



Evaluation of F₁ hybrids in Onion Developed through Male Sterility

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ABSTRACT

Eight F₁ hybrids viz., DOGR Hy-1, DOGR Hy-2, DOGR Hy-3, DOGR Hy-4, DOGR Hy-5, DOGR Hy-7, DOGR Hy-8 and DOGR Hy-50 were found promising and have been tested at various locations through All India Network Research Project on Onion and Garlic. Among these, DOGR Hy-1 (413.00 q/ha), DOGR Hy-2 (349.60 q/ha) and DOGR Hy-50 (374.55 q/ha) showed 42.84%, 20.91% and 24.11% heterosis, respectively, for bulb yield over the best check during *rabi* season. DOGR Hy-3 (342.00q/ha), DOGR Hy-4 (340.80 q/ha) and DOGR Hy-5 (387.25q/ha) showed 16.22%, 15.81% and 20.11% heterosis, respectively, over the best check during *kharif* season. DOGR Hy-7 (407.50 q/ha) showed 34.88% heterosis over the best check Bhima Red during *rabi* and also found suitable for *kharif*. DOGR Hy-8 (544.45 q/ha) showed 23.57% heterosis over the best check Bhima Shakti during late *kharif*. Although all hybrids had good storability, early maturity and free from doubles and bolters, two hybrids namely DOGR Hy-7 and DOGR Hy-50 were the best in respect of these characters.

Keywords: Onion, F₁ hybrids, performance, short day, MS line, earliness and uniformity



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INTRODUCTION

Onion (*Allium cepa* L.) is a high-value spice cum bulbous vegetable crop cultivated in almost all parts of the country. In India, onion occupies an area of 1.32 million hectares with the production of 20.93 million tonnes. Even though India ranks first in the area under onion in the world and second in production but its productivity is low (15.9 t/ha) as compared to world's productivity (20.4 t/ha). One option to achieve a quantum jump in yield is through the exploitation of heterosis. Heterosis breeding provides an opportunity for improvement in productivity, earliness, uniformity, and yield attributing characters. Most of the area under onion cultivation in India is covered by open-pollinated varieties and whereas the areas under hybrid have been increased in other countries. Nowadays, a development of F₁ hybrids has been increased in both private and public sector in India.

Onion is a highly cross-pollinated crop due to protandrous nature of flowers. Development of hybrids through hand emasculation and pollination is very difficult and impossible to produce hybrids economically. In 1925, the discovery of cytoplasmic male sterility in the onion variety Italian Red by led to the commercial production of hybrids (Havey, 1993). Due to the importance of heterosis breeding, male sterility proved an asset particularly in crops like onion. Before Jones and Clarke (1943) reported male sterility in onion from an interaction between recessive nuclear gene (chromogene) and cytoplasmic factor (cytogene), all onion varieties were open-pollinated offering little genetic and marketing protection for seed companies.

Development of hybrids in onion faces major difficulty because of the high rate of inbreeding depression with drastic

decreases in growth, bulb size, and seed production after only two cycles of self-pollination (Jones and Davis, 1944). Despite reports on high percentage of heterosis, hybrids in onion have not made headway in India.

Very little work has been done in India in the field of onion hybrids. Despite controversial issues, hybrids are most needed to achieve a quantum jump in yield, bringing uniformity in bulb and plant characteristics. Therefore, the present investigation was undertaken to study the response of different F₁ hybrids developed through male sterile lines in order to develop commercial hybrids with important horticultural traits.

MATERIALS AND METHODS

The present study was conducted in the experimental field of ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune (Maharashtra) during *kharif*, late *kharif* and *rabi* 2010-11 to 2014-15. Twelve male parents viz., Bhima Super, Bhima Red, Bhima Raj, RGO-53, DOGR-592, DOGR-595, DOGR-1133, DOGR-1168, DOGR-1203, Bhima Kiran, Bhima Shakti and N-2-4-1; and five male sterile lines (female) viz., MS 111A, MS 222A, MS 1600A, MS 48A and MS 65A were utilized in the hybridization programme. They were planted in 2:1 ratio at the spacing of 30 x 45 cm in the plot size of 4 x 4 m. (Fig. 1).



Fig.1: Hybrid seed production in onion

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Strict pollination was followed under nylon cages and pollination by keeping honey bee boxes. F₁ seeds obtained were sown in the month of June for *kharif*, early September for late *kharif* and November for *rabi* and about 45 days old seedlings of 60 F₁ hybrids along with its parents and checks were transplanted in the field at the spacing of 10 × 15 cm in the plot size of 1.0 × 1.05 m (Fig. 2).



