Journal of Crop and Weed, 15(3): 07-11 (2019)
ISSN- O : 2349 9400 ; P : 0974 6315

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Evaluation of F_4 segregating population of bitter gourd (*Momordica charantia* L.) for qualitative and quantitative traits

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Received : 07.09.2019 ; Revised : 12.10.2019 ; Accepted : 22.10.2019

DOI : 10.22271/09746315.2019.v15.i3.1228

ABSTRACT

Seventeen breeding lines (ten F_4segregants along with seven parents) of bitter gourd were evaluated for twenty three characters to study its performance during late kharif season of 2018 at Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India. The experiment was laid out in randomized block design replicated thrice. All the F_4segregating breeding lines of bitter gourd showed significant variations for both qualitative and quantitative characters. The overall performance on vegetative parameters indicated superiority of PhuleGreen Gold (PGG) X Priyawith respect to relatively higher vine length (4.78 m), significantly highest primary branches vine^{-1} (17.97) and relatively lower internodal length (6.28 cm). Similarly, F_4 segregant of Hirkani Local (HL) x Tushi (45.27 days) was noted for earliness in appearance of 1st female flower. Lowest sex ratio (male: female) was recorded in Tushi x PusaDo Mousumi (PDM) (0.09). Earliest harvestable maturity wasexhibited by NakharaLocal(NL) X PDM (67.67 days) followed by NLX Priya (69.33 days) and PGG X NL (69.93 days). Significantly, longest fruit length and relatively higher fruit girth was observed in PGG X NL (10.74 cm and 12.04 cm).Heavier fruit was recorded in PGG X Priya (76.17 g). Among F_4crosses, Tushi X PDM (145.13 days) showed longer crop duration. The cross between HL X Tushi (52.52) recorded highest number of fruits vine^{-1} and was statistically at par with Tushi X PDM (48.68) and NL X Tushi (47.37). Lower number of seeds fruit^{-1} was recorded in NL X Tushi (13.66). Maximum total green fruit yield vine^{1} was recorded in PGG X Priya (3.18 kg), closely followed by HL X Tushi (3.14 kg) and NL X Priya (2.51 kg). Significantly highest TSS (5.33 °Brix) and relatively higher ascorbic acid (108.63 mg 100g^{-1}) was observed in PGG X NL. Based on overall findings of the present study, it can be concluded that among F_4segregants, PGG X Priya, HL X Tushi, NL X Tushi and NL X Priya are best performing segregants producing maximum total green fruit yield vine^{-1}along with other desirable traits in bitter gourd.

Keywords **:** Bitter gourd, mean performance, F_4 segregants

Bitter gourd (*Momordica charantia* L.) is an important monoecious cross pollinated vegetable crop belongs to family Cucurbitaceae. It is locally known as Bitter Melon, Karela, Maiden apple and Balsam pear etc. It is believed to be originated in Tropical Asia, particularly eastern India (*i.e.* state of Odisha, West Bengal, Assam, Jharkhand and Bihar) and south China *i.e.* Indo Burma centre of origin (Zevan and Zhukovsky, 1975).

It is an important contributor of iron, phosphorus and ascorbic acid (Singh *et al*., 2012). The fruit contains two alkaloids *viz*., momordicin and cucurbitacin (bitter glucoside) which prevents the spoilage of cooked vegetable and keeps fit for consumption even for two to three days (Jatav *et al*., 2016). A hypoglycemic principle called "charantin" has been isolated which is used for the treatment of diabetes (Raman and Lau, 1996). A basic protein MAP-30 that inhibits human immune deficiency virus (HIV) is present both in seed and fruit (Lee *et al*., 1995). The fruits are usually consumed fresh but can also be dried and pickled (Vinning, 1995).

In spite of having a numerous potential, due attention was not given towards a need based crop improvement programme. This crop still remains less explored with respect to crop improvement by adopting various breeding methods. So, the basic key is to develop cultivars with high yield, early flowering, early fruiting, high female to male sex ratio, less seeds fruit^{-1}, thick fruit suitable for stuffing, resistant to insect pest and diseases through selection, either from genotypes or from segregating population of the crop. Considering all the above mentioned facts, this experiment was undertaken to evaluate the mean performance of 17 breeding lines including parents in F_4segregating generation of bitter gourd.

