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Assessment of vegetable purpose watermelon [(*Citrullus lanatus* (Thunb.) Matsum and Nakai] genotypes collected from laterite belt of eastern India

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Abstract
Twenty vegetable purpose watermelon landraces, popularly known as 'Khero', were collected locally and evaluated for yield and various other traits under Red and Laterite Zone of West Bengal. This is the first experimental report on vegetable purpose watermelon from Eastern India. The result revealed the presence of significant variation among the genotypes for all the studied traits. Maximum vine length was observed in VC-13, VC-17 and VC-1, whereas VC-12 produced maximum branch number per plant. VC-1 identified as early type for days to first male and female flower opening. VC-11 was noted for maximum average fruit weight, while VC-12 produced highest number of fruits and fruit yield per plant. Correlation study revealed the positive association between fruit yield per plant and branch number, number of fruits per plant and rind thickness of immature fruit of vegetable purpose watermelon.

Keywords: *Citrullus,* cucurbitaceae, landrace, flowering, yield, West Bengal.

Introduction

Watermelon is a member of the family Cucurbitaceae, and is believed to be African origin. Fursa (1972) [4] proposed three species of cultivated watermelon *viz*., *Citrullus lanatus* var. *lanatus*, *C. lanatus* var. *citroides* and *C. mucusospermus*. At present, five diploid (n=11) species (two cultivated and three wild) are recognized in genus *Citrullus* that are naturally grow in xerophytic and semi-arid habitats (Reddy *et al*., 2013) [20]. The cultivated species are *Citrullus lanatus* (Thunb.) Matsum. et Nakai (most cultivated) and *Citrullus colocynthis* (L.) Schrad. (Colocynth; sparingly cultivated). The *Citrullus lanatus* var. *lanatus* includes red sweet dessert type, white flesh types and egusi watermelon. On the other hand, *Citrullus lanatus* var. *citroides i.e.* Citron or Preserving melon used as a medicinal plant in the pharmaceutical industry. The watermelon fruits are seldom cooked as vegetable when immature (Jadhav *et al*., 2014) [7]. However, the indigenous landraces of cooking and seed type watermelons were reported from India (Mahla and Choudhary, 2013) [14] and Africa (Maggs-Kölling *et al*., 2000 [13]; Loukou *et al*., 2007 [9] and Dolo Nantoumé *et al*., 2012 [3]).

Watermelon landraces, locally known as 'Khero', is a traditional underutilized cucurbitaceous crop grown in Birbhum district and adjoining areas, which comes under Red and Laterite Zone of West Bengal, an Eastern State of India. It is cultivated during spring-summer months mostly in river beds and river banks commonly as rainfed crop with very little care. Fruits are harvested at immature stage and cooked as vegetable. Occasionally mature fruits, often known as 'pand', consumed with jaggery. An informal survey to the locality revealed that a good amount of variability exists in this crop in terms of earliness, growth, fruit and seed traits. Maggs-Kölling *et al*. (2000) [13], Oliveira *et al*. (2008) [17] and Gichimu *et al.* (2009) [6] reported presence of low variability among the commercial watermelons. A severe bottleneck in genetic diversity existed in watermelon during the initial breeding practices (Ji Hyun *et al*., 2011) [8]. Gichimu *et al.* (2009) [6] suggested expanding the genetic base of the cultivated watermelon. Singh *et al*. (2017) [21] suggested hybridization between landraces and exotic cultivars to expand the genetic variability. Plant vigour, resistance and seed characters in some of the watermelon landraces may be important traits for breeding for both local purposes and for commercial varieties (Maggs-Kölling and Christiansen, 2003) [12]. Madidi and Hakimi (2018) [10] noted that the modern watermelon varieties were more susceptible to the hydric stress than the local landraces. Dolo Nantoume *et al.* (2012) [3] and Madidi and Hakimi (2017) [11] reported that watermelon landraces possess high heat and drought tolerance than modern varieties of watermelon, which is a trait of interest to enhance food security in arid and desert areas. Presence of variation among the genotypes provides good opportunity to the breeder for the selection of desired types. The improved genotypes of vegetable purpose watermelon can be directly used as varieties which serve the farmers' to get maximum market benefit. Selected genotypes can also be used in various hybridization programmes for genetic enhancement of dessert type watermelon. Thorough literature survey confirmed that no study has been done before on this minor vegetable in this region. Therefore, the present research programme was undertaken to know the growth, flowering and yield attributes of vegetable purpose watermelon genotypes collected locally from Red and Laterite Zone of West Bengal. This is the first comprehensive report on vegetable purpose watermelon from Eastern India.