Fig.2: Field performance of F₁ hybrids in onion

The experiment was laid out in Randomized Block Design with three replications. The observations were recorded on five randomly selected plants and bulb yield on plot basis in each replication for each F₁ hybrid on twenty-one important growth, yield, and quality parameters. All statistical analysis was carried out based on twenty-one traits using INDOSTAT software available in the Directorate.

RESULTS AND DISCUSSION

The present investigation revealed that the significant variation among all the entries in *kharif*, late *kharif* and *rabi* seasons. When large numbers of test cross were made, only

certain crosses result in desirable F₁s. Therefore, a number of adapted male-sterile and maintainer lines needs to be used in the development of F₁ hybrid. Breeding for hybrid technology in onion has been described in details by Veere Gowda and Gupta, 2014 and Gupta et.al. 2015. Heterosis for yield, earliness, uniformity, storage quality and dry matter content has been reported by many workers. In 1959 onion hybrids in New York surpassed open-pollinated varieties by 30% in yield and increase in storage life up to 40%, which stimulated the growing of F₁ onion hybrids in the northern United States and Canada. Variety protection was a second strong stimulus for the popularity of F₁ hybrids in onion.

F₁ hybrids developed under hybrid network programme at ICAR-DOGR by using two CMS lines indicated very high percentage of heterosis over standard checks which ranged from 17 to 59 per cent over N-2-4-1 and 11 to 50 per cent over Agrifound Light Red (Lawande, 2004). Eight F₁ hybrids viz., DOGR Hy-1, DOGR Hy-2, DOGR Hy-3, DOGR Hy-4, DOGR Hy-5, DOGR Hy-7, DOGR Hy-8 and DOGR Hy-50 were found promising and have been tested at various locations through AINRPOG (Table 1, Table 2 and Table 3).

On the basis of mean data, growth and quality parameters of promising F₁ hybrids along with checks for were estimated. During *rabi* season, plant height ranged from 56.88-59.07 cm, number of leaves 9.00-9.88, collar thickness 11.05-12.08 mm, polar diameter 45.98-49.52 mm, equatorial diameter 54.03-56.27 mm, percent marketable yield 93.57-96.51, TSS (%) 11.82-12.12% and plant establishment ranged from 91.50-96.08% (Table 1). Whereas during *kharif*, plant height ranged from 54.11-56.60 cm, number of leaves 7.30-8.28, collar thickness 11.42-12.18 mm, polar diameter 42.62-44.61 mm, equatorial diameter 47.74-51.83 mm, neck thickness 3.52-4.90 mm, % marketable yield 83.38-88.51, TSS (%) 11.44-12.05% and plant establishment ranged from 64.29-81.00%.

Table 1: Performance of growth and quality parameters of promising F₁ hybrids in onion during *rabi*

Entries	Plant height (cm)	No. of leaves per plant	Collar thickness (mm)	Polar diameter (mm)	Equatorial diameter (mm)	Neck diameter (mm)	%		Centerness of bulb	% Plant Establishment	E:P ratio
							Marketable bulbs	TSS %			
DOGR-Hy-1	59.02	9.88	12.08	47.71	55.64	5.92	95.75	11.82	1.50	94.46	1.17
DOGR-Hy-2	58.00	9.17	11.48	47.69	54.85	5.96	96.51	11.95	1.57	96.08	1.15
DOGR-Hy-3	57.87	9.22	11.82	45.98	55.83	5.58	94.03	11.88	1.40	92.79	1.21
DOGR-Hy-4	56.88	9.22	11.28	46.59	54.03	5.19	93.57	11.88	1.50	94.83	1.16
DOGR-Hy-5	58.01	9.43	11.49	49.52	56.27	5.55	95.16	12.07	1.43	91.50	1.14
DOGR-Hy-7	59.07	9.05	11.05	47.97	55.06	5.88	95.43	11.99	1.57	93.96	1.15
DOGR-Hy-8	58.59	9.00	11.67	48.35	56.07	5.81	94.29	12.06	1.43	93.33	1.16
DOGR-Hy-50	58.23	9.52	11.11	47.19	55.36	5.93	95.14	12.12	1.53	93.95	1.17
ArkaKirtiman (C)	58.79	9.27	11.02	46.08	51.50	5.81	93.97	11.75	1.50	92.18	1.12
ArkaLalima (C)	58.99	9.83	11.90	42.52	52.14	3.07	92.31	12.41	1.67	94.75	1.23
BhimaKiran (C)	56.61	9.07	11.47	46.85	54.85	4.95	95.77	11.85	1.43	94.42	1.17
Bhima Red (C)	56.62	8.43	11.56	46.65	53.77	4.88	93.41	11.60	1.43	90.21	1.15
Bhima Shakti (C)	57.22	8.73	11.17	48.66	55.30	5.97	95.09	11.71	1.37	89.58	1.14
Mean	58.21	9.31	11.50	47.62	55.39	5.73	94.99	11.97	1.49	93.86	1.16
C.V	3.76	5.71	8.23	5.17	6.55	10.32	2.68	1.81	10.72	4.18	1.27
S.E	1.27	0.31	0.55	1.43	2.05	0.58	1.47	0.13	0.09	2.24	1.43
C.D at 5%	3.71	0.91	1.60	4.17	6.00	1.67	4.28	0.37	0.26	6.54	1.44

