pant Sujata, it might be due to less fruit set percent and more fruit drop. Variation in qualitative attributes of different germplasm at different locations might be due to adaptability to varied agroclimatic conditions, root distribution pattern of the crop and genetic make-up of the germplasm (Nagar et al., 2017). Increase in yield might be due to the specific climatic requirement of the variety and the genetic makeup of the cultivar (Kumar et al., 2021).

Fruit shape: Fruit shape of different bael genotypes exhibit wide range of genetic variability. The results pertaining to variation in fruit shape such as fruit apex, fruit base (shallow, flattened and depressed), fruit shape (round, ovate, globose and elliptical) in respect of various cultivars are presented in Figure 1. The fruit apex was observed as shallow in NB 5, CISHB 1, CISHB 2, NB 16; flattened in NB 9 and depressed in NB 17, Pant Aparna and Pant Sujata. The fruit base of cultivars NB 5, CISHB 2 and NB 16 was observed depressed, while in rest of the cultivars it was observed as shallow. There was a great variation in fruit shape of different cultivars. The shapes of different cultivars were observed as ovate (NB 9), globose (NB 17) and elliptical (CISHB 2), whereas, all other cultivars were round in shape. Sharma and Dubey (2013) also observed fruit shape as spherical, oblong, cylindrical, pear-shaped and flat in different cultivars. Variation in fruit shape of different bael cultivars was also observed in Uttar Pradesh and Bihar (Jauhari et al., 1969).

Correlations: Fruit yield is main parameter in all kind of studies in horticultural crops and it relay in several yield contributing traits. The results on fruit yield correlation with its contributing traits are presented in figures 2-4. In the present study, bael fruit yield showed significant positive correlation with fruit setting (%). Above findings were supported by Dahal et al., 2015. But fruit yield was found negatively correlated with fruit drop (%) and fruit creaking (%).

Conclusions

NB 9 and NB 5 cultivars of the bael performed best in terms of different parameters such as fruit drop, fruit yield, fruits cracking as compared to other cultivars. These cultivars can be recommended for commercial cultivation or social forestry in semiarid zone of Haryana.