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Table 1: The details of breeding lines used in the experiment

Sl. No.	Breeding lines (F_4 segregants/ Parents)
1	Phule Green Gold × Nakhara Local (PGG × NL)
2	Phule Green Gold × Priya (PGG × Priya)
3	Improved Kathi × Priya (IK × Priya)
4	Improved Kathi × Pusa Do Mousumi (IK× PDM)
5	Hirkani Local × Tushi (HL× Tushi)
6	Nakhara Local × Tushi (NL× Tushi)
7	Nakhara Local × Priya (NL× Priya)
8	Nakhara Local × Pusa Do Mousumi (NL× PDM)
9	Tushi × Pusa Do Mousumi (Tushi × PDM)
10	Priya × Pusa Do Mousumi (Priya × PDM)
11	Phule Green Gold (PGG)
12	Improved Kathi (IK)
13	Hirkani Local (HL)
14	Nakhara Local (NL)
15	Tushi
16	Priya
17	Pusa Do Mousumi (PDM)

MATERIALS AND METHODS

This investigation was conducted at Department of Vegetable Science, College of Agriculture, Odisha Universityof Agriculture and Technology, Bhubaneswar, Odisha, India during late *kharif* season, 2018. The experiment was laid out in Randomized Block Design replicated thrice with 17 breeding lines (ten F_4segregants and seven parents) (Table 1). The spacing adopted was 1.75 m between rows and 1.25 m between pits. All the recommended package of practices was followed uniformly to all the 17 breeding lines in order to raise a good crop stand. The data were analysed statistically (Sukhatme and Amble, 1995)

RESULTS AND DISCUSSION

Vegetative growth parameters

The mean performances of 17 breeding lines of bitter gourd for 23 characters are presented in table 2. Vine length at the time of final harvest ranged from 3.19 m (PDM) to 5.17 m(PGG X NL). Significantly maximum number of primary branches vine^{-1} was recorded inPGG x Priya (17.97) followed by NL X Priya (17.89). Inter nodal length range was observed maximum for IK X PDM (8.50 cm) and was minimum for PDM (3.87 cm) with a mean value of 5.61 cm. Overall results on vegetative growth parameters of bitter gourd in F_4 segregating generation showed that wherever PGG and Priya were used as parents, their F_4 progeny performed better for vegetative growth parameters. Similar results were also recorded by Gowda (2017) for the genotype PGG in bitter gourd. However, it was also revealed that the genotype, PGG x Priya recorded relatively higher vine length (4.78 m), significantly highest primary branches vine^{-1} (17.97) and relatively lower internodal length (6.28 cm).

Flowering parameters

The genotype, PDM showed earliness for appearance of 1st male flower (39.33 days). However, earliest female flower was recorded in HL x Tushi (45.27 days). Interestingly, the genotype HL had taken maximum time (51.17 days and 59.70 days) for appearance of both 1st male and female flower. The F_4segregant of NL x Tushi flowered 1st male flower significantly at lowest node of 9.01 but significantly lowest node number for appearance of 1stfemale flower was observed in Tushi (13.37). However, IK produced 1st male and female flower at highest node (13.50 and 17.67). Significant variations were also observed for sex ratio (male: female) among the tested population, ranging from 0.09 (Tushi x PDM) to 0.27 (Priya) with an average of 0.13. Results also showed that, among F_4segregants, involvement of Tushi and NL as one of the parent induced early appearance of male flower, female flower, lower node to 1st male flower, lower node to 1st female flower and lower sex ratio. The above findings were in conformity with the findings of Gowda (2017) for NL.

