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Evaluation of drumstick genotypes suitable for semi-arid ecosystem of western India

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ABSTRACT

Drumstick (*Moringa oleifera* Lamk.) is one of the important perennial vegetable grown in India; having almost every part of plant valued for food, but is also enriched with more nutrition and high mineral and vitamins at cheaper inputs. Except its edible pod, no other exploitation has been done in drumstick in India yet, though seed oil (lubricator in delicate machineries, manufacturing of perfumes and hair dressings), seed powder (a water clarifier). Considering the above said facts, an attempt has been made to identify a suitable type for this region through an experiment comprising 14 diverse genotypes were evaluated with three replications in randomized block design. The results revealed a significant difference for all the characters under study. The economically important parameters like fruit length ranged from 32.5 (MO-8) to 123.1 cm (PKM-2), pulp weight ranged from 35.1 to 169.8 g and number of fruit per plant ranged from 78.5 to 314.7. The highest seed weight was observed in Dwarf moringa (12.8 g) having 23.5 seeds per fruit. Drumstick cv. PKM-2 recorded the highest yield of 44.3 kg per tree followed by PKM-1 (36.7 kg) under semi-arid ecosystem of western India.

Key words: Drumstick, evaluation, semi-arid ecosystem, genotype.

INTRODUCTION

In India, the current status on vegetable production (94.0 MT) is capable to supply only 175 g vegetables per capita per day against the recommendation by dietician (300 g). To fulfill the recommended consumption level, 220 MT of vegetables are required to be produced by 2020 to the projected population of 1.5 billion. The threat of shrinking agricultural land ignited an opportunity for crop diversification and a crop with richest nutritional value at cheaper input would be an ideal approach to attain nutritional security for the tropical countries like India, as it is prone to malnourished children. Presently, drumstick is the most widely known perennial drought tolerant vegetable (Palada, 10) for its highly nutritious pods (Ramachandran *et al.*, 16) grown at about 380.5 km^2 area producing 1.1 to 1.3 million tonnes of tender fruits (Rajangam *et al.*, 15). Not only every part of drumstick valued for food, but it is also enriched with more nutrition and high minerals and vitamins. Except its edible pod, no other exploitation has been done in drumsticks in India yet, though seeds oil (lubricator in delicate machineries, manufacturing of perfumes and hairdressings), seed powder (a water clarifier). In recent years, drumstick has established as a stable commercial crop in southern part of India. Considering the food habit and lack of suitable variety for the western and northern part hampered its production, although perennial types are cultivated traditionally despite of small size fruits and slightly bitter taste. Considering the above said facts, an attempt has been made to identify a suitable type of annual drumstick for the semi-arid region of western India.

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MATERIALS AND METHODS

A field experiment was conducted at Central Horticultural Experiment Station, CIAH, Vejalpur. The experimental site is located at 22° 41' 33" and 73° 33' 22" and lies between 110 to 115 m amsl. The annual rainfall is mainly confined to three months (July to September) with an average of 35 rainy days a year. The annual maximum and minimum temperature range from 42 to 43°C in May and 6 to 7°C in January, respectively. The annual potential evapo-transpiration ranged from 1500 to 1600 mm against the annual precipitation of 750 mm. The soils have pH of 6.9 to 7.22, EC of 0.1 to 0.2 dSm^{-1}, and available N ranging from 112.5 to 207 kg/ha, P ranging from 6.75 to 22.05 kg/ha and K ranging from 139.5 to 253.125 kg/ha. Fourteen diverse drumstick genotypes were evaluated in a randomized block design with three replications. The nursery was raised in the month of January and the seedlings were transplanted in the month of July in the main field at a spacing of 5.0 m × 3.0 m. The crop was maintained in good condition by following the recommended package of practices in order to assess the full potential of different genotypes. The observation on different morphological characters *viz.*, plant height (cm), number of branches per plant, height at first branch emergence (cm) , number of flowers per panicle, days to 50% flowering, fruit set (%), fruit weight (g), fruit length (cm), fruit girth (cm), skin weight (g), pulp weight (g), seed weight (g), edible to non edible ratio, number of seed per fruit, number of fruits per plant, yield per plant (kg) were recorded from four randomly selected plants and the average was subjected to statistical analysis of variance (Panse and Sukhatme, 11).

