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Genotypic response to bolting tolerance in short day onion (*Allium cepa* L.)

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Abstract

Onion is considered as an important vegetable crop in the world. India is the second largest producer of onion contributing about 20% world production. At the present times, onion is adapted to various agro-climatic conditions of India and cultivated in all seasons (*kharif*, *late kharif* and *rabi*) using advanced technology and improved varieties. Bolting is a physiological disorder and reduces quality and marketable yield of onion and having poor storability. Onion plants are biennials i.e. they normally flower in the second season of their development. However, under favourable conditions, some sensitive varieties bolt in the first season itself. Bolting is a result of complicated interaction between genotype, plant age and environmental factors. Bolting is essential for seed production, but undesirable during bulb production. Bolting varies with genotype susceptibility and resistance, and is clearly influenced by temperature or cultivar or both. This problem occurs mostly in *late kharif* due to variation in temperature during vegetative growth under Indian plains. With suitable screening method more potent lines can be screened by critical selection for bolting resistance. Twelve advance lines/ varieties of short day onion were screened for bolting tolerance during *late kharif* season with five dates of planting at 15 days interval. On the basis of two years data, highest marketable yield was recorded in DOGR-1168 (38.84 t/ha) followed by DOGR-595 (37.02 t/ha) with the minimum bolting percentage (<5%). Thus, these lines can be further exploited in breeding programme.

Key words: Screening, bolting, tolerant, variety, short day and onion

Introduction

Onion is the most important crop among vegetables in the world. It is a photo-sensitive crop and on the basis of day length varieties are divided into short day and long day types. Long day types are high yielder but have poor shelf life, whereas short day types have better shelf life with low yielding capacity and are sensitive to bolting. Onion is grown as an annual plant for commercial purpose, although they are biennial plant for completing life cycle, which means that it takes two seasons to go from seed to seed. First year bulbs are produced and next year bulbs are planted to produce seed. When onion is grown as bulb crop, some seed stalks are produced before formation of normal bulbs which is known as bolting. Bolting is not desirable because it stops the development of bulbs in bulbing crop. These bulbs become fibrous and light in weight. The bulbs become unfit for consumption and such bulbs do not have long keeping quality because these have hard core in the centre and are prone to rotting. The seeds obtained from such bolts are not desirable and have tendency to bolt in next generation.

Onion is adapted to various environments for example it is cultivated around the majority of cities in the country with one or several cultivars with acceptable yield. Nevertheless, genetic information about this plant is relatively limited (Brewester 1994). One of the important breeding objectives of onion is resistant to bolting (Hu et al. 2003). One factor of escaping from bolting is the genotype and the other is the plant age when it confronts low temperature (Brewester 1994). Bulb production in onion depends on genotypes, temperature, photoperiod and their interactions (Ansari and Mamghani 2008, and Brewester 1994). Thus, each landrace variety is adapted to a specific climatic condition. The amount of bolting depends on variety, time of transplanting, seedling size, and environment. The bolting percentage is highest during years in which temperatures are relatively low in late *kharif* at critical stage of development in sensitive varieties. Even bolting in onion sometimes takes place to the extent of 50-80% in early *rabi* or late *kharif* crop. To minimize bolter bulbs and to enhance marketable yield, the experiment was conducted during late *kharif* using

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twelve onion advance lines/ varieties to screen out bolting tolerant varieties suitable for late *kharif* season.

Materials and Methods

The investigation was carried out at the Experimental Farm of ICAR- Directorate of Onion and Garlic Research, Rajgurunagar for two years i.e. 2010-11 to 2011-12. Twelve advance lines/ varieties *viz.,* Bhima Kiran, Bhima Raj, Bhima Red, Bhima Shakti, Bhima Super, Bhima Shweta, N-2-4-1, DOGR-595, DOGR-1133, DOGR-1168, RGO-53 and W-448 were taken for the study. Seedlings of 50 days old were transplanted in main field during late *kharif* at five dates in the 15 days interval from 16 September to 16 November. Each genotype was raised in a net plot size of 3x2 m at spacing of 10x15 cm from plant to plant and row to row, respectively. A total of 400 plants were accommodated in each plot. The experiment was conducted under randomized block design in three replications. All the recommended package of practices were followed for raising the crop. Observations were recorded from 10 randomly selected plants for plant height, number of leaves, collar thickness, polar diameter, equatorial diameter, neck thickness and total soluble solids. Observations for marketable yield, total yield, percentage doubles and bolters were calculated on plot basis. Days to harvest after transplanting and percentage plant establishment were calculated. The total soluble solids (TSS) were determined with digital refractometer calibrated using distilled water. Monthly average maximum and minimum temperatures, photoperiod and total rainfall from ICAR-DOGR weather station for 2010-11 and 2011-12 are presented in Fig. 1. All statistical analysis was carried out based on twenty one traits using INDOSTAT software available in the Directorate.