Yield attributing parameters

Regarding yield attributing characters of bitter gourd (days to 1st harvest, days to final harvest, fruit length, fruit girth, average fruit weight, fruits vine^{-1}and seeds fruit^{-1}) significant variations were observed among F_4 segregatingpopulation including parents. Results showed that the parent, PGG recorded relatively higher fruiting duration (142.11 days), longest fruit (13.57 cm), relatively maximum fruit girth (12.83 cm), heavy fruit (45.13 g), relatively higher number of fruits vine^{-1} (30.33) and maximum seeds fruit^{-1} (24.07). This was followed by Priya whichshowed earliest days to 1st fruit harvest (65.00 days), relatively higher fruiting duration (139.90 days), longer fruit (13.03 cm), relatively higher fruit girth (9.67 cm),fruit weight (53.62 g) and number of seeds fruit^{-1}(18.24). NL showed relatively lower days to 1st harvest (67.67 days). On the other hand, Tushi as a parent, showed relatively earlier days to 1st harvest (65.67 days), significantly lowest fruit length (7.97 cm),lowest fruit weight (26.65 g), lowest number of seeds fruit^{-1} (12.51) and maximum number of fruits vine^{-1} (55.95). Significantly earliest harvestable maturity was recorded in NL x PDM (67.67 days) followed by NL x Priya (69.33 days), PGG x NL (69.93 days) and NL x Tushi (70.52

Table 2 : Mean performance of 17 breeding lines (F_4 segregants and parents) of bitter gourd for quantitative and qualitative parameters

Parents/ F_4 segregants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
PGG×NL	5.17	12.86	5.54	46.98	53.62	9.64	13.42	0.11	69.93	136.34	10.74	12.04	59.73	34.08	1.77	0.35	2.13	19.35	5.33	108.63	0.63	1.29	1.92
PGG×PRIYA	4.78	17.97	6.28	39.95	50.82	12.03	15.03	0.11	73.67	135.14	10.57	12.44	76.17	39.58	2.85	0.32	3.18	17.78	5.33	99.12	0.61	1.34	1.95
IK×PRIYA	3.84	15.13	7.44	41.36	48.50	11.15	15.58	0.12	73.58	135.60	9.99	10.87	51.95	42.05	2.03	0.26	2.29	17.17	4.73	103.90	0.58	1.34	1.92
IK×PDM	4.44	14.94	8.50	41.58	52.18	11.58	15.52	0.12	72.53	144.95	10.03	10.63	52.73	35.94	1.72	0.30	2.02	20.55	4.57	112.30	0.55	1.37	1.92
HL×TUSHI	3.59	16.42	5.19	40.61	45.27	11.62	15.03	0.10	73.17	143.83	10.26	9.79	56.89	52.52	2.90	0.24	3.14	14.58	4.53	110.54	0.68	1.28	1.97
