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Full Length Article

FAKHAR-E-CHAKWAL: A Short Duration, High Yielding, Pink Seed Coat Colored Peanut Variety for the Punjab Barani Tract

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Abstract

Peanut is an important oilseed crop of barani areas of Pakistan. The yield potential of this crop is around 4000 kg ha^{-1} but in our country its average yield is 600–1000 kg ha^{-1}. Hence, the development of new and high yielding varieties is the ultimate solution to fill this yield gap. Fakhar-e-Chakwal, a new peanut variety, was developed to encounter the predilections of farmers, processors and end users. Current study was carried out for seven consecutive years (2013–2019). Pod yield, shelling percentage, early maturity, disease and drought tolerant with good quality traits were the main objectives of this study. The recommended experimental design by Punjab Seed Council (PSC) *i.e*., Randomized Complete Block Design was used to execute the research work. Based on good yield performance at diverse locations in yield trials, best suited variety for general cultivation. The potential and average yield of Fakhar-e-Chakwal is 2600 and 2000 kg ha^{-1} respectively and it is tolerant to drought and Early Tikka disease with 60–65% recovery after shelling. It matures 120 days in comparison with existing varieties which takes 180 days for maturity. Fakhar-e-Chakwal has more oil content (44.1%), oleic acid (62%) and calcium (57.5 mg g^{-1}) than check variety *i.e*., BARD-92. Hence, it could be concluded that Fakhar-e-Chakwal is a high yielding, short duration variety with improved quality parameters than existing peanut varieties. Furthermore, it is best suited in existing cropping season and farmers have enough time for sowing of winter crops which was not possible by growing long duration peanut varieties.

Keywords: Peanut; New variety; High yield; Short duration; Good quality

Introduction

There are three main types of groundnuts *i.e*., Virginia, Spanish and Valencia. *Arachis hypogaea* sub-spp. Fastigiata var. *vulgaris* are Spanish bunch types, *Arachis hypogaea* subspp. Hypogaea var. *hypogaea* is Virginia type and *A. hypogeal* subspp. Fastigiata var. *fastigiata* is Valencia in type. Cultivated peanut (*A. hypogaea* L.) is self-pollinated (2n = 4x = 40) with a genome size 2891 Mbp. The genus Arachis belongs to the family Fabaceae, subfamily Faboideae. Morphologically, terrestrial dissemination and based on crossing ability, the genus has been classified in to nine taxonomic groups. The genus consists of 80 designated species (Valls and Simpson 2005), that include diploids and tetraploids, of which *A. hypogaea* L. is the utmost significant and extensively cultivated. Peanut (*Arachis hypogaea* L.) is an annual leguminous crop in all over the world (Aninbon *et al*. 2017). With good quality oil, it is also mostly consumed as a raw roasted snack (Chibarabada *et al*. 2017). The peanut grain is a rich source of oil (40–60%) and protein (20–40%) and 10–20% carbohydrates (Ahmed *et al*. 2016). Groundnut provides 567 kcal of energy from 100 g of grains (USDA nutrient database). Additionally, it contains several nutrients that promote health, including minerals, antioxidants and vitamins. Peanut grain contains lipids, Fats 49.66 g, fibre (8.0 g), energy 2448 kJ (585 kcal) and water 1.55 g (Settaluri *et al.* 2012). Groundnut grain contains antioxidants like p-coumaric acid, Vitamin E and vital B-complex like thiamin, pantothenic acid, vitamin B-6, foliates and niacin. Peanut is a dietetic source of polyphenols, flavonoids and isoflavones. As they are extremely nutritious and groundnut foodstuffs are used as nourishing foods for energy and to combat malnutrition among the poor. 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

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of cookies (Timbadiya *et al*. 2017). Worldwide, 41% of peanut production is consumed and 49% is pressed for oil production. The oilcake meal is used as protein supplement and industrial raw material for livestock feed (Janila *et al*. 2016). Groundnut hierarchical is at 5th among oilseed crops globally after oil palm, soybean, rapeseed, and sunflower (FAO 2013).

