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2019-20



PULSES RESEARCH INSTITUTE,

AYUB AGRICULTURAL RESEARCH INSTITUTE,

FAISALABAD

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INTRODUCTION

Pulses are basic part of balance nutrition and have been shown to have an important role in preventing illnesses such as cancer, diabetes and heart disease. These are very high in fiber containing both soluble and insoluble fibers. Soluble fiber helps to decrease blood cholesterol levels and control blood sugar levels, and insoluble fiber helps with digestion and regularity. These provide sufficient amounts of vitamins and mineral. Some of the important minerals include: iron, magnesium, potassium and zinc. Several studies have shown that legumes could be an important dietary factor in improving long life.

Research work on pulse crops was started during 1938 in cereal section. During 1970-71, independent pulses research section was established which was upgraded to Pulses Research Institute (PRI) Faisalabad during 1982. Pulses research institute has three sub-stations; at Kallurkot (Bhakkar), Rakhuttra (Khushab) and Sahowali (Sialkot). Since its inception Institute has developed 26 varieties of pulses crop. Main objectives of the institute are to evolve pulses varieties resistance against biotic (blight, rust, wilt, viruses) and abiotic stresses (drought, cold, heat) with high yield potential, better quality and soil disorder. Pulses Research Institute has developed new promising/ advanced lines of different pulses which may come up as candidate future varieties. Pulses Research Institute got approved kabuli chickpea variety Noor-2019 and two Lentil varieties Punjab Masoor-2019 and Punjab Masoor-2020 during the year.

Mung (*Vigna radiata L. Wilczek*) and Mash (*Vigna mungo L. Hepper*) are two important pulse crops grown in kharif and spring season in Pakistan. Mung bean leads in acreage and production among Kharif pulses. In national scenario mung bean production during last five years Punjab leads with 90% contribution. Leading mungbean producing districts are Bhakkar, Layyah and Mianwali. Pakistan is deficient in mash bean production to meet the domestic demands. Pakistan needs to import mash bean to meet its requirements. Leading mash bean producing districts are Narowal, Rawalpindi and Sialkot. But the area in these districts is continuously decreasing. Pulses Research Institute has intensified its efforts to increase domestic production of mung, mash and cowpeas with introduction of high yielding and disease resistant genotypes coupled with climate resilient production technology.

Chief Scientist

BREEDING

CHICKPEA (*Cicer arietinum* L.)

A. CHICKPEA DESI (*Cicer arietinum* L.) 2n = 16

1) GERMPLASM STUDIES

Three hundred and twelve (312) accessions of local origin were sown on 30-10-2019 in an augmented design at Faisalabad along with three checks Bittal-2016, Bhakkar-2011 and NIAB CH-2016 for their maintenance and evaluation. Each entry was planted in 4m long row by keeping row to row distance of 30 centimeters. The check varieties were planted after every 20 test entries for comparison. Entries were marked and selected for further use in breeding program on the basis of yield, earliness, growth habit and seed size. It was harvested on 24-4-2020. Range of different traits is given in below table 1.

Table -1: Germplasm range for different traits

Traits	Range	Group-I No. of Entries	Range	Group-II No. of Entries	Range	Group-III No. of Entries
Plant height (cm)	38-50	59	51-65	99	65-95	147
Days to Flowering	80-90	182	90-100	112	100-102	11
Primary branches/ Plant	1-2	35	2-4	264	4-7	6
Secondary branches/ Plant	2-5	125	5-8	70	8-12	10
Pods/ plant	17-50	92	51-100	207	100-117	6
Days to Maturity	144-150	111	150-155	86	155-163	108
100- grain weight (g)	16-22	76	22-30	220	31-35	9

2) HYBRIDIZATION PROGRAMME AND STUDY OF FILIAL GENERATIONS

For creation of genetic variability 10 parents possessing like wider adaptability, high yield potential, moderately herbicide tolerance, double pod character, thermo and photoperiod insensitivity were attempted in 30 cross combinations. It was sown on 30-10-2019 and 24 successful crosses were harvested on 24-4-2020 for raising F1 generation during next crop season as shown in table 2 and crossing parents characteristics were shown in table 3.