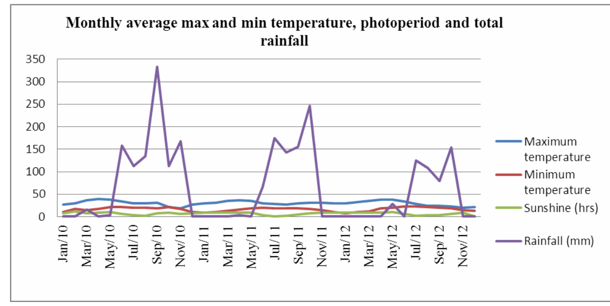

Fig. 1: Monthly average maximum and minimum temperature, photoperiod and total rainfall from DOGR weather station for 2010-11 and 2011-12.

Results and Discussion

The present investigation revealed that the significant variation among the twelve advance lines/ varieties in late *kharif* season, which indicated the presence of significant genetic variability for all the traits including bolting tendency. During first year, on the basis of overall mean of different dates of planting, minimum bolting percentage was recorded in Bhima Kiran (4.35%) followed by DOGR-595 (4.50%) and DOGR-1168 (5.55%) whereas highest marketable yield was recorded in DOGR-1168 (41.51 t/ha) followed by DOGR-1133 (39.44 t/ha) and DOGR-595 (38.32 t/ha) as presented in Table 1. Highest percentage of marketable yield was recorded in Bhima Kiran (79.52%) followed by DOGR-595 (79.04%) and DOGR-1133 (78.00%). DOGR-1168 exhibited maximum percentage of A grade bulbs (49.40%) followed by DOGR-1133 (49.30%) and Bhima Kiran (49.17%) whereas W-448 recorded maximum average bulb weight (121.60 g) followed by DOGR-1168 (112.64 g) and DOGR-595 (111.53 g). These results are in conformity with the findings of Sawant et

Table 1a: Mean performance of advance lines/ varieties during late **kharif** 2010-11.

S. No.	Entries	1 PH (cm)	2 NOL	3 CTh (mm)	4 P (mm)	5 E (mm)	6 N (mm)	7 % AGB	8 % BGB	9 % CGB	10 % Double	11 % UMB
1	Bhima Kiran	63.58	11.21	18.49	45.35	53.71	5.35	49.17	22.74	7.62	11.55	4.57
2	Bhima Raj	60.01	12.59	17.73	46.85	50.74	5.35	44.13	20.78	9.01	12.21	2.63
3	Bhima Red	62.87	11.83	17.74	46.03	52.69	5.05	38.26	18.68	7.23	13.74	2.33
4	Bhima Shakti	62.67	11.53	18.32	45.01	54.10	5.00	40.32	21.78	6.60	19.70	3.68
5	Bhima Super	62.40	11.58	17.17	45.78	52.80	4.17	41.14	21.17	8.08	9.08	2.79
6	Bhima Shweta	64.09	11.71	18.31	46.86	52.56	5.23	29.29	19.41	5.82	15.30	3.83
7	N-2-4-1	63.07	11.88	18.69	44.99	53.69	5.59	34.75	28.98	9.63	9.93	4.36
8	DOGR-1133	66.51	12.19	18.97	45.44	52.25	4.36	49.30	21.57	7.14	11.11	3.66
9	DOGR-1168	66.50	12.98	18.38	45.19	54.64	4.65	49.40	20.65	7.31	14.15	2.84
10	DOGR-595	65.97	11.74	18.89	44.98	56.20	5.28	47.83	23.45	7.75	12.92	3.41
11	RGO-53	64.43	11.88	17.63	43.31	51.01	4.29	38.91	16.79	4.75	18.03	1.56
12	W-448	60.45	12.43	18.51	44.74	53.27	5.25	36.27	17.55	7.08	14.42	2.64
	Mean	63.55	11.96	18.24	45.38	53.14	4.96	41.56	21.13	7.33	13.51	3.19
	SE	2.27	0.61	0.81	1.55	2.07	0.61	4.19	3.20	1.65	2.26	0.82
	CD 5%	6.65	1.78	2.38	4.56	6.08	1.79	12.28	9.39	4.83	6.56	2.40

PH = Plant height, NOL = Number of leaves, CTh= Collar thickness, P = Polar diameter, E = Equatorial diameter, N = Neck thickness, % AGB = % A grade bulbs, % B = % B grade bulbs, % C = % C grade bulbs, % D = % Double bulbs, %UMB = % Unmarketable bulbs.

al. (2002), Gupta et al. (2011a), Bosekeng and Coetzer (2013) and Gupta et al. (2015).

