



RESEARCH PAPER

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BARI-2016, A high yielding, disease and drought tolerant peanut variety approved for commercial cultivation in Rainfed areas of Pakistan

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Abstract

BARI-2016 is the peanut variety developed by hybridizing two peanut genotypes No. 334 and Pw. during 1995 at Barani Agricultural Research Institute (BARI), Chakwal. F₁ to F₇ generations were raised following the pedigree selection method was used for focusing high yield, maximum number of seeds pod⁻¹, shelling percentage and vigorous plant type. On the basis of better yield performance of BARI-2016 at different locations in yield trials Punjab Seed Council approved it for general cultivation based on its better yield performance and is having cultivated. The potential and average yield of BARI-2016 is 4100 and 2900kg ha⁻¹, respectively and it is tolerant to drought and Cercospora leaf spot with 60-70% recovery after shelling. More than 40% pods of BARI-2016 have 3-4 seeds pods⁻¹ which is a distinguished character of BARI-2016 and differentiate it from earlier approved varieties of peanut.

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Introduction

Peanut (*Arachis hypogaea* L.) is an annual leguminous crop in all over the world (Aninbon *et al.*, 2017). With good quality of oil, it is mostly consumed as a raw roasted snack (Chibarabada, *et al.*, 2017). The peanut grain is rich source of oil (43-55%) and protein (27-33%) Ahmed *et al.*, 2016. Peanut considered as a good nutritive food, it contains carbohydrates, proteins, important vitamins and minerals. Peanut grain contains carbohydrates (21.51g), lipids Fats 49.66g, fiber (8.0g), proteins (23.68g), energy 2448kJ (585 kcal) and water 1.55 g (Settaluri *et al.*, 2012). Peanut skins are rich in phenolic compounds and these polyphenols act as antioxidants (Lindsey *et al.*, 2018) and its butter is also widely used in cookies which improve the nutritional quality of cookies (Timbadiya *et al.*, 2017).

In Pakistan peanut being conventionally used as roasted nimko and in confectionery products. Its grain is not only the economic product but its haulm is also used to feed the domestic livestock (Naeem-Ud-Din *et al.*, 2012). It is cash crop of kharif season usually grown on sandy loam and well drained soils in Pakistan. In Pakistan, districts of Chakwal, Jhelum, Attock, Rawalpindi, Sahngar, Karak, Swabi are the major groundnut growing areas (Naeem-Ud-Din *et al.*, 2009 and Ahmed *et al.*, 2016). Peanut per hectare pod yield in the country is too low due to uncertain rainfall, insufficient application of inputs, unpredictable environmental factors, and unavailability of quality seed of new disease resistant high yielding varieties.

New genetic material and varieties play a key role to enhance the overall production (Naeem-Ud-Din *et al.*, 2005). Groundnut is not easy to hybridize Naeem-Ud-Din *et al.*, (2009). But on the other hand hybridization is a key method to create genetic variation in crop plants (Kalve and Tadege, 2017) for better yield and yield components.

The main objective for the development of BARI-2016 was to provide a variety which can replace the existing low yielding cultivars lacking desirable traits for disease and drought tolerance. Moreover, this new

variety has in built resistance to diseases and drought with more number of seeds pod⁻¹(3-4 seeded pod).

Material and methods

Location

The experimental site located within an elevation range of 32°55'49"N latitude and 72°51'20"E longitude, above the sea level with annual mean temperature 22.3°C, and annual average rainfall of 519mm. A field experiments were conducted at the Barani Agricultural Research Institute, Chakwal Punjab, Pakistan on sandy loam soil with field capacity and permanent wilting point values of 14.0 and 5.0% on weight basis with bulk density 1.65 gcm⁻³, respectively.

Soil analysis

Composite soil samples were collected at depth of 0–15 and 16-30cm before planting. The samples were weighed, air-dried and ground to pass through a 2 mm sieve before analysis. The soil profile was a sandy loam and the 0–30cm layer had 0.47% organic matter, 1.40% nitrogen (N), 4.20ppm available phosphate (PO₄⁻³) and 135ppm available potassium (K) with soil pH 7.74 with 60, 30 and 10% sand, silt and clay, respectively.