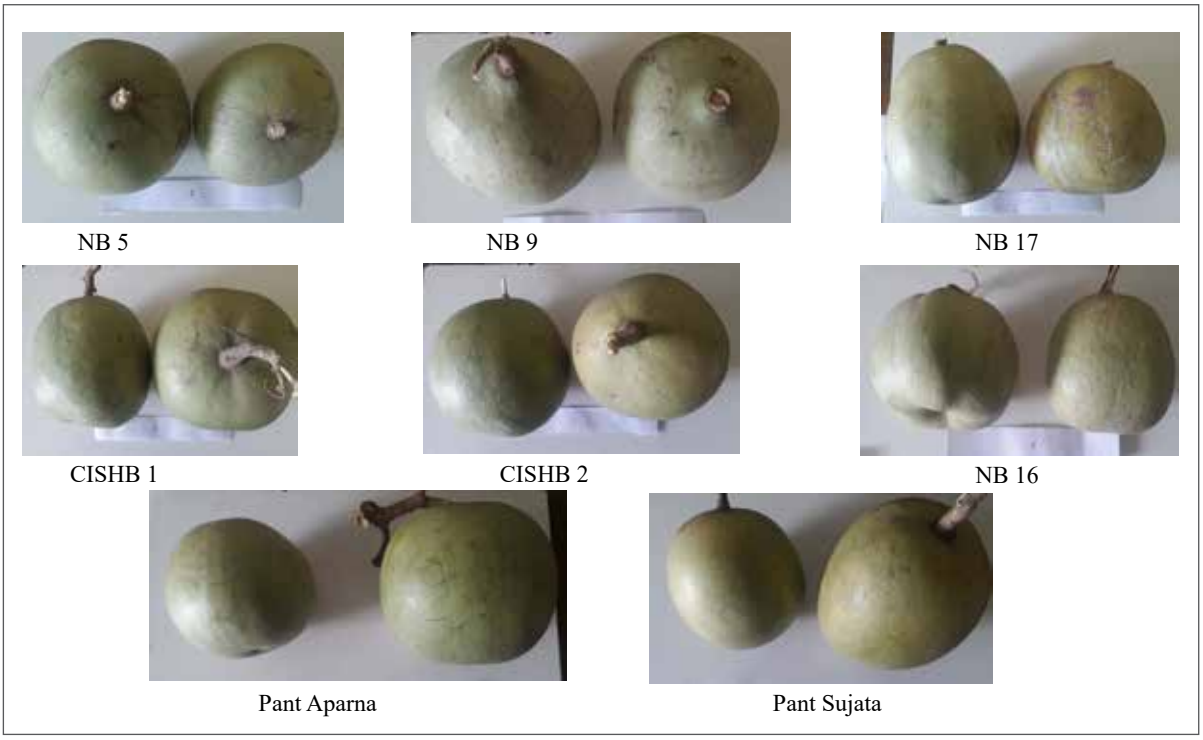

Figure 1. Fruit shape of different bael genotypes. (Original)

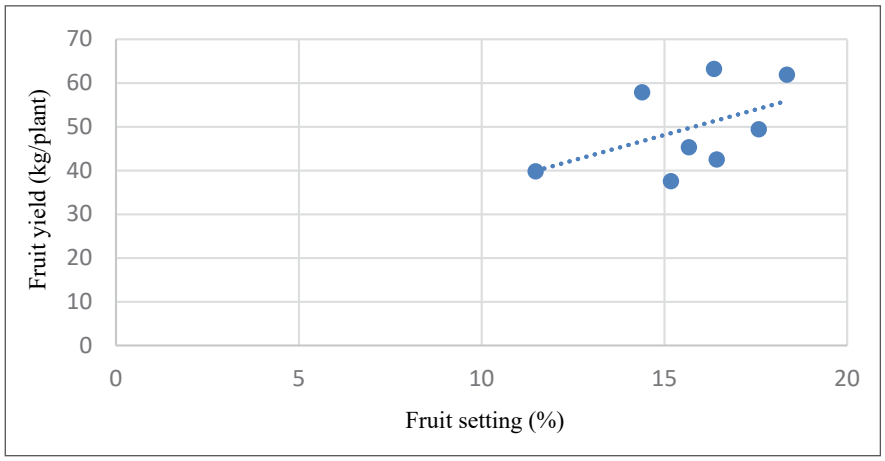

Figure 2. Fruit yield positive association with fruit setting (%).

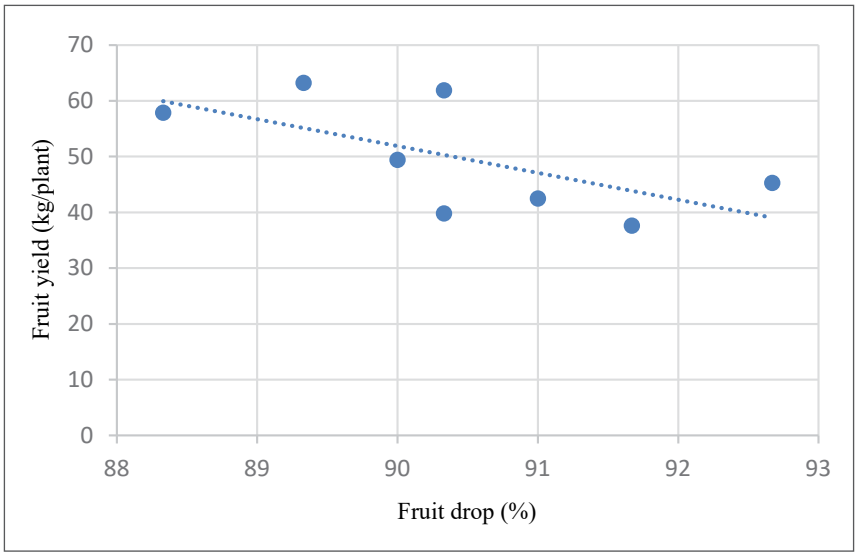

Figure 3. Fruit yield negative association with fruit drop (%).