Table-2: Hybridization Program

Chickpea (Desi) cross combinations							
1.	Bittal-2016	X	CH-2016	16.	D-13011	X	"
2.	Punjab-2008	X	"	17.	D-14005	X	"
3.	Bhakkar2011	X	"	18.	D-15024	X	"
4.	D-13011	X	"	19.	Bittal-2016	X	D-16004
5.	D-14005	X	"	20.	Punjab-2008	X	"
6.	D-15024	X	"	21.	Bhakkar2011	X	"
7.	Bittal-2016	X	TG-1410	22.	D-13011	X	"
8.	Punjab-2008	X	"	23.	D-14005	X	"
9.	Bhakkar2011	X	"	24.	D-15024	X	"
10.	D-13011	X	"	25.	Bittal-2016	X	D-14005
12.	D-15024	X	"	27.	Bhakkar2011	X	"
13.	Bittal-2016	X	CH 32/10	28.	D-15024	X	"
14.	Punjab-2008	X	"	29.	D-14005	X	"
15.	Bhakkar2011	X	"	30.	D-15033	X	"

Table-3: Salient characteristics of Parents used in hybridization program

Sr.#	Variety	Salient Characters
1.	TG-1410	Stood 1 st in NUYT 2018-19, Blight Tolerant
2.	CH-32/10	Resistant to Blight
3.	D-15024	Stood 2 nd in NUYT 2018-19
4.	D-14005	Stood 3 rd in NUYT 2018-19, Blight and Herbicide tolerant

5.	D-13011	Stood first in NUYT 2017-18
6.	D-16004	High yielding and herbicide tolerant
7.	CH-2016	High Yielding approved variety
8.	Bittal-2016	High Yielding bold seeded approved variety
9.	Punjab-2008	High Yielding approved variety
10.	Bhakkar 2011	High Yielding bold seeded approved variety

The following filial generations were studied by using bulk/pedigree method shown in table 4.

Table-4: Selection of recombinants in segregating Filial Generation

Filial Generation	
F₀	Thirty cross combinations were attempted and harvest 24 successful crosses
F₁	Twenty nine cross combinations were planted along with their parents. All crosses were harvested and bulked for raising F ₂ generation.
F₂	Thirty three crosses harvested during last season were planted. All crosses were harvested for next generation.
F₃	Thirty three crosses were planted and made selection of 155 desirable single plants
F₄	One Hundred and forty four 144 single plant progenies out of 19 crosses were planted and selected 144 desirable single plants.
F₅	One Hundred and thirty two plant to row progenies of 17 crosses were planted and made selection of 66 single plants for raising F ₆ generation
F₆	Seventy two progenies from 16 crosses were planted in 4.2m ² area. Each progeny was evaluated and selected 32 uniform line to add in regular yield tails.

3) PRELIMINARY YIELD TRIAL

The objective of the trial was to select high yielding lines for advanced yield trial. It consists of two sets and each set has 18 entries along with two checks CH-16 and Bittal-2016 at two locations Faisalabad(sown on 28-10-2019, harvested on 25-4-2020) and kallurkot(D.O.S. 5-11-2019 and D.O.H. 27-4-2020). It was laid out in RCB design having plot size of 4m × 1.2m in three repeats keeping plant to plant and row to row distance of 15 and 30 cm respectively. The yield data is given in table 5 and table 6.

Table-5 Grain Yield data of Chickpea Preliminary Yield Trial (Set – I)

Rank	Entry	PRI	GBRSS	Av. Yield kg/ha
1	D -19009	583	1441	1012
2	D -19001	594	1319	957
3	D -19012	490	1333	912
4	D -19010	376	1403	889
5	D -19002	532	1139	835
6	Bittal -2016	282	1257	769
7	D -19011	307	1188	747
8	D -19013	552	868	710
9	D -19018	307	1066	686
10	D -19003	350	1000	675
11	D -19015	453	896	674
12	CH-2016	510	729	620
13	D -19005	276	903	590
14	D -19004	385	729	557
15	D -19007	222	847	534
16	D -19014	383	667	525
17	D -19017	219	809	514
18	D -19006	278	715	497
19	D -19016	347	632	490
20	D -19008	311	660	485
	CV %	6.25	8.20	
	LSD (0.05)	50	26	

The Entry D-19009 gave highest average yield (1012 kg/ha) followed by entry D-19001 (957 kg/ha) and entry D-19008 gave lowest average yield of 485 kg/ha at Faisalabad. D-19009 gave highest yield of 1441 kg/ha at GBRSS kalurkot.