In second year, on the basis of overall mean of different dates of planting, minimum bolting percentage was recorded in Bhima Kiran (2.31%) followed by DOGR-595 (2.56%) and DOGR-1168 (3.05%) whereas the highest marketable yield was found in Bhima Shakti (36.83 t/ha) followed by DOGR-1168 (36.17 t/ha) and DOGR-595 (35.71 t/ha) as shown in Table 2. Highest percentage of marketable yield was recorded in DOGR-595 (92.90%) followed by Bhima Kiran (91.72%) and DOGR-1168 (90.74%). Whereas Bhima Shakti exhibited maximum percentage of A grade bulbs (40.37%) and average bulb weight (80.29 g) followed by DOGR-1168 (40.34% & 78.14 g) and Bhima Kiran (38.76% & 73.72 g), respectively. These results are in conformity with the findings of Gupta et al. (2011b) and Gupta et al. (2015). Bhattarai et al. (1995) found significant variation between the tested cultivars for different characters including bolting tendency. Cramer (2003) reported earlier sowing dates resulted in larger plants with more leaves than later sowing dates when compared early in the growing season. The mechanism of bolting resistance for cultivar may be a smaller plant size and/or a greater plant size required for receptivity to bolting-inducing temperatures compared to bolting-susceptible cultivars. In general, cultivars exhibited less bolting, later maturity dates and increase in bulb yield with a delay in sowing.

Table 1b: Mean performance of advance lines/ varieties during late *kharif* 2010-11.

S.	Entries	12	13	14	15	16	17	18	19	20	21
No.		% Bolters	% ROT	% Mrk.	MY (t/ ha)	TY (t/ ha)	(%) TSS	Centre	MBW (g)	DTH	%Pl. Estab.
1	Bhima Kiran	4.35	0.00	79.52	36.33	45.45	12.68	1.40	104.17	144	69.57
2	Bhima Raj	11.24	0.01	73.92	33.77	45.63	11.85	1.75	98.04	145	76.01
3	Bhima Red	19.72	0.05	64.17	28.49	44.57	12.33	1.57	104.22	145	71.02
4	Bhima Shakti	7.80	0.13	68.69	34.14	50.55	12.37	1.37	106.42	145	76.15
5	Bhima Super	17.06	0.66	70.40	33.08	47.08	12.01	1.50	102.77	145	75.60
6	Bhima Shweta	25.89	0.47	54.52	23.41	43.82	12.56	1.87	96.86	144	74.92
7	N-2-4-1	12.36	0.00	73.35	31.13	41.35	12.51	1.38	98.07	145	67.00
8	DOGR-1133	7.20	0.03	78.00	39.44	49.02	12.48	1.47	111.89	144	70.77
9	DOGR-1168	5.55	0.11	77.35	41.51	54.03	12.42	1.43	112.64	145	77.04
10	DOGR-595	4.50	0.13	79.04	38.32	48.51	12.28	1.57	111.53	144	71.18
11	RGO-53	19.78	0.18	60.45	28.79	48.31	12.01	1.52	110.27	144	71.69
12	W-448	21.90	0.14	60.90	29.62	49.00	12.47	1.62	121.60	144	73.02
	Mean	13.11	0.16	70.03	32.91	47.28	12.33	1.54	106.54	144.31	72.83
	SE	2.51	0.35	3.67	1.46	1.67	0.28	0.15	7.15	0.13	4.23
	CD 5%	7.36	1.02	10.78	4.29	4.89	0.83	0.43	20.97	3.63	12.40

%Mrk. = % of marketable bulbs on weight basis, MY = Marketable yield, TY = Total yield, TSS = Total soluble solids, MBW = Average marketable bulb weight, DTH = Days to harvest after transplanting, %Pl. Estab.= % Plant establishment.

