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Phule bhaskar- a new variety of sunflower (*Helianthus annuus* L.), with higher seed yield and oil content suitable for cultivation in *kharif* season under rainfed regions of Maharashtra

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Abstract
The variety Phule Bhaskar was evaluated in Station Trials (2009-2014), University Multilocation Trials (2009-2014), State Population Trials (2009-2014) and in All India Coordinated Initial Hybrid Trial (2011). The variety Phule Bhaskar consistently and significantly recorded the higher seed yield than all the checks included in respective trials. On the basis of overall mean performance of 116 trials, the variety Phule Bhaskar (1807 kg ha^{-1}) had shown 21.3, 27.7, 66.0, 77.5, 21.8, 32.0 and 10.9 per cent increased seed yield over the check Bhanu, SS-56, LSF-8, Morden, Phule Raviraj, GK-2002 and TNAUSUF-7 respectively. The mean oil content of variety Phule Bhaskar had 37.9 per cent as against the standard checks Bhanu (36.0 %) and SS-56 (36.2 %). In addition to seed yield, the variety Phule Bhaskar has several advantages over the checks. The sunflower variety Phule Bhaskar comprises most of the desired attributes such as black and bold seed size (5.20 g. per 100 seed weight), higher seed yield (18.07q/ha), more potential seed yield (31.63 q/ha), high oil content (37.9 %), low hull content (24.4%) and early maturity (85 days). The cultivar Phule Bhaskar (SS-0808) was found moderately resistant to Alternaria leaf spot, Bud Necrosis and Powdery mildew. The cultivar Phule Bhaskar has shown minimum and comparable incidence of leaf hoppers, thrips, defoliators, helicoverpa and stem borer. Phule Bhaskar is recommended for release for cultivation under rainfed conditions in Maharashtra state during *kharif* season.

Keywords: Phule Bhaskar, seed yield, oil content, rainfed

Introduction
Sunflower (*Helianthus annuus* L) is one of the important oilseed crop, mostly used for edible oil purpose. It is an important source of unsaturated fatty acids like oleic and linoleic acids, which is desirable in human nutrition. Sunflower oil is the largest selling oil in the branded oil segment. It's wider adaptability, high yield potential, shorter duration, responsiveness to management practices and more profitability has played a significant role in cultivation across varied agro climatic zones in the country. Many improved varieties of sunflower are available; however, they are meager in seed yield and oil content. Hence, efforts are being made to develop variety with better yield and high oil content. The proposed improved variety Phule Bhaskar (SS-0808) is developed during 2008. The cultivar SS-0808 (Phule Bhaskar) was selected from the germplasm line GP-688-1 having black and medium bold seed size, high oil content, moderate resistance to alternaria leaf spot, Bud Necrosis and Powdery mildew and higher yield potential under rainfed conditions.

Materials & Methods
The variety Phule bhaskar (SS-0808) is a pidegree selection from germplasm line GP-688-1. The germplasm line GP-688-1, which is received from Directorate of Oilseeds Research, Hyderabad. The selected germplasm line GP-688-1 was tested at Zonal Agricultural Research Station, Solapur during kharif seasons of 2009 to 2014 in station trials. It was also tested in university multilocation trials at 7 locations of western Maharashtra viz; Savalvihir, Karad, Niphad, Jalgaon, Chas, Dhule and Solapur and in state population trials at 8 locations of Maharashtra viz; Akola, Buldhana, Ambejogai, Latur, Yawatmal, Badnapur, Savalvihir and Solapur during kharif seasons of 2009 to 2014. During kharif 2011, it was tested in All India Coordinated initial hybrid trials at 7 rainfed locations of India viz; Akola, Badnapur, Buldhana, Latur, Nandyal, Raichur and Solapur. During kharif seasons of 2013 and 2014, it was tested in 43 adaptive trials on various farmers field of Maharashtra. The experiment was conducted in random complete block design (RCBD) with a spacing of 45 x 30cm.

Observations of yield related traits were taken on five randomly selected plants from each row for days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), volume weight (g), 100 seed weight (g), hull content (%). The oil content was estimated by oil analysis through NMR, at Regional Agricultural Research Station, Raichur (Karnataka). The data of seed yield per hectare, oil yield per hectare and pest-disease resistance were recorded from different trials and analyzed by adopting methods suggested by Panse and Sukhatme (1967) [6].