Table-6 Yield data of Chickpea Preliminary Yield Trial (Set – II)

Rank	Entry	PRI	GBRSS	Av. Yield kg/ha
1	D -19025	281	1840	1061
2	D -19029	357	1764	1060
3	D -19036	292	1764	1028
4	D -19019	564	1431	997
5	D -19028	426	1524	975
6	D -19030	497	1431	964
7	D -19031	252	1660	956
8	D -19034	242	1660	951
9	D -19022	289	1563	926
10	D -19027	432	1368	900
11	D -19021	309	1451	880
12	D -19026	415	1313	864
13	Bittle-16	281	1444	863
14	D -19020	292	1424	858
15	D -19023	335	1375	855
16	D -19032	321	1378	850
17	CH-2016	421	1257	839
18	D -19035	263	1243	753
19	D -19033	290	1181	735
20	D -19024	288	1049	668
	CV %	12	5	
	LSD (0.05)	34	58	

The Entry D-19025 gave highest average yield (1061 kg/ha) followed by entry D-19029 (1060kg/ha) and entry D-19024 gave lowest average yield of 668 kg/ha. D-19025 gave highest yield of 1840 kg/ha at GBRSS Kallurkot.

4) ADVANCE YIELD TRIAL

The trial comprised of 14 entries along with two checks viz. NIAB CH 16 and Bittle-16 were sown on 28-10-2019 at pulses research institute Faisalabad in three replications following RCB design. It was conducted at two locations i.e. Faisalabad (D.O.H.25-4-2020) and Kallurkot (D.O.S. 5-11-2019 and D.O.H. 17-5-2020 on both locations). The grain yield data is shown in table 7 and table 8.

Table 7 Grain Yield data of Chickpea Desi Advance Yield Trial (Set I)

Rank	Entry	PRI	GBRSS	Av. Yield kg/ha
1	D-18009	465	2500	1483
2	D-18004	715	1771	1243
3	D-18007	668	1628	1148
4	D-18008	593	1701	1147
5	D-18020	236	1993	1115
6	D-18017	346	1674	1010
7	CH-2016 (C)	625	1389	1007
8	D-18013	463	1458	961
9	Bittle-16 (C)	322	1569	945
10	D-18002	469	1375	922
11	D-18012	448	1396	922
12	D-18019	185	1594	889
13	D-18001	448	1201	825
14	D-18010	257	1340	799

15	D-18003	490	944	717
16	D-18005	319	701	510
	CV %	7.0	6.0	
	LSD (0.05)	25.0	72.0	

The Entry D-18009 gave highest average yield (1483 kg/ha) followed by entry D-18004 (1243 kg/ha) and entry D-18005 gave lowest average yield of 510 kg/ha. The entry D-18009 gave highest yield of 2500 kg/ha at GBRSS Kallurkot.

Table 8 Grain Yield data of Chickpea Desi Advance Yield Trial (Set –II)

Rank	Entry	PRI	GBRSS	Av. Yield kg/ha
1	D-18032	494	2632	1563
2	D-18036	293	2757	1525
3	D-18026	473	2476	1474
4	D-18025	454	2472	1463
5	D-18027	324	2583	1453
6	D-18028	177	2618	1398
7	D-18022	265	2181	1223
8	Bittle-16	220	1826	1023
9	TS-50/16	183	1816	1000
10	CH-2016	537	1354	945
11	D-18024	319	1462	891
12	TS-55/16	146	1576	861
13	TS-12/16	288	1413	851
14	D-18021	238	1319	778
15	TS-97/16	196	1306	751
16	TS-06/16	265	844	555
	CV %	7.0	4.0	
	LSD (0.05)	18.0	69.0	

The Entry D-18032 gave highest average yield (1563 kg/ha) followed by entry D-18036 (1525 kg/ha) and entry TS-06/16 gave lowest average yield of 555 kg/ha. D-18032 gave highest yield of 2632 kg/ha at GBRSS, Kallurkot.

5) COOPERATIVE YIELD TRIAL

The aim of this experiment was to evaluate advance lines of PRI and sister organizations in different agro-ecological zones. Thirty two entries were tested in two sets including two checks i.e. NIAB CH 16 and Bittal-2016. Each set comprising of 16 entries and was sown at twelve locations. It was laid out in RCB design in three repeats keeping row to row and plant to plant distance 30 and 15 cm respectively (D.O.S. 28-10-2019 and D.O.H. 27-4-2020 at PRI, Faisalabad). The yield data of set I was compiled in table 9 and set II in table 10.