Table 2a: Mean performance of advance lines/ varieties during late *kharif* 2011-12.

S.	Entries	1	2	3	4	5	6	7	8	9	10	11
No.		PH (cm)	NOL	CTh (mm)	P (mm)	E (mm)	N (mm)	% AGB	% BGB	% CGB	% Double	% UMB
1	Bhima Kiran	58.41	9.21	14.07	46.33	51.82	5.72	38.76	38.27	14.70	3.23	2.56
2	Bhima Raj	59.11	9.05	13.33	46.05	51.54	5.80	33.64	37.68	14.80	5.82	2.08
3	Bhima Red	59.02	9.13	12.88	46.37	50.30	5.35	36.67	32.57	14.69	5.56	3.10
4	Bhima Shakti	58.65	9.21	13.59	48.39	53.90	5.95	40.37	37.98	11.55	4.09	1.71
5	Bhima Shweta	58.46	9.03	12.87	44.33	50.05	5.03	36.63	31.67	13.39	6.00	2.54
6	Bhima Super	57.86	8.91	12.28	45.72	50.58	4.81	33.36	37.37	15.17	3.60	1.90
7	N-2-4-1	59.12	9.08	13.57	45.70	49.90	6.11	33.69	31.11	13.37	4.38	3.82
8	DOGR-1133	58.90	9.58	14.10	46.51	52.22	5.26	38.60	34.62	15.42	4.22	1.99
9	DOGR-1168	58.58	9.12	13.05	46.88	52.23	5.59	40.34	37.26	13.14	3.65	2.29
10	DOGR-595	58.22	9.28	13.65	43.86	50.53	5.30	38.26	38.66	15.98	2.28	1.95
11	RGO-53	57.84	8.94	12.67	46.21	51.35	4.99	38.61	32.69	11.90	4.06	2.62
12	W-448	58.31	9.44	13.06	42.93	51.48	5.70	32.95	30.82	13.55	7.09	2.01
	Mean	58.54	9.17	13.26	45.77	51.33	5.47	36.82	35.06	13.97	4.50	2.38
	SE	1.05	0.23	0.80	1.78	0.99	0.49	3.27	2.44	2.51	0.67	1.18
	CD 5%	4.03	0.95	2.11	4.75	5.01	1.78	11.67	9.12	7.24	5.02	3.30

PH = Plant height, NOL = Number of leaves, CTH= Collar thickness, P = Polar Diameter, E = Equatorial diameter, N = Neck thickness, % AGB = %A grade bulbs, % B = % B grade bulbs, % C = % C grade bulbs, %D = %Double bulbs, %UMB =% Unmarketable bulbs.

Table 2a: Mean performance of advance lines/ varieties during late *kharif* 2011-12.

S. No.	Entries	12 % Bolters	13 % ROT	14 % Mrk.	15 MY (t/ ha)	16 TY (t/ ha)	17 (%) TSS	18 Centre	19 MBW (gm)	20 DTH	21 %Pl. Estab.
1	Bhima Kiran	2.31	0.19	91.72	32.68	35.65	13.14	1.24	73.72	135.67	78.68
2	Bhima Raj	5.77	0.23	86.11	31.67	37.08	12.65	1.40	69.36	134.13	82.07
3	Bhima Red	6.93	0.49	83.93	29.53	35.43	11.98	1.33	71.29	134.73	77.49
4	Bhima Shakti	4.22	0.08	89.91	36.83	41.06	12.67	1.23	80.29	135.40	80.67
5	Bhima Shweta	9.45	0.32	81.69	27.85	34.14	12.49	1.51	70.32	135.13	76.96
6	Bhima Super	8.44	0.16	85.90	31.43	36.73	12.12	1.28	69.69	134.47	81.85
7	N-2-4-1	13.39	0.24	78.17	28.96	37.44	12.71	1.33	72.44	136.20	79.20
8	DOGR -1133	5.10	0.05	88.64	33.85	38.36	12.75	1.33	74.36	135.27	81.47
9	DOGR -1168	3.05	0.27	90.74	36.17	40.00	12.99	1.29	78.14	134.93	81.62
10	DOGR-595	2.56	0.31	92.90	35.71	38.47	13.04	1.15	73.57	135.33	83.73
11	RGO-53	9.03	1.10	83.20	31.02	37.41	12.62	1.19	73.12	134.67	81.17
12	W-448	12.54	1.03	77.32	26.42	34.45	12.13	1.47	71.49	135.13	75.86
	Mean	6.90	0.37	85.85	31.84	37.18	12.61	1.31	73.15	135.09	80.06
	SE	1.90	0.00	2.08	1.03	1.04	0.33	0.18	2.23	0.74	1.99
	CD 5%	6.99	1.80	8.36	4.16	4.49	1.15	0.40	11.26	2.69	10.40

%Mrk. = % of marketable bulbs on weight basis, MY = Marketable yield, TY = Total yield, TSS = Total soluble solids, MBW = Average marketable bulb weight, DTH = Days to harvest after transplanting, %Pl. Estab.= % Plant establishment.