RESULTS AND DISCUSSION

A healthy vegetative growth is an ideal indicator of the plant ability to survive under moisture stress condition in the semiarid ecosystem. In the present study, among the seventeen morphometric parameters studied, all the characters showed significant variation indicating they being influence by the genotype (Table 1). Among the vegetative parameters a wide range of variation was observed in plant height from 303.0 cm in MO-9 to 521.5 cm in Dwarf moringa. Number of branches per plant ranged from 5.7 to 13.5. Dwarf moringa, MO-10, MO-9, MO-12 were observed to be denser by producing 13.5, 12.9, 11.0 and 11.0 branches respectively. The lowest number of branches per plant was observed in MO-8 (5.7). The height at first branch emergence is an ideal character isolating the high yielding genotypes. The genotype MO-5 showed the lowest height for first branch emergence (23.0 cm) followed by Dwarf moringa (29.2 cm) and MO-12 (29.3 cm). On the other hand, MO-6 and MO-13 produced branches at the maximum height of 50.3 and 59.6 cm, respectively. The appreciable performance on vegetative characters may be due to the congenial environment to express the dominant gene in the genotypes. The increase in these characters could be due to higher uptake of nitrogen as it plays a vital role in protoplasm and effect on chlorophyll content of leaves might have increased the synthesis of carbohydrate, amino acids etc from which phyto-hormones have been synthesized resulting increase in vegetative parameters (Maynard and David, 9).

Among the flowering parameters, the earliest flowering was observed in MO-5 at 83.1 days after transplanting, followed by MO-10. Late flowering was recorded in MO-8 and MO-3 at 118.1 and 115.7 days, respectively. The early flowering could be due to more dry matter accumulation, absorption of more N and other nutrients, and nutrient uptake in addition to prevailing favorable environment. Leopold and Kriedemann (8) reported that earliness is an expression of plants to become reproductive with age and many species are amenable to environmental conditions of earliness thus reproductive developments are triggered by such environmental variables like temperature, light and photoperiods. Since the variable change with season, programming of reproductive activities on a seasonal basis become possible. The fruit set percent is a pivotal character, which decides the number of fruits per plant of genotypes and ultimately reflects on yield. Among the genotypes tested in the present study, PKM-1 showed the highest fruit set per cent (3.6) per panicle followed by MO-5 (3.3). Contrary to this, MO-8, MO-3, MO-1, MO-2, MO-12 and MO-13 recorded very less fruit set percent which was observed less than 1.0 per cent. All the genotypes showed significant variation in the initial set of fruits per panicle and the retention found to vary drastically due to drop heavily at later stage under the prevailing environmental conditions. In the present study too, it is obvious from the data that genotype MO-2, MO-12 and Dwarf moringa registered higher number of fruits per panicle at initial stage and found heavy drop at harvestable stage indicating the adjustability of the genotypes to the semi-arid condition.

Analysis of variation revealed that the genotypes PKM-2, Dwarf moringa, MO-3 are superior in respect of fruit weight as compared to other genotypes. The maximum fruit weight of 285.9 g was recorded in PKM-2 followed by Dwarf moringa (218.0 g) against the lowest fruit weight genotype MO-10 (75.9 g). As far as drumstick is concerned, fruit length is an important character, which decides the consumer attraction. The medium fruit length (< 60 cm) is preferred in the local market, where the lengthiest fruit (> 1.0 m) suitable for processing industry. It is understood from the fact that, generally in the western Indian local markets, the lengthier fruits are cut into pieces in the market itself for easy packing, where as it was not prevalent in southern Indian markets. Similarly, too smaller size fruits are also not preferred by the consumers due to non-appealing nature. In the present study, PKM-2 recorded the lengthiest fruit of 123.1cm followed by MO-3. None other variety than PKM-2 reached more than a meter length. The genotypes MO-8, MO-9 and MO-11 produced lower fruit length of 32.5 cm, 51.3 cm and 51.2 cm, respectively. This result is in conformity with findings of Das *et al.* (5) in sapota.

In general, the fruits are characterized with thick exocarp at marketable stage, which is a drawback in chewing or eating the boiled pods with wheat based food preparations (chappatti) in west and northern part of India. On the contrary, if the pods are harvested at early stage to avoid hardness of fruit, the pulp content reduces drastically. However, no such reports in drumstick in relation to variation in the edible to non edible ratio, although many researchers found variation for many quantitative characters (Suthanthirapandian *et al.*, 19). In the present study, the ratio of skin in the pod indicates the lowest in PKM-2 and PKM-1 at 37.4 and 39.6% respectively against the MO-3, MO-5 and

Table 1. Analysis of variance for various horticultural traits of drumstick genotypes under semi-arid ecosystem.

Parameter	Mean sum of squares value								
	df	Plant height (cm)	Number of branch per plant	Height at first branch emergence (cm)	Height at first panicle emergence (cm)	No. of flowers per panicle	Days to 50% flowering (days)	Fruit set (%)	Fruit weight (g)
Replication	2	1.55	0.87	2.39	4.23	4.47	8.87	0.13	3.65
Treatment	13	18951.2**	17.67**	323.5**	537.8**	155.8**	339.0**	3.12**	9031.8**
Error	26	224.9	0.06	2.29	1.70	1.38	3.61	0.26	8.48

Table 1. (Contd...)