NL×TUSHI	3.98	16.61	7.60	41.33	50.27	9.01	14.50	0.10	70.52	133.26	8.28	8.38	50.65	47.37	2.30	0.27	2.57	13.67	5.17	110.42	0.65	1.20	1.85
NL×PRIYA	4.55	17.89	4.88	42.84	52.91	9.50	13.62	0.11	69.33	136.30	9.84	11.25	60.27	36.77	2.20	0.31	2.51	18.07	5.06	100.62	0.55	1.43	1.98
NL×PDM	3.44	15.29	5.00	40.86	49.53	10.69	15.29	0.10	67.67	136.78	7.63	10.45	55.05	41.73	2.23	0.24	2.47	12.82	5.30	97.14	0.59	1.30	1.89
TUSHI×PDM	3.74	16.75	4.32	42.62	52.39	11.80	15.88	0.09	69.54	145.13	7.56	10.24	46.62	48.68	2.19	0.26	2.45	14.40	5.10	104.12	0.52	1.38	1.90
PRIYA×PDM	3.98	15.47	6.29	43.40	52.92	12.92	16.43	0.15	75.33	139.72	9.22	10.77	50.69	42.74	1.96	0.27	2.23	16.01	5.27	102.03	0.68	1.26	1.95
PGG	5.08	12.50	5.14	45.50	55.53	12.73	15.67	0.11	71.33	142.11	13.57	12.83	45.13	30.33	1.36	0.35	1.70	24.07	4.83	98.75	0.56	1.39	1.94
NL	4.08	15.53	7.23	43.40	52.53	11.00	14.70	0.11	67.67	132.60	9.80	11.77	43.50	32.03	1.31	0.28	1.59	22.00	5.20	101.64	0.58	1.35	1.93
TUSHI	3.24	15.53	4.88	41.67	51.07	11.53	13.37	0.16	65.67	136.50	5.20	7.97	26.65	55.95	1.56	0.22	1.78	12.81	5.27	104.15	0.63	1.35	1.98
PRIYA	5.06	17.00	5.27	44.67	49.70	10.73	15.53	0.27	65.00	139.90	13.03	9.67	53.62	21.87	1.60	0.28	1.88	18.24	4.93	96.05	0.69	1.27	1.97
PDM	3.19	15.17	3.87	39.33	53.50	12.33	14.67	0.18	68.67	133.00	10.90	12.77	49.71	31.43	1.52	0.25	1.77	22.33	5.13	101.62	0.66	1.30	1.96
IK	4.45	13.87	4.07	50.67	58.42	13.50	17.67	0.14	69.33	133.50	13.50	11.83	47.50	23.33	1.36	0.22	1.58	23.00	3.88	94.27	0.52	1.21	1.73
HL	4.51	14.60	3.93	51.17	59.70	12.50	16.50	0.13	69.70	134.20	9.83	13.37	57.40	30.17	1.33	0.24	1.56	23.33	4.15	97.73	0.51	1.19	1.70
Grand Mean	4.18	15.50	5.61	43.64	52.81	11.42	15.20	0.13	70.15	134.07	10.17	11.00	52.01	38.03	1.89	0.27	2.16	18.37	4.92	102.53	0.59	1.30	1.90
C.V.	7.68	3.90	9.03	3.28	2.54	3.62	3.64	12.04	1.62	2.64	9.14	4.24	8.92	7.67	9.17	9.95	7.92	6.58	9.95	4.19	3.63	2.05	2.16
SEm(±)	0.19	0.35	0.29	0.83	0.78	0.24	0.32	0.01	0.66	2.10	0.54	0.27	2.68	1.68	0.10	0.02	0.10	0.70	0.28	2.48	0.01	0.02	0.02
SE(d)	0.26	0.49	0.41	1.17	1.10	0.34	0.45	0.01	0.93	2.97	0.76	0.38	3.79	2.38	0.14	0.02	0.14	0.99	0.40	3.51	0.02	0.02	0.03
LSD(0.05)	0.54	1.01	0.85	2.39	2.25	0.69	0.92	0.03	1.90	6.07	1.55	0.78	7.75	4.87	0.29	0.05	0.29	2.02	0.82	7.18	0.04	0.05	0.07