Table 3: Performance of onion advance lines/ varieties for bolting tolerance during 2010-11 & 2011-12

S. No.	Entries	% Double			% Bolters			MY t/ha		
		2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
1	Bhima Kiran	11.55	3.23	7.39	4.35	2.31	3.33	36.33	32.68	34.51
2	Bhima Raj	12.21	5.82	9.01	11.24	5.77	8.50	33.77	31.67	32.72
3	Bhima Red	13.74	5.56	9.65	19.72	6.93	13.32	28.49	29.53	29.01
4	Bhima Shakti	19.70	4.09	11.90	7.80	4.22	6.01	34.14	36.83	35.49
5	Bhima Shweta	9.08	6.00	7.54	17.06	9.45	13.26	33.08	27.85	30.47
6	Bhima Super	15.30	3.60	9.45	25.89	8.44	17.16	23.41	31.43	27.42
7	N-2-4-1	9.93	4.38	7.15	12.36	13.39	12.87	31.13	28.96	30.05
8	DOGR-1133	11.11	4.22	7.67	6.58	5.10	5.84	39.44	33.85	36.64
9	DOGR-1168	14.15	3.65	8.90	5.55	3.05	4.30	41.51	36.17	38.84
10	DOGR-595	12.92	2.28	7.60	4.50	2.56	3.53	38.32	35.71	37.02
11	RGO-53	18.03	4.06	11.04	19.78	9.03	14.40	28.79	31.02	29.91
12	W-448	14.42	7.09	10.76	21.90	12.54	17.22	29.62	26.42	28.02
	Mean	13.51	4.50	9.00	13.06	6.90	9.98	33.17	31.84	32.51
	S.E.	2.26	1.67	2.46	2.51	1.90	2.20	1.46	1.03	1.25
	C.D. 5%	6.56	5.02	5.79	7.36	6.99	7.17	4.29	4.11	4.20

On the basis of pooled data of both the years, Bhima Kiran (3.33%) recorded lowest bolting percentage followed by DOGR-595 (3.53%) and DOGR-1168 (4.30%) whereas highest marketable yield was recorded in DOGR-1168 (38.84 t/ha) followed by DOGR-595 (37.02 t/ha) and DOGR-1133 (36.64 t/ha) as shown in Table 3 and Fig. 2. Highest percentage of marketable yield recorded in DOGR-595 (85.97%) followed by Bhima Kiran (85.62%) and DOGR-1168 (84.05%). DOGR-1168 exhibited maximum percentage of A grade bulbs (44.87%) followed by DOGR-1133 (43.95%) and Bhima Kiran (43.97%) whereas W-448 recorded maximum average bulb weight (96.55 g) followed by DOGR-1168 (95.39 g) and Bhima Shakti (93.35 g). Similar results were reported by Patil et al. (2003) and found significant differences among genotypes at each crop stage for yield and bolting during late kharif season.

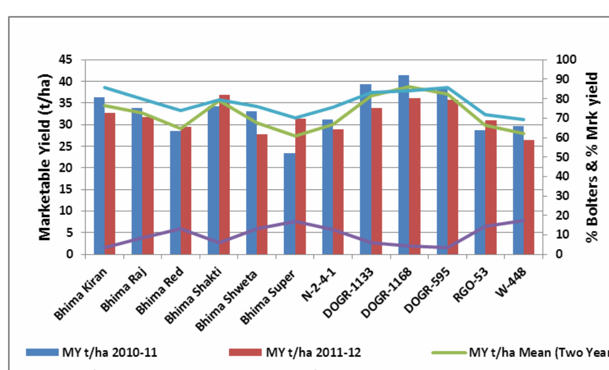

Fig. 2: Screening of onion advance lines/ varieties for bolting tolerance

Supe et al. (2008) reported genotype S-1 was superior in terms of growth and yield parameters including lowest premature bolting percentage.