Developmental procedure

BARI-2016 is a new high yielding peanut variety developed through crossing between two peanut genotypes No.334 x Pw. This cross was made during crop season of peanut in 1995 at field area of Barani Agricultural Research Institute, Chakwal. Peanut line, Pw, white and pink virginia type with variegated seed coat having 10-15% pods with 3 seed and medium leaf size. Female parent line No.334 was a local cultivar early maturing with small and compact pods. Pedigree method was used for evolving the BARI-2016. Rigorous selection carried out from F₂ to F₄ generations as plant to row progeny with parents from 1997-1999. The selection in filial generations based on pod length, shelling %age, number of seeds pod⁻¹, number of pods plant⁻¹ disease reaction and drought tolerance was exercised. In F₅ generations a uniform line was picked up during 2000 on the base of breeding behavior with desired traits and these

were confirmed through progeny rows in F₆ to F₇ generations from 2001-2002.

The selected line was tested in preliminary yield trials (PYT), regular yield trial (RYT) and micro yield trial (MYT) at BARI, Chakwal along with standard check varieties. From 2003-2004 and 2005-2006, respectively along with check varieties at same site. The BARI-2016 was further evaluated in National Uniform Yield Trials for consecutive three years from 2008-2010 along with standard checks at the institute as well as at different locations of groundnut growing areas.

Layout and statistical analysis

BARI-2016 along with other groundnut material was tested in Randomized Complete Block Design (RCBD) maintaining plant to plant and row to row distance of 15 and 45 cm, respectively. During evaluation period, observations were recorded from 10 randomly selected plants. The data recorded throughout the developmental period for each trait, were subjected to statistical analysis of variance to establish the significant means of values following Steel *et al.*, 1997. Statistix 8.1 software was used for analysis of variance.

Results and discussion

Breeding history of BARI-2016 is depicted in Table 1. Hybridization programme was started in 1990-1995. All formalities for variety evolution were completed in 2013 by conducting event of spot examination. The yield data depicted in Table 2 revealed that BARI-2016 gave an average yield of 3259 kg ha⁻¹ while BARI-2000 and Golden (check) produced 2758 and 3112 kg ha⁻¹ pod and as such BARI-2016 showed yield increase of 18.22 and 4.67% over BARI-2000 and Golden varieties of groundnut. Higher yield of BARI-2016 than check varieties might be due higher shelling percentage and more 100 seed weight. BARI-2016 proved unique amongst approved varieties as it possessed 40%, 3-4 seeded pods, variegated seed coat and higher shelling percentage.

BARI-2016 surpassed by 14.3% over check BARI-2000 in PYT and also gave 24.2 and 18.8% yield edge over standard (BARI-2000 and Golden) in RYT, respectively. The candidate variety excelled the yield

by 15.6% over check BARI-2000. The excellent performance of BARI-2016 might be referred to its better yield components like higher number of pods plant⁻¹, greater number of seeds pod⁻¹, higher 100 grain weight and more 20 pods length as compared to standards checks which proved its superiority on other varieties.

Table 1. Developmental history of BARI-2016.

Sr. No.	Year	Generations/Trials
1.	1995	45 Crosses attempted (Hybridization work)
2.	1996	F ₁ 40 Generations
3.	1997	F ₂ 30 Progenies evaluated and selection of single plants
4.	1998	F ₃ 200 Progenies evaluated and selection for yield and other characters
5.	1999	F ₄ 210 Progenies evaluated and selection for yield and other characters
6.	2000	F ₅ 150 Progenies evaluated and selection for yield and other characters
7.	2001	F ₆ 80 Progenies evaluated and selection for yield and other characters
8.	2002	F ₇ 50 progenies evaluated and 20 lines for PYT
9.	2003 & 04	Preliminary Yield Trial (PYT)
10.	2005 & 06	Regular Yield Trial (RYT)
11.	2007	Micro/Advance Yield Trial
12.	2008 -2010	National Uniform Yield Trial (NUGYT)
13.	2013	Spot Examination was held in October-2013

Table 2. Yield performance of BARI-2016 in PYT, RYT and MYTs.

Sr. No.	Year	Name of Trial	BARI-2016	BARI-2000 *(c)	Golde n** (c)	% increase Over Check
1	2003	Preliminary Yield Trial	2905	2547	-	14.3*
2	2005	Regular Yield Trial	3644	2933	3067	24.2*, 18.8**
3	2007	Micro Yield Trial	3222	2787	3157	15.6*, 2.06**
Average yield kgha ⁻¹			3257	2755	3112	18.22*, 4.66**
% increase over check				18.22	4.67	

Groundnut advance line o2CG002 (BARI-2016) was evaluated in National Uniform Groundnut Yield Trial for consecutive three years 2008-2010. BARI-2016 was tested against competitive checks i.e BARI 2000, BARD-4079 and GOLDEN. BARI-2016 gave encouraging results depicted in Table 3. BARI-2016 gave 6.66, 9.25 and 12.69% higher yield than

BARI-2000, BARD-479 and Golden, respectively. NUGYT conducted at different localities which warrants the wider adaptability and acclimatization of BARI-2016 as compared to checks varieties.