Table 9 consolidated results of cooperative yield trial- set 1 (CHICKPEA DESI)

Entry	PRI, Fsd	NIAB Fsd	K.Kot	AZRI. Bkr	B.Pur	K.Kot (Barani)	AZRI. Bkr (Barani)	K.Kot (Farmer Field)	K.Kot (Farmer Field)	Rakhutra (Barani)	AZRI. Bkr (Farmer Field)	AZRI. Bkr (Farmer Field)	Av. Yield (Kg/h)
	1	2	3	4	5	6	7	8	9	10	11	12	
CH21/13	762	1767	2583	2069	3438	1514	580	229	319	188	751	1554	1313
D-17028	457	1607	2097	1813	3576	1465	767	510	455	201	863	1516	1277
D-17006	537	1793	2139	1976	3507	1375	682	250	299	243	1201	1299	1275
D-17019	767	1560	2375	1196	3576	1597	806	476	497	313	847	1167	1265
CH28/13	463	1621	2069	2298	3229	1618	547	392	580	188	910	1235	1262
D-17003	774	1429	2250	1758	2951	1799	493	517	344	208	1168	1389	1257
TG-1427	867	1395	1826	1969	3785	1299	739	302	306	292	1142	1153	1256

CH30/12	118	1248	2528	2182	2986	1500	721	413	413	271	1028	1278	1224
CH39/13	299	1250	2063	2174	2882	1576	567	524	486	181	1121	1361	1207
TG-1504	479	1558	1705	1712	2743	1306	838	292	278	271	1008	1179	1114
Bittal-16	370	1002	2056	1821	2431	1535	744	392	431	347	760	1303	1099
BRC-474	490	1206	1438	1819	3021	1521	560	375	382	236	664	1386	1091
TG-1510	358	1309	1861	2072	2257	896	835	306	361	285	1145	1381	1089
D-17015	160	1068	1688	1507	3229	1076	972	226	323	222	969	1357	1066
CH-2016	448	1012	1576	1851	3958	514	607	170	365	139	816	1301	1063
TG-1430	412	1147	1670	1865	1701	1694	551	174	260	160	997	1374	1001
CV	6.61	16.0	3.00	8	19	5.0	7.0	10	8.0	13.00	9.0	7.0	
LSD(0.05)	24.00	125.0	52.0	138.	111.0	61.00	66.00	28.0	28.0	32.00	99.0	24.00	

In SET-1 the entry CH 21/13 gave highest yield (1313 kg/ha) followed by entry D-17028 (1277 kg/ha). The entry TG-1430 gave lowest yield 1001 kg/ha. The entry CH 21/13 gave highest yield (3438 kg/ha) at Bahawalpur.

Table 10 COOPERATIVE YIELD TRIAL Set- 2 OF CHICKPEA (DESI)

COOPERATIVE YIELD TRIAL Set- 2 OF CHICKPEA (DESI)													
Entry	PRI, Fsd	NIAB Fsd	K.Kot	AZRI. Bkr	B.Pur	K.Kot (Barani)	AZRI. Bkr (Barani)	K.Kot (Farmer Field)	K.Kot (Farmer Field)	Rakhutra (Barani)	AZRI. Bkr (Farmer Field)	AZRI. Bkr (Farmer Field)	Av. Yield (Kg/h)
	1	2	3	4	5	6	7	8	9	10	11	12	
CH30/13	753	2429	2681	2458	3403	1174	908	382	587	340	1567	1600	1523
CH26/13	719	2073	1910	2253	3299	1882	1021	347	448	323	1640	1438	1446
D-17016	771	2017	2410	1976	2882	1990	1458	375	580	306	1136	1396	1441
TG-1305	389	2490	1674	2299	2965	1403	1061	431	552	431	1653	1011	1363
D-17005	754	2219	1476	2135	2354	1958	1038	493	493	264	1476	1444	1342
TG-1428	417	2229	2076	2358	3076	813	1060	378	396	378	1540	1135	1321
D-17002	289	2875	1559	2628	2674	1674	949	215	274	122	1128	1122	1292
D17035	282	2371	1222	2458	2569	1646	1044	326	361	194	1645	1267	1282
D-17027	424	1725	1896	1874	2847	1236	1431	403	410	403	1049	1528	1269
CH15/13	431	1771	1899	1828	2500	1778	1085	396	399	385	1125	1145	1228
CH13/12	726	1573	1569	1805	2535	1396	1279	344	538	135	951	1313	1180
Bittal-16	456	1871	1809	2058	2125	1222	868	354	486	326	1406	1177	1180
TG-1501	166	2115	1660	2110	1653	1188	1388	260	295	240	1578	1410	1172
D-17014	247	1844	1597	2094	2271	1104	1431	368	385	368	1034	1319	1172
CH-2016	347	1750	1750	1792	2833	792	1000	257	295	257	1417	1444	1161
BRC-446	179	1406	1403	1791	2674	1479	840	392	444	264	1206	1035	1093
CV %	6.70	13.12	4.07	8.30	25.12	5.62	11.32	7.73	9.05	17.90	9.71		
LSD (0.05)	26.54	147.0	66.3	127.	632.0	63.86	63.56	21.89	28.16	34.24	76.24		