Materials and Methods

Twenty vegetable purpose watermelon landraces have been collected from different areas of Birbhum and Bardhaman Districts (farmers' field and local weekly markets) of West Bengal, India during 2014 (Table 1).

Table 1: Details of seed collection of vegetable purpose watermelon.

Area of Collection (Community Development Block / Sadar)	District	Genotypes
Bolpur Block	Birbhum	VC-1, VC-6, VC-10, VC-11, VC-12, VC-13, VC-18
Siuri	Birbhum	VC-2, VC-4
Illambazar Block	Birbhum	VC-3, VC-9, VC-14, VC-19
Laudoha Block	Bardhaman	VC-5, VC-17
Nanoor Block	Birbhum	VC-7, VC-8
Ausgram-1	Bardhaman	VC-15, VC-20
Labpur	Birbhum	VC-16

The assessment of these genotypes was carried out in Horticulture Farm, Sriniketan during summer 2015. The experiment was laid out in a randomized block design with three replications. Channel and bed system of planting method was followed to grow the crop. The width of channel was kept 50 cm and each channel was prepared 2.5m apart. FYM (15 t/ha) and NPK fertilizers (80:50:50 kg /ha) were applied to grow this crop. Well decomposed farm yard manure, half amount of nitrogen and potash and full dose of phosphorous were mixed at the time of field preparation as basal application. Rest half amount of nitrogen and potash were applied as top dressing 30 days after sowing. Urea (46% N), Single Super Phosphate (16% P_2O_5) and Muriate of Potash (60% K_2O) was used as source of chemical fertilizer. Pre-soaked seeds were sown only one side of the channel keeping plant to plant distance at 50 cm. Irrigation water was provided through the channels only and the area between two channels (bed) was utilized for spreading the vines. A single row, comprising 20 plants of each genotype, constituted one replication of which five plants were tagged randomly for data collection. Observations was recorded for vine length (cm), branch number, days to first male and female flower opening, node to first male and female flower appearance, average fruit weight (g), number of fruits per plant, fruit length (cm), fruit circumference (cm), rind thickness (mm) and fruit yield per plant (kg). The total variation for different genotypes was tested for significance by 'F test' using analysis of variance technique. Critical differences were calculated for each trait to test the significance of difference between means of different genotypes. Correlation has been studied to see the inter-relationship among the various studied traits. Statistical analysis was perfomed as per Panse and Sukhatme (1985) [18].

Results and Discussions

The analysis of variance study revealed that the genotypes of vegetable purpose watermelon were highly significantly differed among themselves for all the traits (Table 2). It indicated the presence of genetic variability in the studied genotypes. Mohanta and Mandal (2016) [15] reported significant differences among watermelon genotypes for different characters grown under Lateritic belt of West Bengal. The mean data of various traits obtained from replicated experiment were analyzed, presented (Table 3 & 4) and discussed below:

Table 2: Analysis of variance for growth and flowering traits of vegetable purpose watermelon.

Source	Vine Length	Branch number	Node to first male flower appeared	Node to first female flower appeared	Days to first male flower opening	Days to first female flower opening	Average fruit weight	Number of fruits /plant	Fruit length (cm)	Fruit circum-ference (cm)	Rind thickness (mm)	Fruit yield /plant
Replication	335.88	0.06	0.01	0.87	4.87	1.11	1246.10	0.65*	7.51	6.29	1.05	0.018
Treatment	5655.75**	8.06**	1.68**	16.87**	66.11**	97.90**	12906.71**	10.15**	19.33**	13.45**	11.20**	2.45**
Error	455.78	0.20	0.33	2.32	5.62	5.09	2732.14	0.15	2.34	2.81	0.96	0.032

Note: * and ** means statistically significant at p=0.05 and 0.01, respectively.

Table 3: Growth and flowering traits of vegetable purpose watermelon genotypes.