Shelling percentage is an important and distinguishing yield component in groundnut and that it was 66% in case of BARI-2016 (Table 4). Good shelling percentage plays a vital role in pod yield in peanut (Naeem-ud-din *et al.*, 2012 and Liang *et al.*,

1996). BARI-2016 having higher shelling percentage has yield edge over other varieties therefore, candidate variety surpassed the check varieties. Biotic stresses especially diseases are major yield limiting factor in peanut whereas the newly evolved variety BARI-2016 is moderately resistant to *Cercospora* leaf spot and early tikka disease (Table 5) which ultimately resulted to higher yield of candidate strain and its release as commercial variety would minimize the yield gap in groundnut production.

Table 3. Yield performance of BARI-2016 in National Uniform Groundnut Yield Trial (NUGYT) 2008 to 2010.

Sr. No	Locations	2008			2009			2010		
		BARI-2016	BARD-479	GOLDEN	BARI-2016	BARD-479	GOLDEN	BARI-2016	BARD-479	GOLDEN
1	NARC, Islamabad	1920	2422	2697	2907	2838	2305	4126	3207	3047
2	Faisalabad	3220	2782	2012	3332	2530	2777	1388	1434	1943
3	BARI, Chakwal	2235	2054	2063	2013	1897	1889	2566	2560	2272
4	Quetta	2221	2320	2190				2055	1743	2063
5	Mingora	3077	2730	2683						
6	D I Khan	1069	1481	898						
7	Karak	3192	2998	3262						
8	Average	2419	2398	2258	2751	2422	2357	2533	2263	2331
9	% increase over Check		0.88	6.66		13.59	16.72		13.28	8.67

Table 4. Shelling percentage of BARI-2016 in NUGYT at five different locations during, 2010.

Entries	Location*				Mean
	NARC, Islamabad	BARI Chakwal	AARI, Faisalabad	QAARI, Quetta	
BARI-2016	70	62	62	70	66
BARD-479 (C)	67	58	58	72	64
Golden (C)	65	63	63	70	65

BARI-2016 was tested in 17 different locations during its evaluations history against three standard checks varieties and it gave an average yield advantage of 6.74, 10.68 and 22.81% over GOLDEN, BARI-2000 and BARD 479, respectively. It was fortunate that BARI-2016 gave 13.74% yield edge over three standard checks (Table 6) showing its wider adaptability to different ecological zones. Twenty pods length in groundnut is considered an important attribute and BARI-2016 attained first position on the victory stand regarding this character (Table 7).

It is depicted from yield data (Table 8) that maximum pod yield (2407kg ha^{-1}) was obtained by applying 20:80:20 NPK kg ha^{-1} at the time of sowing while gypsum was used @ 500kg ha^{-1} at flowering stage which gave maximum yield benefits compared to other fertilizer

doses. As far as row spacing is concerned, 45 cm row spacing proved to be the best for tested material under given environmental conditions.

Table 5. Average disease rating of BARI-2016 in NUGYTs during 2008, 2009 and 2010.

S. No.	Entry	Average disease rating
1	BARI-2016	5
2	BARI-2000	5
3	Golden	6
4	02CG003	7
5	02CG004	6

*BARI-2016 was under category 5 in 1-10 Florida *Cercospora* leaf spot disease scoring scale which shows moderate resistance against disease.

Tabulated data show that maximum pod yield in ground was recorded by using 160kg pods per hectare for three consecutive years (Table 9).

Maximum average yield 2383kg ha⁻¹ were observed by using 160kg pods as seeding rate closely followed by 180 kg seeding rate with average yield of 2252kg/ha.

Table 6. Summary of Yield performance of BARI-2016 in nineteen yield trials.

Year	Trial	Locations	Pod Yield (kg/ha ⁻¹)			
			BARI-2016 (o2CG 002)	BARD-479 (Chcek)	BARI-2000 (Check)	Golden (Check)
2003 & 04	PYT	2	2905	-	2547	-
2005 & 06	RYT	2	3644	-	2933	3067
2007	MYT	1	3222	-	2787	3157
2008	NUGYT	7	2419	2398	2258	-
2009	NUGYT	3	2751	2422	-	2357
2010	NUGYT	4	2533	2236	-	2331
Mean		19	2912	2352	2631	2728
Yield increase (%) over Checks				23.81	10.68	6.74
Over all yield increase (%)				13.74		

Table 7. Average 20 pods length (cm) of BARI-2016 in NUGYT 2010.