Note: 1.Vine length 2.Primary branches vine^{-1} 3.Internodal length 4.Days to1st male flower 5. Days to 1st female flower 6. Node of 1st male flower 7.Node of 1st female flower 8. Sex ratio 9.days to 1st harvest 10. Days to final harvest 11. Fruit length 12.Fruit girth 13.Average fruit weight 14.Fruits vine^{-1} 15.Marketable green fruit yield 16. Unmarketable green fruit yield 17.Total green fruit yield 18.Seeds fruit^{-1} 19.TSS 20. Ascorbic acid 21.Reducing sugar 22. Non-reducing sugar 23.Total sugar

days) which indicated that when NL was used as a parent, earliest harvestable maturity was obtained. Significantly, longest fruit length and relatively higher fruit girth was observed in PGG x NL (10.74 cm and 12.04 cm) which was *statistically at par* with PGG x Priya (10.57 cm and 12.44 cm) as against PGG (13.57 cm and 12.83 cm)which indicate that in presence of PGG as parent, there was inheritance of high fruit length and fruit girth. Similar results were reported by Nandakumar (2014) and Gowda (2017) in bitter gourd.Similarly, among F_4 segregants and parents, significantly heavier fruit was recorded in PGG x Priya (76.17 g) followed by NL x Priya (60.27 g) and PGG x NL(59.73 g), being relatively heavier fruit was noticed in parent, Priya (53.62 g) and PGG (43.50 g) in the present study. Similar report of significantly heavy fruit in PGG was reported by Gowda (2017). It was also observed that due to significantly lower fruit weight of parent, Tushi (26.65 g), among F_4 segregating population, significantly lower fruit weight was noticed where Tushi was used as a parent such as Tushi x PDM (46.62 g) and NL x Tushi (50.65 g). Among F_4 crosses, Tushi x PDM (145.13 days) recorded significantly longer crop duration which was followed by IK x PDM (144.95 days). This results might be due to presence of parent, PDM (133.00 days) having relatively higher crop duration. Significant variations were observed among F_4 segregants for fruits vine^{-1}. It was revealed from the data presented in table 2 that the cross between HL x Tushi (52.52) recorded highest number of fruits vine^{-1} and was *statistically at par* with Tushi x PDM (48.68) and NL x Tushi (47.37). This might be due to presence of Tushi (55.95) as one of the parent in the present study. Number of seeds fruit^{-1} in bitter gourd is an important trait towards consumer's acceptance. Results indicated significantly highest seeds in IK x PDM (20.55). However, significantly lower number of seeds fruit^{-1}, which is a desirable trait in bitter gourd was recorded in NL x Tushi (13.66), Tushi x PDM (14.40) and HL x Tushi (14.58). This might be due to presence of Tushi, which recorded significantly lowest number of seeds fruit^{-1} (12.51).

Fruit yield parameters

It was noticed that marketable green fruit yield vine^{-1} was significantly highest in HL x Tushi (2.90 kg) among both parents and F_4segregants, which was *statisticallyat par* with PGG x Priya (2.85 kg). However, among the parents, relatively higher marketable green fruit yield vine^{-1} was recorded in Priya (1.60 kg) closely followed by Tushi (1.56 kg). Lowest unmarketable green fruit yield was recorded in Tushi (0.22 kg). This might due to less infestation by various pests. On the other hand, maximum total green fruit yield vine^{-1} was recorded in PGG x Priya (3.18 kg), closely followed by HL x Tushi (3.14 kg) and NL x Priya (2.51 kg).This might be due to significant positive correlation between total green fruit yield vine^{-1} and characters like primary branches vine^{-1}, average fruit weight and fruits vine^{-1} in bitter gourd. Similar observations on correlation of green fruit yield vine^{-1} with characters like fruits vine^{-1} and fruit weight were recorded by Sundaram (2010), Singh *et al*. (2014), Khan *et al*. (2015), Rani *et al*. (2015), Jatav*et al*. (2016) and Moharana *et al.* (2018) in bitter gourd.

Quality parameters

Significantly highest TSS (°Brix) of 5.33 and relatively higher ascorbic acid of 108.63 mg 100g^{-1} was observed in PGG x NL which was *statistically at par* with NL x Tushi (5.17 °brix and 110.42 mg 100g^{-1}) than other genotypes. However, among the parents, highest TSS and ascorbic acid content was observed in Tushi (5.27 °brix and 104.15 mg 100g^{-1}) closely followed by NL (5.20 °brix and 101.64 mg 100g^{-1}). In general, the F_4segregant was having NL or Tushi as one of the parent showed superior trend in fruit quality parameters. Similar results on fruit quality were also reported by Gowda (2017) for the parent, NL in bitter gourd.

It can be concluded that among the parents, Phule Green Gold and Priya were identified as best parent for vegetative growth parameters. It was also observed that involvement of Tushi and Nakhara Local as one of the parent induced early flowering (both male and female), minimum node to bear both 1st male flower and 1st female flower and lower sex ratio (male: female). Thus, they were considered to be the best parents for flowering parameters. On the other hand, Phule Green Gold and Priya were identified as best parents for inheritance of longer and heavier fruit in bitter gourd. Tushi as a better parent was identified for inheritance of maximum number of fruits vine^{-1} and minimum number of seeds fruit^{-1}. Among the F_4 segregants, it may be concluded that Phule Green Gold x Priya, Hirkani Local x Tushi, Nakhara Local x Tushi and Nakhara Local x Priya were the best performing segregants.

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