Genotypes	Vine length (cm)	Branch number	Node to first male flower appeared	Node to first female flower appeared	Days to first male flower opening	Days to first female flower opening
VC-1	389.7^{ab}	7.1^{h}	5.7^{abcd}	24.0^{fgh}	26.8^{a}	39.8^{a}
VC-2	299.4^{f}	7.5^{efgh}	6.8^{efg}	26.3^{hi}	33.0^{bc}	58.7^{hi}
VC-3	360.0^{bcd}	8.2^{de}	5.5^{ab}	22.1^{cdef}	40.2^{ghi}	54.9^{fg}
VC-4	294.0^{fg}	7.3^{fgh}	6.7^{def}	22.8^{defg}	43.7^{hij}	50.8^{d}
VC-5	353.3^{cd}	7.9^{defg}	6.5^{bcde}	24.2^{fgh}	44.8^{j}	55.8^{fgh}
VC-6	253.0^{h}	6.0^{i}	5.5^{ab}	25.1^{ghi}	32.3^{b}	44.5^{b}
VC-7	345.2^{de}	7.0^{h}	5.3^{a}	19.5^{ab}	40.0^{fgh}	50.2^{d}
VC-8	363.7^{bcd}	8.0^{def}	6.7^{def}	26.8^{i}	44.7^{j}	61.3^{i}
VC-9	351.0^{cd}	10.6^{b}	6.5^{bcde}	21.0^{bcd}	36.5^{cdefg}	43.2^{ab}

VC-10	373.0^{bcd}	9.0^{c}	6.8^{efg}	21.1^{bcde}	35.4^{bcde}	46.3^{bc}
VC-11	366.3^{bcd}	7.2^{gh}	6.6^{cde}	22.1^{cdef}	43.0^{hij}	54.2^{efg}
VC-12	312.3^{ef}	12.0^{a}	6.0^{abcde}	22.4^{def}	34.5^{bcd}	49.6^{cd}
VC-13	412.3^{a}	5.1^{j}	7.8^{g}	20.3^{bcd}	44.2^{ij}	57.8^{ghi}
VC-14	368.3^{bcd}	7.5^{efgh}	5.6^{abc}	24.5^{fghi}	35.2^{bcde}	50.2^{d}
VC-15	340.3^{de}	8.3^{cd}	5.7^{abcd}	23.9^{fgh}	36.0^{bcde}	53.0^{def}
VC-16	354.3^{cd}	6.9^{h}	6.5^{bcde}	23.6^{efg}	38.8^{efg}	54.4^{efg}
VC-17	380.7^{abc}	6.1^{i}	5.8^{abcde}	24.1^{fgh}	36.5^{cdefg}	58.8^{hi}
VC-18	349.3^{cd}	8.2^{de}	7.7^{fg}	17.7^{a}	38.9^{efg}	54.6^{fg}
VC-19	260.0^{gh}	10.6^{b}	7.7^{fg}	19.6^{abc}	36.2^{bcdef}	57.9^{ghi}
VC-20	278.3^{fgh}	7.2^{gh}	6.7^{def}	24.3^{fgh}	37.2^{defg}	55.5^{fgh}
SEd(±)	17.4	0.4	0.5	1.2	1.9	1.8
LSD (0.05)	35.3	0.7	1.0	2.5	3.9	3.7

Note: Similar alphabets in a column denote that they are statistically *at par*.