Globally, groundnut is grown on an area of 29596 thousand hectare with yield of 1647 kg ha^{-1} while Pakistan is getting very low yield of 918 kg ha^{-1} from an area of 102 thousand hectares (FAO 2019). In Pakistan peanut is being conventionally used as roasted nuts 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*. 2005). 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 and Swabi are the major groundnut growing areas (Naeem-Ud-Din *et al.* 2009; Ahmed *et al.* 2016). Peanut per hectare pod yield in the country is very 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; Shah *et al.* 2020). Groundnut is not easy to hybridize (Naeem-Ud-Din *et al.* 2009; Kalve and Tadege 2017). But on the other hand; introduction, acclimatization and selection of better genotypes is the cheapest and fastest breeding method to overcome the shortage of varieties of agricultural crops.

In barani areas availability of water is a serious problem for growing of crops. As peanut is one of the major oilseed crops of barani area, hence it is important to develop such plant types which can withstand with less water and can gave more yield. Hence, the main objectives of this work were to develop new high yielding and drought tolerant peanut genotype. Early maturity and disease resistant were also the target traits in this work.

Material and Methods

Location

The experimental site located at 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 519 mm. Field experiments were conducted at the Barani Agricultural Research Institute, Chakwal Punjab, Pakistan for seven consecutive years (2013–2019) 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 g cm^{-3}, respectively.

Soil analysis

Composite soil samples were collected at depth of 0–15 cm and 16–30 cm 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 0–30 cm layer had 0.47% organic matter, 1.40% nitrogen (N), 4.20ppm available phosphate (PO_4^{-3}) and 135ppm available potassium (K) with soil pH 7.74 with 60, 30 and 10% sand, silt and clay, respectively.

Developmental procedure

Fakhar-e-Chakwal is a new high yielding peanut variety developed through screening and selection from the exotic germplasm from 2013–2014 at field area of Barani Agricultural Research Institute, Chakwal. Peanut line selected was an early maturing with bold and compact pods. The selection from the exotic germplasm was based on pod length, shelling percentage, number of seedspod^{-1}, number of pods plant^{-1}, disease reaction and drought tolerance. The uniform line was picked up during 2015 on the base of its adaptability with desired traits.

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 2015, 2016 and 2017. The Fakhar-e-Chakwal was further evaluated in National Uniform Yield Trials for two consecutive years from 2018 to 2019 along with standard check at the institute and at other groundnut growing areas.

Crop husbandry

Peanut is an important cash crop of barani areas. A sandy loam, well-drained and coarse textured are the best suitable soils for peanut production. One month before planting, tillage operations should be performed. Deep tillage with mouldboard ploughs up to the depth of 25–30 cm is recommended. Soils in barani areas is normally deficient in many important nutrients, hence organic fertilizers like farmyard manure should be applied one month before sowing and incorporated properly in soil to correct the nutrient deficiency. In case of chemical fertilizers 20 kg ha^{-1} nitrogen, 80 kg ha^{-1} phosphorous and 60 kg ha^{-1} potash was used. Gypsum also plays and important role for higher production and 400–500 kg ha^{-1} was applied just at the beginning time of monsoon season. Early March to end of April is the sowing time of peanut in Pakistan. Normally 45–60 cm row to row and 10 cm between plant to plant is maintained depends upon the type of peanut varieties. All other cultural practices like irrigation, spray for weed and disease control etc. are continued throughout growing season for better growth and yield.

Layout and statistical analysis

Fakhar-e-Chakwal 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). Statistixs 8.1 software was used for analysis of variance.

Results

Breeding history and yield performance trials

Breeding history and pedigree of Fakhar-e-Chakwal is depicted in Table 1. Acclimatization, selection and evaluation process was completed from 2013 to 2019. All formalities for variety evolution was completed in 2019 and spot examination was carried out. The yield data depicted in Table 2 revealed that Fakhar-e-Chakwal gave an average yield of 2200 kg ha^{-1} while BARD-92 (check) produced 1800 kg ha^{-1} pod and as such Fakhar-e-Chakwal showed yield increase of 22.2% over BARD-92 in PYT. Fakhar-e-Chakwal surpassed check variety due to its higher growth rate, shelling percentage and higher 100 seed weight. Fakhar-e-Chakwal proved unique amongst approved varieties as it possessed more number of seeds per pod.