Parameter	Mean sum of squares value								
	df	Fruit length (cm)	Fruit girth (cm)	Skin weight (g)	Pulp weight (g)	Seed weight (g)	Edible: non-edible ratio	No. of seeds per fruit	No. of fruits per plant	Yield per plant (kg)
Replication	2	31.44	0.008	24.2	16.2	0.11	0.004	2.75	94.04	0.25
Treatment	13	883.2**	0.43**	2224.0**	2256.7**	5.27**	0.150**	18.66**	9374**	137.3**
Error	26	3.04	0.008	0.66	2.50	0.02	0.002	0.24	73.5	0.52

Table 2. Mean performance of genotypes of drumstick for different morphological characters under semi-arid ecosystem.

Genotype	Plant height (cm)	No. of branches per plant	Height at first branch emergence (cm)	Height at first panicle emergence (cm)	No. of flowers per panicle	Days to 50% flowering (Days)	Fruit set per cent (%)	Fruit weight (g)
MO-1	349.3	5.7	47.5	121.5	79.7	110.6	0.71	134.8
MO-2	433.7	7.9	41.3	89.0	83.3	105.9	0.81	90.5
MO-3	345.2	6.7	46.3	94.7	74.3	115.8	0.59	191.0
PKM-2	412.6	9.2	46.8	89.0	88.3	102.9	2.94	285.9
MO-5	313.6	7.1	23.1	98.9	96.4	83.1	3.38	91.7
MO-6	325.0	9.3	59.7	82.8	90.5	103.2	1.86	156.0
MO-7	356.0	9.6	31.1	73.8	89.6	105.4	1.97	76.9
MO-8	386.4	5.7	47.2	112.1	76.5	118.2	0.58	152.3
MO-9	521.5	11.0	34.3	77.4	94.7	95.4	2.72	93.2
MO-10	271.2	12.9	25.8	79.7	99.3	87.4	1.09	75.9
PKM-1	360.0	9.8	36.3	87.1	86.5	104.9	3.6	145.7
MO-12	424.0	10.9	29.3	80.3	95.4	90.9	0.99	77.1
MO-13	378.3	8.9	50.4	89.7	95.2	94.6	1.80	94.8
D. moringa	303.0	13.5	29.2	70.8	81.4	112.9	0.99	218.0
Mean	362.8	9.1	39.1	88.9	88.0	102.2	1.72	134.5
SE±	4.30	0.20	0.65	0.99	0.95	1.56	0.08	1.19

Table 2. (Contd…)

Genotype	Fruit length (cm)	Fruit girth (cm)	Skin weight (g)	Pulp weight (g)	Seed weight (g)	Edible: non-edible ratio	No. of seeds per fruit	No. of fruits per plant	Yield per plant (kg)
MO-1	81.5	6.2	72.8	55.6	7.9	0.87	18.7	163.7	26.6
MO-2	61.2	5.9	36.3	46.7	7.6	1.49	26.3	210.1	19.5
MO-3	92.7	6.0	99.8	82.4	7.9	0.90	20.8	86.6	23.4
PKM-2	123.1	6.9	106.8	169.8	8.7	1.67	21.5	214.9	44.3
MO-5	60.9	5.7	47.7	37.4	8.8	0.97	20.9	299.9	22.9
MO-6	56.3	5.8	63.5	80.1	8.5	1.40	17.4	249.1	23.6
MO-7	64.4	5.8	33.5	35.1	7.9	1.30	17.5	241.5	22.6
MO-8	32.5	6.7	60.0	77.5	8.2	1.43	17.9	78.5	16.9
MO-9	51.3	5.9	40.8	42.2	7.5	1.22	12.9	278.5	25.7
MO-10	68.0	5.8	32.8	35.5	7.9	1.32	18.4	235.6	19.9
PKM-1	75.8	5.7	62.3	87.3	7.5	1.52	17.3	314.7	36.7
MO-11	51.3	6.0	30.9	37.5	8.9	1.50	15.3	267.8	28.6
MO-12	64.6	6.4	41.4	45.3	7.9	1.29	20.1	219.6	21.5
D. moringa	78.0	6.5	104.3	99.4	12.8	1.07	23.6	125.3	35.2
Mean	68.7	6.0	59.5	66.5	8.4	1.33	19.2	213.3	26.2
SE±	1.07	2.40	0.75	0.83	1.16	0.13	0.40	13.10	0.82