Table 4: Yield and yield attributes of vegetable purpose watermelon genotypes

Genotypes	Average fruit Weight (g)	Number of fruits/plant	Fruit length (cm)	Fruit circumference (cm)	Rind thickness (mm)	Fruit yield /plant (kg)
VC-1	489.2^{bcd}	7.7^{f}	20.7^{ef}	27.2^{cdef}	2.5^{fg}	3.2^{ef}
VC-2	427.7^{defg}	9.0^{cd}	22.4^{cde}	26.0^{def}	8.0^{a}	4.1^{bc}
VC-3	363.0^{fgh}	8.5^{de}	24.7^{bc}	27.7^{cde}	4.3^{de}	3.1^{fg}
VC-4	458.7^{bcde}	7.4^{fghi}	20.9^{ef}	26.3^{cde}	8.3^{a}	2.4^{ij}
VC-5	522.7^{bc}	7.5^{fgh}	29.4^{a}	31.1^{a}	5.0^{d}	4.3^{b}
VC-6	477.2^{bcde}	6.8^{ij}	23.7^{cd}	25.7^{ef}	5.3^{cd}	2.7^{hi}
VC-7	512.5^{bcd}	7.1^{fghi}	21.2^{def}	28.8^{abcd}	5.3^{cd}	3.8^{cd}
VC-8	350.4^{gh}	8.6^{de}	21.5^{def}	24.8^{fg}	5.0^{d}	4.4^{b}
VC-9	531.7^{b}	11.2^{b}	24.3^{c}	28.2^{bcde}	4.3^{de}	3.2^{ef}
VC-10	332.5^{h}	9.4^{c}	18.1^{g}	22.1^{g}	8.0^{a}	3.5^{de}
VC-11	602.5^{a}	7.1^{fghi}	27.2^{ab}	31.0^{ab}	6.7^{bc}	2.3^{j}
VC-12	455.9^{bcde}	13.8^{a}	21.5^{def}	25.5^{ef}	7.0^{b}	5.2^{a}
VC-13	398.3^{efgh}	6.3^{jk}	24.1^{c}	27.3^{cdef}	4.3^{de}	1.9^{kl}
VC-14	508.5^{bcd}	7.0^{ghi}	23.7^{cd}	26.6^{cdef}	3.0^{ef}	2.8^{gh}
VC-15	453.1^{bcde}	7.4^{fghi}	22.6^{cde}	27.6^{cdef}	1.0^{g}	1.8^{l}
VC-16	436.2^{defg}	5.7^{k}	22.6^{cde}	24.8^{fg}	2.7^{efg}	2.2^{jk}
VC-17	497.5^{bcd}	7.6^{fg}	21.1^{ef}	27.9^{de}	5.0^{d}	2.7^{hi}
VC-18	463.6 ^{bcde}	6.9^{hij}	22.8^{cde}	25.6^{ef}	4.3^{de}	2.3^{j}
VC-19	496.0^{bcd}	7.0^{ghi}	22.6^{cde}	26.6^{cdef}	4.3^{de}	2.5^{hij}
VC-20	444.0^{cdef}	8.6^{de}	19.3^{fg}	29.0^{abc}	4.0^{def}	3.1^{fg}
SEd(±)	42.7	0.3	1.2	1.4	0.8	0.1
LSD (0.05)	86.4	0.6	2.5	2.8	1.6	0.3

Note: Similar alphabets in a column denote that they are statistically *at par*.

Table 5: Correlation coefficient of twenty genotypes of vegetable purpose watermelon.

	Vine length	Branch number	Node to first male flower appeared	Node to first female flower appeared	Days to first male flower opening	Days to first female flower opening	Average fruit weight	Number of fruits/ plant	Fruit length	Fruit circumference	Rind thickness	Fruit yield/ plant
Vine length	1.000	-0.290	-0.0509	-0.155	0.244	0.010	-0.148	-0.121	0.168	0.079	-0.264	-0.088
Branch number		1.000	0.1071	-0.281	-0.195	-0.171	0.034	0.756**	-0.089	-0.241	0.150	0.443*
Node to first male flower appeared			1.000	-0.439	0.443*	0.516*	-0.186	-0.150	0.052	-0.207	0.153	-0.270
Node to first female flower appeared				1.000	-0.200	0.160	-0.112	0.062	0.034	0.045	-0.015	0.323
Days to first male flower opening					1.000	0.618**	-0.034	-0.242	0.432	0.294	0.216	-0.070
Days to first female flower opening						1.000	-0.298	-0.253	0.176	0.111	0.053	-0.016
Average fruit weight							1.000	-0.154	0.536*	0.824**	-0.085	0.176
Number of fruits/ plant								1.000	-0.225	-0.175	0.389	0.701**
Fruit length									1.000	0.621**	-0.130	-0.081
Fruit circumference										1.000	-0.245	-0.075
Rind thickness											1.000	0.447*

Note: * and ** means statistically significant at p=0.05 and 0.01, respectively.

Vine length and Branch number per plant

Maximum vine length was observed in VC-13, which was found statistically at par with VC-17 and VC-1. On the other hand, minimum vine length was noted in genotype VC-6, which was found statistically at par with VC-19 and VC-20. Genotype VC-12 was recorded maximum branch number per plant. Average vine length and number of branches per plant was recorded 340.2 cm and 7.9 respectively. Compact plant type with moderate vine length and more number of branches are desirable in cucurbits, as it has occupy less space and thus, can accommodate more number of plants per unit area. Increased branch number increases probable fruiting sites and thereby helps to increase yield (Mohanta and Mandal, 2016) [15]. Gichimu *et al*. (2010) [5] observed that the watermelon landrace produced the highest yield owing to its long vine and extensive branching. Fruit yield per plant in watermelon was positively correlated with number of primary branches per plant and number of fruits per plant (Choudhary *et al*., 2012) [2].