Table 2: Performance of growth and quality parameters of promising F₁ hybrids in onion during *kharif*

	Plant height (cm)	No. of leaves per plant	Collar thickness (mm)	Polar diameter (mm)	Equatorial diameter (mm)	Neck diameter (mm)	% Marketable bulbs	TSS %	Center ness of bulb	% Plant Establishment	E:P ratio
DOGR-Hy-1	55.59	7.75	12.07	43.71	50.41	4.90	83.38	11.75	1.32	68.63	1.15
DOGR-Hy-2	55.42	7.30	11.42	42.62	51.38	3.93	86.87	11.58	1.34	70.04	1.21
DOGR-Hy-3	56.26	7.92	12.18	43.95	50.64	4.50	87.96	11.60	1.34	77.00	1.15
DOGR-Hy-4	55.27	8.22	12.12	42.92	49.46	3.52	87.99	11.85	1.20	73.88	1.15
DOGR-Hy-5	56.60	7.62	11.96	42.91	47.74	4.03	88.51	11.44	1.27	79.04	1.11
DOGR-Hy-7	54.52	7.85	11.72	43.94	51.83	4.54	85.45	11.81	1.24	64.29	1.18
DOGR-Hy-8	54.37	7.87	11.57	43.64	49.42	4.14	85.20	11.70	1.39	74.63	1.13
DOGR-Hy-50	54.11	8.28	12.18	44.61	49.52	3.98	87.30	12.05	1.16	81.00	1.11
ArkaKirtiman (C)	55.18	8.42	10.22	43.78	46.82	4.05	84.81	11.73	1.22	41.21	1.07
ArkaLalima (C)	50.36	8.12	10.40	41.44	48.43	4.09	87.93	11.68	1.24	45.63	1.17
Bhima Dark Red (C)	58.21	8.55	13.23	44.49	51.37	3.91	86.03	11.88	1.24	76.83	1.15
Bhima Red (C)	51.31	7.50	12.53	42.79	43.01	4.39	84.33	12.31	1.22	47.33	1.01
Bhima Super (C)	55.54	8.30	12.60	47.96	50.39	3.57	90.76	11.46	1.39	70.21	1.05
Mean	55.27	7.85	11.90	43.54	50.05	4.19	86.58	11.72	1.28	73.56	1.15
C.V	3.98	11.85	8.04	6.57	9.42	11.78	5.00	5.55	12.11	11.63	1.43
S.E	1.17	0.52	0.55	1.68	2.51	0.64	2.53	0.38	0.13	6.55	1.49
C.D at 5%	3.39	1.49	1.59	4.84	7.24	1.84	7.30	1.10	0.37	18.91	1.49

DOGR Hy-1 was suitable for *rabi* season and its bulbs were light red and flat-globe in shape. It was free from doubles and bolters. The average bulb weight was 68.20 g with a thin neck (Fig.1). This hybrid was harvested within 103 days. This hybrid produced 413.00 q/ha marketable yield which was 42.84% higher than check Bhima Kiran (289.10 q/ha). DOGR Hy-2 was suitable for *rabi* season and its bulbs were dark red

and globe in shape. It was free from doubles and bolters. The average bulb weight was 64.50 g with a thin neck (Fig.3). This hybrid was harvested within 100 days. Storage of bulb was very good and fewer storage losses were recorded after four months storage. This hybrid produced 349.60 q/ha marketable yield which was 20.91% higher than check Bhima Kiran (289.10 q/ha).