Fakhar-e-Chakwal surpassed by 15.8% over check BARD-92 in RYT and also gave 19.1% yield edge over standard (BARD-92) in MYT, respectively. Overall Fakhar-e-Chakwal excelled 19.2% yield over standard check with average yield of 2050 kg ha^{-1}. The excellent performance of Fakhar-e-Chakwal might be referred to its rapid growth rate and better yield components like higher number of pods $plant^{-1}$, higher 100 grain weight and more pods length as compared to standards checks which proved its superiority over other varieties.

Groundnut advance line 12CG010 (Fakhar-e-Chakwal) was evaluated in National Uniform Groundnut Yield Trial (NUGYT) for two consecutive years 2018 & 2019 against competitive check *i.e.*, BARD-92. Fakhar-e-Chakwal gave encouraging results depicted in Table 3. Fakhar-e-Chakwal gave 32 and 6.56% higher yield than BARD-92 during 2018 and 2019, respectively. NUGYT conducted at different localities which warrant the wider adaptability and acclimatization of Fakhar-e-Chakwal as compared to check variety. Fakhar-e-Chakwal was tested in 10 different locations during its evaluations history against standard check variety and it gave an average yield advantage of 19.44% over BARD-92 (Table 4) showing its wider adaptability to different ecological zones.

Shelling percentage, disease resistance and other physiochemical performance

Shelling percentage is an important and distinguishing yield component in groundnut and it was 62% in case of Fakhar-e-Chakwal against BARD-92 which has 58% (Table 5; Fig. 1). Fakhar-e-Chakwal 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 Fakhar-e-Chakwal is moderately resistant to *Cercospora* leaf spot for both early and late leaf spot (Table 5) which ultimately resulted to higher yield of the candidate strain and its release as commercial variety would minimize the yield gap in groundnut production.

Table 1: Chronological development of Fakhar-e-Chakwal (12CG010)

Year	Pedigree	Remarks
2013-14	-	Acclimatization and Screening trials
2015	12CG010	Preliminary Yield Trial
2016	12CG010	Regular Yield Trial
2017	12CG010	➢ Micro Yield Trial ➢ Sowing dates Trial ➢ Fertilizer Requirement Trial
2018	12CG010	➢ National Uniform Yield Trial (4 locations) ➢ Sowing dates Trial ➢ Fertilizer Requirement Trial
2019	12CG010	National Uniform Yield Trial

Fig. 1: Pictorial View of Fakhar-e-Chakwal pods, plant and grains

"Twenty pods length" in groundnut is considered an important attribute and Fakhar-e-Chakwal attained first position regarding this character (Table 5) securing 74.6 cm vs 63 cm length in case of BARD-92.

Quality attributes of Fakhar-e-Chakwal in comparison with check are presented in Table 5, which showed that Fakhar-e-Chakwal had 44.1% oil contents with 62% oleic acid in comparison with BARD-92 showing 40.8% oil contents with 55% oleic acid. Protein being the important part of the seed ranged between 22–23% in Fakhar-e-Chakwal whereas its range recorded in BARD-92 is 21–22%.

Sowing date trials

Sowing time is the most important factor positively associated with the occurrence of rainfall and availability of moisture which increases germination per unit area and ultimately the yield of groundnut. Tabulated data showed variable response to different sowing dates (Table 6). On overall basis, 1st April to 30th May seemed to be the suitable time for subject area depicting 15th April as most suitable time for its sowing.