Entries	NARC, Islamabad	BARI, Chakwal	AARI, Faisalabad	Mean (cm)
BARI-2016	81	67	59	69
PG-1104	67	73	57	66
PG-1101	72	66	58	65
PG-492	70	67	56	64
BARD-479 (C)	63	61	61	62
PG-1092	61	66	57	61
Golden (C)	62	61	55	59
Location	68	66	58	
Mean				

Twenty pod length in groundnut is considered an important character. BARI-2016 remained at top securing 69 cm 20 pod length thus gave 12.29 and 16.95% more length there BARD-492 and Golden, respectively.

Table 8. Impact of Fertilizer doses and planting geometry on pod yield (kg ha⁻¹).

N:P:K (kg ha ⁻¹)	Row spacing (cm)			Average
	30 cm	45 cm	60 cm	
0:0:0	1329	1340	1260	1310
10:40:10	1600	1750	1400	1583
20:80:20	2360	2560	2300	2407
30:120:30	2200	2400	2350	2317
CV (%)	12.20			
LSD _{0.05}	130.25			

Table 9. Response of BARI-2016 to different seeding rates.

Seeding Rate (kg/ha ⁻¹)	2012	2013	2014	Average
100	1420	1400	1450	1423
120	1500	1575	1560	1545
140	1800	1900	1950	1883
160	2300	2400	2450	2383
180	2260	2300	2195	2250
CV (%)	8.75	10.12	12.6	
LSD _{0.05}	98.5	123	118.50	

Table 10. Response of BARI-2016 to different sowing date.

Year Genotypes	1 st March	15 th March	1 st April	15 th April	1 st May	15 th May	1 st June	15 th June
	2012 BARI-2016	1154	1851	2574	2439	2370	1800	1630
Golden	1810	1850	2488	2170	1850	1641	1601	1620
2013 BARI-2016	1753	1421	2456	2342	1753	1986	1385	1187
Golden	1919	1875	2288	2212	1560	1296	1200	1120

Table 11. Production technology for BARI-2016.

Soil	Loamy to sandy loam
Sowing Time	1 st April to 15 th May Depending upon rain fall
Fertilizer	20: 80: 20 N.P.K kg/ha ⁻¹ at sowing and 500 kg/ha Gypsum at flowering
Planting Geometry	Row to Row 45 cm, Plant to Plant 15-20 cm
Weed Control	Manual or pre-emergence or Post emergence
Harvesting	Mechanical
Threshing	Mechanical

Table 12. Physicochemical analysis of BARI-2016 in comparison with commercial variety.

Genotype	Oil contents (%)	Oleic acid (%)	Protein Contents (%)	100 seed weight (g)	Calci um (mg/g)	Shelling (%)
BARI-2016	54	62	27-30	60-65	57.5	65-70
Golden	45	55	23-25	55-60	49.5	62-65

Tabulated data showed variable response to different sowing dates and positively associated with the occurrence of rainfall (Table 10). Availability of moisture increased the germination and thus plant population per unit area and ultimately the yield of groundnut. On average basis, 1st April to 15th May might be the suitable sowing date for subject area. Production technology package is summarized in Table

11 for BARI-2016. Quality attributes of BARI-2016 in comparison with check are presented in Table 12 which depicts that BARI-2016 has 54% oil contents with 62% oleic acid against Golden check variety showing 45% oil contents with 55% oleic acid. Protein being the important of seed ranged from 27-30% in BARI-2016 where as its ranged recorded in Golden is 23-25%.



Fig. (a). Pectoral View of BARI-2016 cross, pods, plant and grains.

Conclusion

BARI-2016 is suitable for edible purposes having oil contents 54% with rich source of protein (27.30) BARI-2016 being bold seeded Variety (60-65gm. 100 seed weight) with high calcium contents (57.5mg/100g) and shelling percentage (65-70). Newly evolved variety is high yielding with fair tolerance to prevailing diseases of groundnut in Pakistan. BARI-2016 has charming variegated seed

color (pink + white) with high yield potential (4100kg/ha⁻¹) recommended for general cultivation in groundnut growing area.

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