Table 3: Yield performance and suitability of promising F₁ hybrids in onion

Entries	MY (q/ha)	% Superiority over best check	ABW (g)	% Bolters	Days to Harvest	Season	Storability	Bulb Shape	Bulb Colour
DOGR-Hy-1	413.00	42.84	68.20	0.0	103	Rabi	Good	Flat Globe	Light Red
DOGR-Hy-2	349.60	20.91	64.50	0.0	100	Rabi	Good	Globe	Dark Red
DOGR-Hy-3	342.00	16.22	68.95	0.0	95	Kharif	Medium	Globe	Medium Red
DOGR-Hy-4	340.80	15.81	80.21	0.0	94	Kharif	Medium	Flat Globe	Dark Red
DOGR-Hy-5	387.25	20.11	75.21	0.0	101	Kharif	Medium	Globe	Dark Red
DOGR-Hy-7	407.50	34.88	68.72	0.0	105	Kharif & Rabi	Very good	Flat Globe	Dark Red
DOGR-Hy-8	544.45	23.57	83.33	3.89	118	LK	Good	Flat globe	Medium Red
DOGR-Hy-50	374.55	24.11	63.44	0.0	106	Rabi	Very good	Globe	Dark Red

LK= Late *Kharif*

DOGR Hy-3 was suitable for *kharif* season and its bulbs were globe with medium red. It produced uniform bulbs and free from doubles and bolters. This hybrid produced 342.00 q/ha marketable yield which was 16.22% higher than best check Bhima Super (294.27 q/ha). The average bulb weight

was 68.95 g with a thin neck. Its bulbs harvested in 95 days after transplant. DOGR Hy-4 was suitable for *kharif* season and its bulbs were uniform, flat-globe with attractive dark red. This hybrid produced 340.80 q/ha marketable yield which was 15.81% higher than best check Bhima Super (294.27 q/ha). It

was free from doubles and bolters. The average bulb weight was 80.21 g with thin neck. This hybrid was early in maturity and harvested in 94 days after transplanting. DOGR Hy-5 was suitable for *kharif* season and its bulbs were uniform, globe with attractive dark red. This hybrid produced 387.25 q/ha marketable yield which was 20.11% higher than best check Bhima Dark Red (322.40 q/ha). It was free from doubles and bolters. The average bulb weight was 75.21 g with thin neck. This hybrid was early in maturity and harvested in 101 days after transplanting (Fig.2).

DOGR Hy-7 was suitable for *rabi* season and its bulbs were flat-globe and dark red. It produced uniform bulbs and free from doubles and bolters (Fig.3). This hybrid produced 407.50 q/ha marketable yield which was 34.88% higher than best check Bhima Red (301.80 q/ha). The average bulb weight was 68.72 g with thin neck. Its bulbs harvested in 105 days after transplanting. Storage of bulbs was very good. Dark red bulbs with good storage during *rabi* season was the need of the day. It was also suitable for *kharif* season. DOGR Hy-8 was suitable for late *kharif* season and its bulbs were flat-globe with medium red. It produced uniform bulbs and free from doubles and 3.89% bolters. This hybrid produced 544.45 q/ha marketable yield which was 23.57% higher than best check Bhima Shakti (440.60 q/ha) (Fig.3). The average bulb weight

was 83.33 g with thin neck. Its bulbs harvested in 118 days after transplant and good in storage. DOGR Hy-50 was suitable for *rabi* season and its bulbs were uniform, globe shape, and attractive dark red. This hybrid produced 374.55 q/ha marketable yield which was 24.11% higher than best check Bhima Red (301.80 q/ha). It was free from doubles and bolters. The average bulb weight was 63.44 g with thin neck. This hybrid was early in maturity and harvested in 106 days after transplanting. Storage of bulbs was very good. It was also suitable for *kharif* season.

DOGR Hy-1, DOGR Hy-2, DOGR Hy-50 were suitable for *rabi* season (Fig.3). On the basis of mean data, DOGR Hy-1 recorded 413.00 q/ha marketable yield and showed 42.84% superiority over best check whereas DOGR Hy-2 and DOGR Hy-50 recorded 349.60 q/ha and 374.55 q/ha marketable yield which showed 20.91% and 24.11% superiority over the best check, respectively. These findings were similar to Shashikanth *et.al* (2007) and Ambresh and Veere Gowda (2013). The average bulb weight of DOGR Hy-1 was 68.20 g whereas DOGR Hy-2 and DOGR Hy-50 had 64.50 g and 63.44 g, respectively (Fig.1). The bulbs of DOGR Hy-1 were light red and flat globe in shape whereas bulbs of DOGR Hy-2 and DOGR Hy-50 were uniform, dark red and globe in shape (Fig.3).