Results & discussion

Performance of Phule Bhaskar for seed yield in station trials

The data on seed yield of Phule Bhaskar in comparison with local varietal checks Bhanu and SS-56 is presented in Table1. In five station trials (2009 to 2014) conducted at Zonal Agricultural Research Station Solapur, Phule Bhaskar recorded higher seed yield (1948 kg/ha) over check Bhanu (1554 kg/ha) and SS-56 (1371 kg/ha), which was 25.4 and 42.1 per cent higher than these varieties, respectively.

Performance of Phule Bhaskar for seed yield in university multilocation varietal trials

The university multilocation trials were conducted at Savalivihir, Karad, Niphad, Jalgoan, Chas, Dhule and Solapur for six years from 2009 to 2014. The pooled mean mean performance of Phule Bhaskar in 34 multilocation trials (Table 1.) revealed that, it had recorded highest 1847 kg/ha seed yield, followed by Bhanu (1559 kg/ha), SS-56 (1510 kg/ha), Phule Raviraj (1515 kg/ha) and GK-2002 (1399 kg/ha), which was 18.5, 22.3, 21.8 and 32.0 per cent higher over theses varieties and hybrids, respectively.

Performance of Phule Bhaskar for seed yield in state population trials

The state population trials were conducted at Savalivihir, Solapur, Akola, Buldhana, Ambejogai, Yawatmal and Badnapur for six years from 2009 to 2014. The pooled mean mean performance of Phule Bhaskar in 34 multilocation trials (Table 1.) revealed that, it had recorded highest 1702 kg/ha seed yield, followed by Bhanu (1396 kg/ha), LSF-8 (1025 kg/ha) and Morden (958 kg/ha), which was 21.9, 66.0 and 77.5 per cent higher over theses check varieties, respectively.

Performance of Phule Bhaskar for seed yield in initial hybrid trial and adaptive trials

During *kharif* 2011, the initial hybrid trials were conducted at seven rainfed locations of Akola, Badnapur, Buldhana, Latur, Raichur, Nandyal and Solapur. The average of these trials (Table 1) showed that, Phule Bhaskar had recorded 1716 kg/ha seed yield, which was 10.9 per cent higher than national check TNAUSUF-7 (1548 kg/ha). During *kharif* 2013 and 2014, total 43 adaptive trials were conducted on farmer's field of Maharashtra, to test the performance of Phule Bhaskar with varietal check Bhanu. The mean performance of Phule Bhaskar in 43 adaptive trials (Table 1) showed that, it had recorded higher seed yield (1655 kg/ha) than check Bhanu (1340 kg/ha), which was 23.5 per cent higher.

Table 1: Mean performance of Phule Bhaskar for seed yield per hectare in comparison with check varieties in different trials.