In SET-II, the entry CH-30/13 gave highest yield (1523 kg/ha) followed by entry CH26/13 (1446kg/ha). The entry BRC-446 gave lowest yield 1093 kg/ha. The entry CH 30/13 gave highest yield (3403 kg/ha) at Bahawalpur.

6) NATIONAL UNIFORM YIELD TRIAL

Nineteen entries including one check were received from coordinator pulses NARC, Islamabad and sown (D.O.S.30-10-2019) as per instructions at PRI, Faisalabad in RCB design having three replications with plot size of 4m×1.8m and it was harvested on 18-4-2020. Yield data shown in table 11.

Table 11 Consolidated results of Chickpea (Desi) National Uniform Yield Trial kg/ha

Entries	Institute	Blight Rating	Locations*											Mean
			PRI, Fsd	ARS Karak	AZRI, Bkr	AZRI, B.Pur	AZRC, DIKhan	BARS, Fateh Jang	BARS, Fateh Jang	NARC, Islamabad	NAIB Fsd	QAARI Larkana	BARI	
			1	2	3	4	5	6	7	8	9	10	11	
CH-1 1/ 1 2	NIAB, Fa isalabad	7	629	1015	1194	2014	1425	626	1833	2117	1136	2427	2257	1516
BRC-474	RARI , Bahawalpur	7	624	1886	1147	2778	794	543	1108	1549	1225	2313	2708	1516
D-16029	PRI, Faisalabad	7	918	1082	1885	1632	471	673	2243	1546	979	2653	2222	1482
D-15024	PRJ , Faisal abad	5	656	957	1544	1806	978	600	2444	2281	1148	2139	1597	1468
TG-1427	AZRI , Bhakkar	5	652	798	1545	1875	1239	628	1406	2352	1259	2465	1806	1457
CH35/ 1 0	N IAB, Faisalabad	9	561	1599	1299	1910	1456	635	1215	1994	841	2681	1806	1454
CH-1 2/ 1 2	NIAB, Fa isalabad	7	705	1007	1931	1771	606	618	1958	2176	1061	2326	1806	1451
D-16004	PRI, Faisalabad	7	1071	1052	1264	1944	1317	581	1396	1628	978	2250	2188	1424
SL05-53	A RS. Karak	7	1126	1950	1226	2014	385	665	1715	1653	1017	2250	1597	1418
CH-32/ 1 0	NIAB, Faisalabad	5	633	1213	928	1736	1417	627	1365	2304	1121	2201	2049	1418
TG-1510	AZRI L Bhakkar	7	976	1132	875	1597	1354	644	1559	2469	1041	2431	1458	1412
D-1 6003	PRI, Faisalabad	5	625	757	1170	1910	838	591	1667	2372	1043	2639	1806	1402
TG 305	AZRI L Bhakkar	3	592	643	1217	1632	890	593	2403	2004	939	2472	1979	1397
D-15033	PRI , Faisalabad	5	210	990	1323	1875	1274	653	1722	1956	963	2444	1632	1367
CH24/ 1 1	NIAB, Faisalabad	5	304	1200	1136	1910	725	682	1868	2027	958	2347	1771	1357
D-16020	PRI , Faisalabad	7	240	1048	1105	1979	1197	575	1597	2075	956	2354	1736	1351
INDUS-1 9	CHECK	7	319	1077	1077	1875	914	535	1681	1966	1029	2181	1736	1308
BRC-446	RARI, Bahawalpur	9	219	1111	1069	1694	697	663	1104	2335	897	2486	1632	1264
TG-1430	AZRI, Bhakkar	7	340	913	1068	1597	803	649	1167	2141	967	2181	1764	1235
Location Mean			600	1128	1263	1871	988	620	1655	2050	1029	2381	1871	