Seed rate trials

Tabulated data showed that maximum pod yield in

Table 2: Yield performance of Fakhar-e-Chakwal in PYT, RYT and MYT in kg ha^{-1}

Sr. No.	Year	Name of Trial	Fakhar-e-Chakwal	BARD-92	% increase over Check
1	2015	Preliminary Yield Trial	2200	1800	22.2
2	2016	Regular Yield Trial	1900	1640	15.8
3	2017	Micro Yield Trial	2050	1720	19.1
Average yield kg ha^{-1}			2050	1720	
% increase over check			19.2		

Table 3: Yield performance of Fakhar-e-Chakwal in national uniform groundnut yield trial (NUGYT) 2018 to 2019 in kg ha^{-1}

Sr. No	Locations	2018		2019	
		Fakhar-e-Chakwal	BARD-92	Fakhar-e-Chakwal	BARD-92
1	NARC, Islamabad	1988	1527	-	-
2	BARI, Chakwal	1898	1667	2142	1968
3	GRS Attock	1272	935	1294	1247
4	AZRI Bahawalpur	2607	1742	951	900
	Average yield in kg ha^{-1}	1941	1468	1462	1372
	% increase over Check	32.22		6.56	

Table 4: Summary of yield performance of Fakhar-e-Chakwal in ten yield trials

Year	Trial	Locations	Pod Yield (kg ha^{-1})	
			Fakhar-e-Chakwal (12CG010)	BARD-92 (Check)
2015	PYT	1	2200	1800
2016	RYT	1	1900	1640
2017	MYT	1	2050	1720
2018	NUGYT	4	1941	1468
2019	NUGYT	3	1462	1372
Mean		10	1911	1600
Yield increase (%) over Check in kg ha^{-1}				19.44

Table 5: Physicochemical analysis of Fakhar-e-Chakwal in comparison with commercial variety

Genotype	Oil contents (%)	oleic acid (%)	Protein contents (%)	100 seed weight (g)	20 pod length (cm)	Calcium (mg/g)	Shelling (%)	Tikka disease rating
Fakhar-e-Chakwal	44.1	62	22-23	93	74.6	57.5	62	5
BARD-92	40.8	55	21-22	81	63.0	49.5	58	5

Table 6: Yield response in kg ha^{-1} of Fakhar-e-Chakwal to different sowing date

Year	Genotypes	1st March	15th March	1st April	15th April	1st May	15th May	1st June	15th June
2017	Fakhar-e-Chakwal	1605	1820	2221	2633	2410	2122	2053	1960
	BARD-92	1590	1750	2165	2098	1987	1786	1709	1652
2018	Fakhar-e-Chakwal	1510	1740	2030	2590	2480	2310	1920	1918
	BARD-92	1500	1675	1988	2312	2260	2096	1898	1780

groundnut was recorded showing 160 kg ha^{-1} as seeding rate for three consecutive years (Table 7). Maximum average yield 2519 kg ha^{-1} was observed by using 160 kg pods as seeding rate followed by 180 kg seeding rate with average yield of 2391 kg ha^{-1}.

Impact of fertilizer doses and planting geometry on yield

It is depicted from yield data (Table 8) that maximum pod yield (3218 kg ha^{-1}) was obtained by applying 20:80:30 NPK kg ha^{-1} at the time of sowing while gypsum was used @ 500 kg ha^{-1} at flowering stage which gave maximum yield compared to other fertilizer doses. As far as row spacing is concerned, 45 cm row spacing proved to be the best for tested groundnut genetic material under given environmental conditions. Production technology package is summarized in Table 9 for Fakhar-e-Chakwal.

Discussion

Development of new and improved cultivars is always on the wish-list of a plant breeders. New crop varieties always developed to cope the challenges to feed the ever-increasing population. In addition, variable climatic conditions, diseases and insect attacks also demands to introduce new crop varieties regularly. Peanut, primarily grown for edible seeds and is nutritionally rich food with protein and fats (Shibli *et al.* 2019; Noor *et al.* 2020). In addition, peanut plants also improve the soil fertility by adding nitrogen to soil with the help of nitrogen-fixing bacteria (Mokgehle *et al.* 2014). The current research was designed to develop new, high yielding, disease and drought tolerant peanut variety suitable for barani areas of Pakistani conditions. Developmental breeding history including parental lines and work starting years are shown in Table 1. This information is very much important