In comparison to second year, bolter percentage was more during first year in each line and this may be due to temperature, photoperiod and rainfall variation i.e. climatic variations. But overall Bhima Kiran performed lowest bolting percentage in both the seasons. During first year all the lines were harvested within 144-145 days after transplanting, while in second year from 134 to 136 days were required for harvest after transplanting. These showed that during *late kharif* 2011-12 lines required comparatively less periods for harvesting and recorded less bolting percentage as compared to *late kharif* 2010-11. There is evidence that rapid bulb formation may suppress the emergence of inflorescence which have been initiated but have not yet elongated (Heath and Holdsworth, 1948) and these results also supported by Supe et al. (2008). The selection for maturity was highly efficient and the population selected for early maturity has potential to originate adapted cultivars, with bulb yield and quality superior to the available cultivars (Cardoso and Costa 2003). On the basis of two year data, highest marketable yield was recorded in DOGR-1168 (38.84 t/ha) followed by DOGR-595 (37.02 t/ha) with the minimum bolting percentage (<5%). Both lines also recorded >85% marketable yield, >90 g average bulb weight, >40% A grade bulbs and <10% doubles. Therefore, DOGR-1168 and DOGR-595 have been recommendation as bolting tolerant onion lines and highly suitable for late *kharif* and *rabi* season cultivation.

Lkkjka'k

प्याज को दुनिया में एक महत्वपूर्ण सब्जी फसल माना जाता है। भारत, प्याज के विश्व उत्पादन में 20 प्रतिशत योगदान देने वाला दूसरा सबसे बड़ा उत्पादक देश है। वर्तमान समय में, प्याज को भारत की विभिन्न .षि–जलवायु स्थितियों में उगाया जाता है और उन्नत प्रौद्योगिकी एवं बेहतर किस्मों का उपयोग करके सभी मौसमों (खरीफ, पिछेती खरीफ और रबी) में खेती की जाती है। बोल्टिंग एक शारीरिक विकार है जो प्याज की गुणवत्ता एवं विपणन योग्य उपज को कम करता है तथा इनमें भण्डारण क्षमता भी कम होती है। प्याज के पौधे द्विवार्षिक होते हैं जो आमतौर पर अपने विकास के दूसरे सत्र में फूलते हैं। हालांकि, अनुकूल स्थितियों के तहत, कुछ संवेदनशील किस्में पहले वर्ष मौसम में ही बोल्ट हो जाती हैं। बोल्टिंग प्रभेदों, पौधों की उम्र और पर्यावरणीय कारकों के परस्पर क्रिया का परिणाम है। बीज उत्पादन के लिए बोल्टिंग आवश्यक है, लेकिन कंद उत्पादन के दौरान यह अवांछनीय गुण है। बोल्टिंग प्रभेदों की संवेदनशीलता और प्रतिरोधकता के साथ बदलती है और यह तापमान या किस्म या दोनों से स्पष्ट रूप से प्रभावित होती है। भारत के मैदानी क्षेत्रों में वनस्पतिक विकास के दौरान तापमान में भिन्नता के चलते यह समस्या अधिकतर पिछेती खरीफ मौसम में होती है। उपयुक्त जाँच विधि के साथ बोल्टिंग प्रतिरोधी के प्रभेदों किस्मों का चयन द्वारा अधिक शक्तिशाली पंक्तियों को प्रदर्शित किया जा सकता है। बोल्टिंग के लिए प्रतिरोधी प्रभेद का चयन करने के लिए उपयुक्त जाँच प्रक्रिया की जानी चाहिए। पिछेती खरीफ मौसम के दौरान 15 दिनों के अंतराल पर प्याज की रोपण की पाँच तिथियों के साथ बारह उन्नत प्रभेदों किस्मों की बोल्टिंग प्रतिरोधकता के लिए जांच की गयी। दो वर्ष के परिणाम के आधार पर, सबसे कम बोल्टिंग प्रतिशत (<5%) डीओजीआर–595 (37.02 टन/हेक्टेयर) में पायी गयी तथा दूसरे नंबर पर डीओजीआर–1168 (38.84 टन/ हेक्टेयर) थी जिसमें अधिकतम विपणन योग्य उपज दर्ज की गयी। इस प्रकार, उपरोक्त प्रभेदों/किस्मों का प्रजनन कार्यक्रम में पुनः सुधार के लिए उपयोग किया जा सकता है।

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