S.N	Name of trial/ (Locations)	Phule Bhaskar	Bhanu	SS-56	LSF-8	Morden	Phule Raviraj	GK-2002	TNAUSUF-7	S.E. ±	C. D. at 5%	C.V. (%)
1.	**Station Trial** (Solapur)											
	Kharif-2009	1962	1760	1454	-	-	-	-	-	90.6	250.4	10.3
	Kharif-2010	1698	1528	1240	-	-	-	-	-	73.3	210.1	9.7
	Kharif-2012	1893	1313	1216	-	-	-	-	-	94.7	270.7	13.1
	Kharif-2013	2024	1558	1445	-	-	-	-	-	108.8	309.7	12.4
	Kharif-2014	2165	1611	1498	-	-	-	-	-	135.3	386.1	15.6
	Mean (5)	1948	1554	1371	-	-	-	-	-	-	-	-
	Per cent increase	-	25.4	42.1	-	-	-	-	-	-	-	-
2.	**UMLT (**Savalivihir, Karad, Niphad, Jalgaon, Chas, Solapur, Dhule)											
	Kharif-2009 (5)	1843	1646	-	-	-	-	-	-	90.8	267.7	11.7
	Kharif-2010 (5)	1803	1628	-	-	-	-	-	-	60.4	176.4	8.1
	Kharif-2011 (5)	1859	1534	1697	-	-	-	1285	-	89.8	254.5	13.8
	Kharif-2012 (7)	1691	1377	1316	-	-	1424	-	-	77.3	217.5	13.4
	Kharif-2013 (6)	2029	1584	1516	-	-	1558	1536	-	85.7	243.0	12.6
	Kharif-2014 (6)	1856	1585	-	-	-	1565	1375	-	82.4	248.5	10.3
	Mean (34)	1847	1559	1510	-	-	1515	1399	-	-	-	-
	Per cent increase	-	18.5	22.3	-	-	21.8	32.0	-	-	-	-
3.	**SPT** (Akola, Buldhana, Ambejogai, Solapur, Savalivihir, Yawatmal, Badnapur)											
	Kharif-2009 (6)	1682	1481	-	996	1353	-	-	-	106.5	299.6	19.8
	Kharif-2010 (6)	1438	1112	-	927	842	-	-	-	119.4	336.4	29.1
	Kharif-2011 (7)	1823	1514	-	889	786	-	-	-	93.3	263.1	18.8
	Kharif-2012 (5)	1879	1591	-	1396	-	-	-	-	84.4	241.1	12.5
	Kharif-2013 (4)	1778	1348	-	945	892	-	-	-	74.9	214.9	14.2
	Kharif-2014 (6)	1609	1330	-	998	919	-	-	-	62.5	188.5	12.6
	Mean (34)	1702	1396	-	1025	958	-	-	-	-	-	-
	Per cent increase	-	21.9	-	66.0	77.5	-	-	-	-	-	-
4.	**IHT-AICRP Trial (**Akola, Badnapur, Buldhana, Latur, Nandyal, Raichur, Solapur)											
	Kharif-2011 (7)	1716	-	-	-	-	-	-	1548	40.1	112.2	12.1
	Per cent increase	-	-	-	-	-	-	-	10.9	-	-	-
5.	**Adaptive Trials** (On farmer's field of Maharashtra)											
	Kharif-2013 (23)	1730	1390	-	-	-	-	-	-	-	-	-
	Kharif-2014 (20)	1580	1290	-	-	-	-	-	-	-	-	-
	Mean (46)	1655	1340	-	-	-	-	-	-	-	-	-
	Per cent increase	-	23.5	-	-	-	-	-	-	-	-	-
	Overall mean	1807	1490	1423	1025	958	1515	1399	1548	-	-	-
	Per cent increase	-	21.3	27.7	66.0	77.5	21.8	32.0	10.9	-	-	-

UMLT- University multilocation varietal trial, SPT- State population trial, IHT- Initial hybrid trial

Overall performance of Phule Bhaskar for seed yield

Considering the overall mean performance in station trials, university multilocation trials, state population trials, initial hybrid trials and adaptive trials conducted from 2009 to 2014

(Table 1), Phule Bhaskar had recorded higher seed yield (1807 kg/ha) than Bhanu (1490 kg/ha), SS-56 (1423 kg/ha), LSF-8 (1025 kg/ha), Morden (958 kg/ha), Phule Raviraj (1515 kg/ha), GK-2002 (1399 kg/ha) and TNAUSUF-7 (1548 kg/ha), which was 21.3, 27.7, 66.0, 77.5, 21.8, 32.0 and 10.9 per cent higher over theses varieties and hybrids, respectively.

Overall performance of Phule Bhaskar for oil content and oil yield

Oil content was measured by oil analysis of seed samples through NMR and oil yield was estimated. The overall mean performance of Phule Bhaskar for oil content and oil yield in station trials, university multilocation trials and state population trials conducted from 2009 to 2014 (Table 2) showed that, it had recorded 37.9 per cent mean oil content, which was higher than Bhanu (36.0%) and SS-56 (36.5%) by 5.3 and 4.7 per cent. Considering the overall mean oil yield, Phule Bhaskar had recorded higher oil yield (704 kg/ha) than check Bhanu (545 kg/ha) and SS-56 (532 kg/ha), which was 29.2 and 32.3 per cent higher over Bhanu and SS-56, respectively.

Table 2. Oil content and oil yield performance of Phule Bhaskar in comparison with check varieties Bhanu and SS-56 in different trials.