Table 7: Yield response in kg ha^{-1} of Fakhar-e-Chakwal to different seeding rates

Seeding rate (kg ha^{-1})	2017	2018	2019	Average
100	1551	1567	1652	1590
120	1765	1798	1658	1740
140	1879	1876	1789	1848
160	2445	2634	2478	2519
180	2276	2465	2432	2391
CV (%)	8.5	11.0	10.8	
$LSD_{0.05}$	97.5	153	147	

Table 8: Impact of fertilizer doses and planting geometry on average (2017 & 2018) pod yield (kg ha^{-1})

N:P:K (kg ha^{-1})	Row spacing (cm)		
	30 cm	45 cm	60 cm
0:0:0	1875	2028	1717
20:60:30	2348	2610	2232
20:80:30	3012	3218	2879
20:100:30	2623	2712	2543
20:120:30	2310	2370	2286
CV (%)	9.98		
$LSD_{0.05}$	106.25		

Table 9: Production technology for Fakhar-e-Chakwal

Soil	Loamy to sandy loam
Sowing Time	1st April to 30th June depending upon rain fall
Fertilizer	20-80-30 NPK kg/ha at sowing time + 500 kg/ha gypsum at flowering
Seeding rate	150-170 kg pods/ha
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

to justify the varietal registration case at any forum. Shelling percentage is a unique character of yield and it was 62% for Fakhar-e-Chakwal and this trait plays a vital role in pod yield of peanut (Shah *et al*. 2020). Therefore, this candidate variety surpassed the check variety in reference to yield. Yield trials including preliminary, regular and micro are also very important activity in varietal development process. These trials showed the performance of variety not only at different locations but its stability also verifies across the environments. Normally these trials are conducted by a third party at different locations in comparison with check varieties which are already approved. Overall, candidate variety showed higher yield in comparison to BARD-92 which was used as check variety. Environmental conditions are the main reasons for higher yield. In 2018 the conditions were most favourable for candidate variety *i.e*., Fakhar-e-Chakwal and it gave big increase in yield over check variety (BARD-92), but in case of 2019, one trial was not germinated at NARC Islamabad and climatic were also not more suitable for both varieties, hence only 6.56% increase in yield over check variety was calculated. This information confirms its yield potential and stability across the environments. Improved quality traits were also recorded of Fakhar-e-Chakwal. Because it is an oil seeded crop hence its oil parameters are of prime importance (Tonnis *et al.* 2020; Nkuna *et al.* 2021). It is known that peanut can be easily grown under variable sowing times but, its yield is affected considerably by early or late sowing and is also depends on the region (Meena and Yadav 2015). Hence, different sowing date trials were conducted for candidate variety. Data showed that 15th April and 1st May were the best suited times for sowing of Fakhar-e-Chakwal for maximum yield. Seeding rate is also very important factor which affect the yield and performance of plants. Effects of sowing dates and seed rate on the yield performance of peanut genotypes were also evaluated by Ijaz *et al*. (2021) and Plumblee *et al*. (2018), respectively.

Conclusion

The newly developed candidate peanut variety *i.e.*, Fakhar-e-Chakwal is a high yielding and short duration genotypes which is best for sowing in barani areas of Pakistan. The variety also has very impressive quality attributes *i.e.*, oil contents 44.1% and protein (22–23%). Bold seeded with pink colour, high calcium and significant shelling percentage made it an ideal and attractive variety for farming community. It is best suited in existing cropping system being short duration and early maturing, providing enough time to farmers for preparation of land for sowing of oil seeds, chickpea and wheat in next season. Hence it was recommended for general cultivation in peanut growing area of the country.

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Author Contributions

MFH, MA, and GR planned experiments; AJ conducted the experiments; AH, MI and RA interpreted the results; TH, JA and KM statistically analyzed the data and made illustrations; RA and SN made the writeup of manuscript according to the journal format.

Conflicts of Interest

All authors declare no conflicts of interest

Ethics Approval

Not applicable in this paper

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