DOGR Hy-1



DOGR Hy-2



DOGR Hy-3



DOGR Hy-4



DOGR Hy-5



DOGR Hy-7



DOGR Hy-50



DOGR Hy-8

DOGR Hy-1, DOGR Hy-2 and DOGR Hy-50 were ready to harvest within 110 days and were free from doubles and bolters. DOGR Hy-1 and DOGR Hy-2 had good storability whereas DOGR Hy-50 was very good in storability.

DOGR Hy-3, DOGR Hy-4 and DOGR Hy-5 were suitable for *kharif* season. On the basis of mean data, DOGR Hy-3 recorded 342.0 q/ha marketable yield and showed 16.22% superiority over best check whereas DOGR Hy-4 and DOGR Hy-5 recorded 340.80 q/ha and 387.25 q/ha marketable yield and showed 15.18% and 20.11% superiority over the best check, respectively. These findings were similar to [Shashikanth *et al.* \(2007\)](#) and [Ambresh and Veere Gowda \(2013\)](#). The average bulb weight of DOGR Hy-3 was 68.95 g whereas DOGR Hy-4 and DOGR Hy-5 had 80.21 g and 75.21 g, respectively. The bulbs of DOGR Hy-3 were medium red and globe in shape whereas bulbs of DOGR Hy-4 were uniform, dark red and flat globe in shape and bulbs of DOGR Hy-5 were uniform, dark red and globe in shape. DOGR Hy-3 and DOGR Hy-4 were early in maturity and harvested within 95 and 94 days, respectively whereas DOGR Hy-5 was ready to harvest in 101 days. DOGR Hy-3, DOGR Hy-4 and DOGR Hy-5 were free from doubles and bolters with medium storability.

DOGR Hy-7 was suitable for both *kharif* and *rabiseason* whereas DOGR Hy-8 was suitable for late *khari* fseason. On the basis of mean data DOGR Hy-7 recorded 407.50q/ha marketable yield which showed 34.88% superiority over the best check whereas DOGR Hy-8 produced 544.45 q/ha marketable yield which showed 23.57% superiority over the best check. Average bulb weight of DOGR Hy-7 and DOGR Hy-8 were 68.72 g and 83.33 g, respectively. Bulb shape of

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DOGR Hy-7 and DOGR Hy-8 was flat globe. Bulb colour of DOGR Hy-7 was dark red and DOGR Hy-8 was medium red. DOGR Hy-7 was free from doubles and bolters whereas 3.89% bolters found in DOGR Hy-8. Days to harvest of DOGR Hy-7 was 105 days and very good in storability whereas DOGR Hy-8 was ready to harvest within 118 days with good storability.

Only two onion hybrids Arka Kirthiman and ArkaLalima have been released from IIHR ([Veere Gowda *et al.*, 1998](#)). The adaptation of the hybrids by farmers was slow due to inherent problems associated with traditional onion production system in the country ([Veere Gowda *et al.*, 2002](#)). Some new hybrids are being developed in the country, which is under evaluation. [Gupta *et al.* \(2011\)](#) reported that two F₁ hybrids viz. MS-222A x 1133 (23.7%) and MS-111A x N-2-4-1 (19.7%) were found superior over standard check N-2-4-1. Hybrids developed by ICAR-DOGR were reported by [Veere Gowda](#). Two male sterile lines in onion also reported by [Gupta *et al.*, 2016](#). Improving onion varieties through introgression breeding was reported by [Gupta *et al.*, 2017b](#). Promising F₁ hybrids developed through male sterility was reported by [Gupta *et al.*, 2017a](#).

CONCLUSION

Eight F₁ hybrids viz., DOGR Hy-1, DOGR Hy-2, DOGR Hy-3, DOGR Hy-4, DOGR Hy-5, DOGR Hy-7, DOGR Hy-8 and DOGR Hy-50 were found promising and have been tested at various locations through AINRPOG. Although all hybrids had good storability, early maturity and free from doubles and bolters, two hybrids namely DOGR Hy-7 and DOGR Hy-50 were the best in respect of these characters.

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