S. No.	Name of Trial & Year	Oil content (%)			Oil yield (kg ha^{-1})		
		Phule Bhaskar	Bhanu©	SS-56 ©	Phule Bhaskar	Bhanu ©	SS-56 ©
Station Trial							
1.	*Kharif*-2009	38.1	36.1	38.3	748	635	557
2.	*Kharif*-2010	36.5	35.0	33.8	620	535	419
3.	*Kharif*-2012	37.0	35.1	31.0	700	461	377
4.	*Kharif*-2013	40.4	38.4	39.0	818	598	564
5.	*Kharif*-2014	39.3	36.4	37.1	851	586	556
	Mean	38.3	36.2	35.8	747	563	495
University Multilocation Trial							
6.	*Kharif*-2009	39.1	37.2	-	721	612	-
7.	*Kharif*-2010	37.1	35.8	-	669	583	-
8.	*Kharif*-2011	39.4	38.9	37.8	732	597	509
9.	*Kharif*-2012	37.6	35.9	36.4	644	505	597
10.	*Kharif*-2013	39.6	36.9	36.1	803	585	679
11.	*Kharif*-2014	37.7	35.9	-	731	565	-
	Mean	38.4	36.8	36.8	717	575	595
State Population Trial							
12.	*Kharif*-2009	37.3	36.3	-	627	538	-
13.	*Kharif*-2010	36.9	34.8	-	531	387	-
14.	*Kharif*-2011	36.5	34.5	-	665	522	-
15.	*Kharif*-2012	35.9	33.5	-	675	533	-
16.	*Kharif*-2013	38.5	35.3	-	685	476	-
17.	*Kharif*-2014	38.2	35.6	-	747	550	-
	Mean	37.2	35.0	-	655	501	-
Overall Mean		37.9	36.0	36.2	704	545	532
Per cent increase		-	5.3	4.7	-	29.2	32.3

Performance of Phule Bhaskar in agronomic trial

The data regarding performance of Phule Bhaskar in agronomic trial is presented in Table 3. The genotype Phule Bhaskar had recorded significantly higher seed yield (1829 kg/ha), over check variety Bhanu (1597 kg/ha). The seed yield of Phule Bhaskar and Bhanu increased with increase in fertilizer level of 125% RDF and wider spacing of 60x30 cm. The interaction effects of genotypes x fertilizer levels, spacings x fertilizer levels and genotypes x spacings were found non-significant for seed yield.

Performance of Phule Bhaskar for disease and pest reaction

Phule Bhaskar had screened for reaction to major diseases and pests, along with checks in initial hybrid trial during kharif, 2011 at Akola, Bengaluru, Coimbatur, Hyderabad, Latur, Nandyal and Raichur.

The data regarding reaction to major diseases and pests are present in Table 4.

The variety Phule Bhaskar had shown moderately resistant reaction to Alternaria leaf spot (20.3%), Necrosis (16.4%) and powdery mildew (20.3%).

The Phule Bhaskar found less susceptible to infestation of leaf hoppers (5.9/plant), thrips (1.5/plant), defoliators (1.2/plant), *Helicoverpa* (1.2/plant) and stem borer (13%).

Table 3: Seed yield of Phule Bhaskar as influenced by fertilizer levels and plant spacing during *kharif* 2013.

Genotypes/ Spacings (cm)	Seed Yield (kg ha^{-1})				Mean Seed Yield (kg ha^{-1})
a) Genotypes x Fertilizer levels					
	Control	**75% RDF**	**RDF**	**125% RDF**	
Bhanu	1386	1530	1669	1803	1597
Phule Bhaskar	1464	1643	2035	2175	1829
Mean	1425	1586	1852	1989	1713
b) Spacings x Fertilizer levels					
	Control	**75% RDF**	**RDF**	**125% RDF**	
45 x 30 cm	1325	1539	1792	1868	1631
60 x 30 cm	1525	1633	1913	2111	1796
Mean	1425	1586	1852	1989	1713
c) Genotypes x Spacings					
	45 x 30 cm	**60 x 30 cm**	**-**	**-**	
Bhanu	1524	1669	-	-	1597

Phule Bhaskar	1737	1922	-	-	1829
Mean	1631	1796	-	-	1713
Factors	**SE ±**		**CD at 5%**		
Genotypes	38.7		111.9		
Fertilizer levels	54.8		158.2		
Spacings	38.7		111.9		
Genotypes x Fertilizer	77.5		NS		
Spacings x Fertilizer	77.5		NS		
Genotypes x Spacing	54.8		NS		