Flowering traits

Earliness is an important horticultural trait which offer early market opportunity. Flowering indicates the starting of reproductive phase of cucurbits. In vegetable purpose watermelon, male flower appeared first and then the female flower, like other cucurbits. Appearance of female flower has particular significance in cucurbits as it directly related to fruiting and harvesting. Average number of days taken for male and female flower opening was observed about 38 and 53 days after sowing respectively. VC-1 noted as early type for both first male and female flower appearing in less number of days than other genotypes. First male flower was appeared in lower node number in VC-7, which was observed statistically at par with VC-6, VC-4, VC-1, VC-15 and VC-17. Similarly, first female flower was appeared in lower node number in VC-18, which was noticed statistically similar with genotype VC-7 and VC-19. Choudhary *et al*. (2012) [2] found significant positive correlation between fruit yield per plant and node at which first female flower appeared. The mean male and female flower appearing nodes were 6.4 and 22.8 respectively.

Yield and its attributing traits

Medium sized immature fruits were preferred locally in vegetable purpose watermelons. Genotypes VC-11 and VC-10 was recorded highest and lowest average fruit weight respectively. Mean fruit weight was noted 461.1 g. In watermelon, Anikwe *et al*. (2016) [1] found variation in fruit weight at harvest. Number of fruits per plant is an important yield attributes in cucurbits. Genotype VC-12 has produced maximum number of fruits per plant respectively; whereas VC-16 and VC-13 has produced minimum number of fruits per plant. Sundaram *et al*. (2011) [22] observed that yield per vine showed positive correlation with number of fruits per vine and fruit weight. Genotype VC-5 was recorded maximum fruit length which was observed statistically at par with VC-11. On the other hand, minimum fruit length was noticed in VC-10, which was found statistically similar to VC-20. Genotypes VC-5 and VC-10 has registered maximum and minimum fruit circumferences respectively. Maximum rind thickness of fruit was observed in VC-4, which was found statistically at par with genotype VC-10 and VC-2. Similarly, VC-15, VC-1 and VC-16 were recorded minimum rind thickness. Genotype VC-12 was observed to produce maximum fruit yield of 5.2 kg per plant. Genotypes VC-8, VC-5 and VC-2 were also good producers. Minimum fruit yield was noted in VC-15, which was found statistically at par with VC-13. Jadhav *et al*. (2014) [7], More *et al*. (2015) [16] and Mohanta and Mandal (2016) [15] noted variation in fruit yield per plant in cultivated watermelon. In Namibia, Maggs-Kölling *et al*. (2000) [13] observed a wide variation within the local types of watermelon. In Kenya, Gichimu *et al*. (2010) [5] noted highly significant variation among the watermelon accessions in all the yield components.

Correlation coefficient

The assessment of correlation coefficient has been presented on Table 5. Data revealed that the branch number, number of fruits per plant and rind thickness of immature fruit of vegetable purpose watermelon had significant and positive correlation with fruit yield per plant. Workers reported positive correlation between fruit yield of watermelon with branches per plant (Prasad *et al*., 1988 [19] and Choudhary *et al*., 2012) [2] and number of fruits per plant (Sundaram *et al*., 2011 [22] and Choudhary *et al*., 2012 [2]). Vine length, node to first male flower appeared, days to first male and flowers opening, fruit length and circumference showed non-significant and negative correlation with the fruit yield per plant. On the other hand, fruit yield per plant was non-significantly and positively correlated with node to first female flower appeared and average fruit weight. Node to first male flower appeared was positively and significantly correlated with days to first male and female flower opening. Branch number had highly positive and significant correlation with number of fruits per plant. Positive and significant correlation was noted between average fruit weight and fruit length and circumference. Fruit length showed significant and positive correlation with fruit circumference.

This study has revealed the presence of genetic variation in vegetable purpose watermelon. Genotype VC-12, which was recorded maximum fruit yield per plant, can be advocated to the local growers for productivity enhancement. Genotypes VC-1, VC-6, VC-7 and VC-10 were found early type for flowering, which can be utilized in watermelon improvement programme. Further in depth study is needed to know the usefulness of vegetable type watermelon landraces against various diseases and abiotic stresses or for any other noble traits involving more number of accessions.

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