MO-1, which recorded over 50 per cent indicating the suitability of the former genotype categories as the lower value is an advantageous parameter. Similar report has been reported by Akbarpour *et al.* (1) in pomegranate. In addition to skin ratio, there was a difference in the softness of the exocarp in the genotypes observed while cutting them at optimum maturity stage. In the present study, although, the genotype MO-1 recorded the higher skin ratio, it exhibited soft exocarp. The most probable reason for the variation in the softness might be due to nature of fibre solubility and stage of the fruit where conversion of soluble dietary fiber to insoluble dietary fiber fraction such as cellulose and lignin due to maturation (Selvendran and MacDougall, 17). Punna and Paruchuri (14) also supported that drumstick contains more insoluble dietary fibre over soluble dietary fibre in leaves. Barriere *et al.* (2) explained the mechanism of cross linking of cellulose and lignin in deciding the softness due to the existence of three building blocks (H,G,S) in the composition and structure of lignin in within and among plants and lignin units are interconnected primarily through labile β-*O*-4 and β-*O*-4 ether bonds and smaller amounts of so-called "condensed" C-C (β–5, β–β, and 5–5) and biphenyl ether (4-*O*-5, and 5-*O*-4) bonds that are resistant to cleavage. Baucher *et al.* (3) also supported the differential proportion of H, G, and S units in lignin and its resistance in maize (4, 35, and 61%, respectively), wheat (5, 49, and 46% respectively) and rice (15, 45, 40% respectively).

Pulp weight is an ideal parameter that consumers prefer irrespective of regions. In the present study (Fig. 1), the highest pulp weight was observed in PKM-2 (169.8 g) followed by Dwarf moringa and PKM-1 against the lowest pulpy genotype MO-7. Similarly the pulp weight is depends upon the fruit length and girth, however the ratio of pulp is decided by the skin and seed weight. The highest pulp ratio was observed in PKM-2, PKM-1 and MO-8 they showed more than 50 per cent. Seed ratio in the pod showed greater variation from 3.03 to 11.06 per cent. The lowest seed ratio was recorded in PKM-2 although the number of seed per pod was found highest among the genotypes studied indicating that the proportion to the pod length the seed based in was found low. However, MO-12, MO-10 and MO-7 recorded over 10 per cent seed content although the fruit length was found medium indicating more seed content in these genotypes. Similar finding has been reported by Hazarika *et al*. (6) in aonla. It is clear from the data that PKM-2 and PKM-1 had higher edible ratio (62.6 and 60.3%, respectively) and edible to non edible ratio (1.67 and 1.52%, respectively) indicating their amenability to induct in the food habit of north and western India. Furthermore, MO-1 showed edible ratio (46.3%) and edible to non edible ratio (0.87%) had soft exocarp. This finding is concurred with finding of Bist *et al*. (4), and Prabhuraj *et al*. (12) in pomegranate and jamun, respectively for variation in edible and non-edible parts.

The analysis of variance on number of fruits per plant revealed the maximum in PKM-1 (314.8) and the minimum in MO-8 (78.5). Number of fruits per plant is directly related to the ultimate yield, which in turn determines the potential value of the cultivar. The yield factor is attributed to number of fruits and fruit weight, which vary due to genetic makeup of the cultivar. Apart from genetic makeup, environmental factor and age of the plant affects the number of fruits and size of

Table 3. Variation in the edible and non-edible contribution of drumstick genotypes.

Genotype	Seed ratio	Pulp ratio	Skin ratio	Edible ratio
MO-1	5.78	40.78	53.43	46.56
MO-2	8.40	51.41	40.17	59.82
MO-3	4.15	43.35	52.49	47.50
PKM-2	3.03	59.52	37.43	62.56
MO-5	9.40	39.85	50.73	49.26
MO-6	5.59	52.67	41.72	58.27
MO-7	10.36	45.86	43.76	56.23
MO-8	5.63	53.17	41.18	58.81
MO-9	8.31	46.62	45.05	54.94
MO-10	10.44	46.52	43.03	56.96
PKM-1	4.80	55.55	39.64	60.35
MO-12	11.46	48.55	39.97	60.02
MO-13	8.39	47.87	43.72	56.27
Dwarf moringa	5.90	45.90	48.18	51.81

the fruits, which in turn is responsible for over all yield efficiency. In the present study, PKM-2 registered the highest yield (44.26 kg) per plant followed by PKM-1 (36.73 kg) and Dwarf moringa (35.2 kg). These results are in conformity with the results of Kader Mohideen and Shanmugavelu (7) in drumstick, and Singh (18) in pomegranate. It is concluded from the study that genotypes PKM-2, PKM-1 and MO-1 recorded the higher number of fruits per plant, fruit size, pulp weight and yield per plant coupled with earliness under semiarid ecosystem of western India. Hence, these genotypes can be recommended for commercial cultivation in the region.

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