75%RDF- 37.5:18.75:18.75 (N: P_2O_5: K2O -Kg/ha), RDF- 50:25:25 (N: P_2O_5: K2O -Kg/ha), 125% RDF- 62.5:31.25:31.25 (N: P_2O_5: K2O -Kg/ha)

Table 4: Reaction to major diseases and pests in IHT *kharif* 2011 (Overall locations)

Entry	Alternaria leaf spot %	Necrosis %	Powdery mildew %	Leaf hoppers per plant	Thrips per plant	Defoliators per plant	Helicoverpa per plant	Stem borer incidence %
Phule Bhaskar	20.3 (26.78) (MR)	16.4 (23.89) (MR)	20.3 (26.78) (MR)	5.9	1.5	1.2	1.2	13
DRSH-1	21.9 (27.90) (MR)	19.8 (26.42) (MR)	17.8 (24.95) (MR)	5.8	1.8	1.2	0.9	22.9
KBSH-1	27.2 (31.43) (S)	28.9 (32.52) (MS)	31.5 (34.14) (S)	6.4	1.8	1.1	1.3	15.5
KBSH-44	29.5 (32.89) (S)	21.7 (27.76) (MR)	18.4 (25.40) (MR)	4.7	1.5	1.9	1.2	17.7
TNAUSUF-7	26.8 (31.17) (S)	27.6 (31.69) (MS)	26.5 (30.98) (S)	6.9	2.3	0.9	1	23.9
S.E. ±	2.83	2.29	2.66	0.76	1.16	0.30	0.12	1.75
C.D. at 5%	8.26	7.04	8.69	2.34	3.61	1.19	0.47	5.98

Figures in the parentheses indicate the arcsin values, MR-Moderately resistant, MS-Moderately susceptible, S-Susceptible

The botanical description and characteristics of Phule Bhaskar are present in Table 5. Phule Bhaskar had showed marker characters like, triangular leaves with dark green colour, erect leaf blade orientation, medium hairiness on stem, tall plant height (165-170cm), convex turned down heads and black coloured seeds with no strips. Phule Bhaskar is early maturing variety required 52 to 55 days to 50% flowering and 80 to 85 days after sowing to maturity. Being high yield potential, Phule Bhaskar also showed medium oil content (37.9%), low hull content (24.4%) and market acceptability due to black colored seeds.

Table 5: Botanical description of Phule Bhaskar

Characters		Specifications
Hypocotyls pigmentation	:	Medium
Leaf size	:	25-28 cm
Leaf shape	:	Triangular
Leaf colour	:	Dark green
Leaf blistering	:	Absent
Leaf serration	:	Coarse
Leaf angle of vein	:	Obtuse
Orientation of blade	:	Erect
Leaf hairiness	:	Absent
Petiole anthocyanin	:	Absent
Stem hairiness	:	Present
Stem pigmentation	:	Absent
No. of leaves on stem	:	30-35
No. of ray floret	:	33-36
Shape of ray floret	:	Elongated
Colour of ray floret	:	Dark yellow
Colour of disk floret	:	Yellow
Stigma anthocyanin	:	Absent
Pollen colour	:	Dark yellow
Shape of bracts	:	Elongated
Bract anthocyanin	:	Absent
Head attitude	:	Turned down
Shape of head	:	Convex
Plant branching	:	Absent
Seed shape	:	Ovoid elongated
Seed coat colour	:	Black
Seed coat: Strips	:	Absent
Days to 50 % flowering	:	53-55
Head diameter (cm)	:	18.0 (Medium)
Plant height (cm)	:	165-170 (Tall)
Days to maturity	:	80-85 (early maturity)
100 seed weight (g)	:	5.20 (Medium bold)
Hull content (%)	:	24.4 (Low)
Oil content (%)	:	37.9 (Medium)
Volume weight (g/100 ml)	:	43.38
Marker characters of the variety	:	Dark green and triangular leaves, erect leaf blade orientation, medium stem hairiness, black coloured seeds with no strips
Recommended ecology	:	Suitable for optimum sown rainfed conditions of Maharashtra.

Conclusions

Sunflower genotype Phule Bhaskar (SS-0808) having dark black seed, high seed yield (18.07 q/ha) and high oil content (37.9 %) is recommended for release for cultivation under rainfed conditions in Maharashtra state during *kharif* season.

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