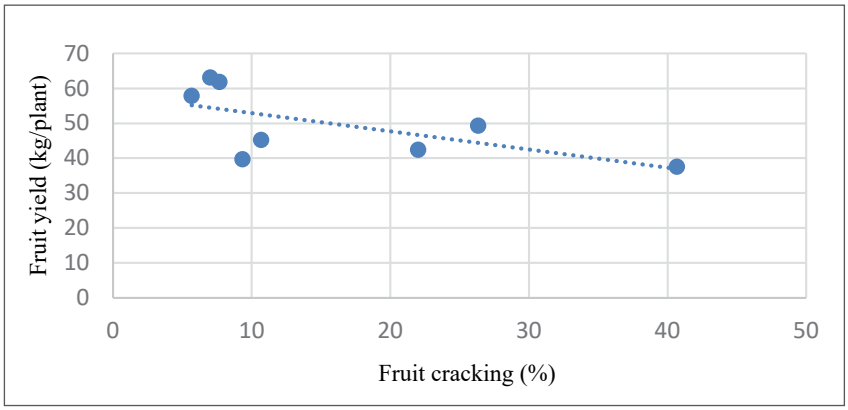

Figure 4. Fruit yield negative association with fruit cracking (%).

Table 1. Phenological parameters of bael cultivars under semi-arid conditions of Haryana.

Cultivars	Date of Leaf Bud Burst	Date of Initiation of Flowering	Leaf Expansion Period (days)	Time Taken From Flowering to Fruit Setting (days)	Time Taken From Fruit Setting to Fruit Maturity (days)	Time Taken to Complete Leaf Fall (days)
NB 5	12 May	19 June	67	60	242	345
NB 9	9 May	22 June	76	63	235	342
NB 17	7 May	12 July	83	47	229	342
CISHB 1	4 May	25 June	75	54	231	336
CISHB 2	6 May	5 July	75	45	235	341
NB 16	30 April	27 June	85	57	224	340
Pant Aparna	5 May	27 June	80	58	229	339
Pant Sujata	10 May	29 June	73	54	237	341
Range	30 April to 12 May	19 June to 12 July	67-85	45-63	224-242	336-345
CD at 5%			6	3	6	4

Table 2. Fruiting and yield character of bael cultivars under semi-arid conditions of Haryana.

Cultivars	Fruit Set (%)	Fruit Drop (%)	Fruit Cracking (%)	2019 (kg/ plant)	2020 (kg/ plant)	2021 (kg/ plant)	Mean (kg/ plant)
NB 5	14.39	88.33	5.67 (13.02) *	55.2	59.9	58.6	57.9
NB 9	16.36	89.33	7.00 (15.37) *	60.1	65.1	64.5	63.2
NB 17	18.35	90.33	7.66 (16.12) *	56.7	65.4	63.6	61.9
CISHB 1	17.58	90.00	26.33 (30.89) *	48.0	51.8	48.3	49.4
CISHB 2	16.43	91.00	22.00 (27.98) *	39.5	44.8	43.1	42.5
NB 16	15.18	91.67	40.67 (39.63) *	37.2	38.1	37.5	37.6
Pant Aparna	15.67	92.67	10.67 (19.10) *	42.2	46.1	47.5	45.3
Pant Sujata	11.48	90.33	9.33 (17.83) *	36.1	40.7	42.6	39.8
Range	11.48-18.35	88.33-92.67	5.67-40.67	36.1-60.1	38.1-65.4	37.5-64.5	39.8-63.2
CD at 5%	1.32	2.46	1.65	3.7	4.7	4.6	4.5

*Values in parenthesis are angular transformed

Table 3. Fruit shape of bael cultivars under semi-arid conditions of Haryana.

Cultivars	Fruit Apex	Fruit Base	Fruit Shape
NB 5	Shallow	Depressed	Round
NB 9	Flattened	Shallow	Ovate
NB 17	Depressed	Shallow	Globose
CISHB 1	Shallow	Shallow	Round
CISHB 2	Shallow	Depressed	Elliptical
NB 16	Shallow	Depressed	Round
Pant Aparna	Depressed	Shallow	Round
Pant Sujata	Depressed	Shallow	Round

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