Entry CH-1 1/ 1 2 and BRC-474 showed highest average yield of 1516 kg/ha followed by entry D-16029 (1482 kg/ha) and D-15024 (1468 kg/ha) contributed by this institute. Entry TG-1430 showed lowest average yield of 1235 kg/ha. Entry CH-1 1/ 1 2 gave highest yield (2427 kg/ha) at QAARI larkana.

07) PRE-BASIC / BASIC SEED PRODUCTION

The single plants were selected during 2015-16 and sown during 2016-17 as single plant progeny rows in 4 meters long and 30 centimeters apart. The true to type progeny rows were harvested separately. Seed of selected progeny rows was sown in blocks during 2017-18. The genetically true to types, disease free and healthy progeny blocks were selected, harvested and bulked as BNS which was used for pre basic seed production during 2019-20. The diseased and off type plants were rouged out before flowering every year. Seed of following genotypes was produced as shown in table 12.

Table-12 Pre-basic / basic seed production

Variety	BNS (Kg)	Pre-basic (Kg)	Total (Kg)
Punjab-2008	200	1950	2150
Bittal- 2016	210	4519	4729
Bittal- 98	-	86	86
Total	410	6555	6965

B. CHICKPEA KABULI (*Cicer arietinum* L.) 2n = 16

8) GERMPLASM STUDIES

Three hundred and twenty (320) accessions of local origin were planted on 2-11-2019 in an augmented design for their maintenance and evaluation. Each entry was planted in 2 m long paired rows by keeping row to row distance of 30 cm. The approved checks/varieties viz; Noor 91, CM 2008, Noor 2009 and Noor 2013 were planted after every 10 test entries for comparison. The entries were harvested on 7-5-2020. The entries were characterized for some quantitative traits. Range of variation of these traits is given in the following table 13.

Table-13 Characterization Of Chickpea Kabuli Germplasm

TRAIT	Range	Group-I No. of entries	Range	Group-II No. of entries	Range	Group-III No. of entries
Plant height (cm)	40-50	72	51-65	104	65-95	144
Days of Flowering	80-90	185	90-100	110	100-115	25
Primary branches/plant	1-2	32	2-4	270	4-8	18
Secondary branches/plant	2-5	135	6-8	105	9-15	80
Pods/plant	10-50	228	51-100	88	101-110	4
Days to maturity	144-150	115	151-155	98	155-163	107

9) HYBRIDIZATION AND FILIAL GENERATIONS

In order to develop new genotypes possessing wider adaptability, high yield potential, resistant to wilt diseases, bold seeded and herbicide tolerant 24 parental lines were planted in paired rows. The parents were sown on 2-11-2019. Twenty four fresh cross combinations were attempted by tackling 25-30 flowers in each combination. The 20 combinations were harvested on 13-5-2020 for raising F1 generation during next crop season as shown in table 14.

Table-14 Successfully Harvested Cross Combinations

Sr.No.	CROSSES			Sr.No.	CROSSES		
1	K-01216	X	CH68/08	11	Noor 2013	X	K-15019
2	K-01209	X	NOOR 2013	12	K-14024	X	CH47/12
3	K-15019	X	CH47/12	13	K-15019	X	K-16025
4	K-15019	X	14FCK02	14	CH68/08	X	K-16027
5	K-18005	X	K17024	15	CH47/12	X	K-204016
6	K-18006	X	K-15019	16	K-01308	X	K-204016
7	K-14024	X	CH68/08	17	K-01213	X	K-204015
8	K-16027	X	K-01241	18	NOOR 2013	X	K-96030
9	K-15014	X	K-1241	19	K-01248	X	K-204016
10	K-14024	X	K-18021	20	K-01242	X	K-16027

Different population of filial generations studied was shown in table 15.

Table -15 STUDIES AND SELECTION OF CROSSES AND SINGLE PLANT PROGENIES

Filial generation	Crosses/ progenies studied	Crosses/progenies selected/harvested	Uniform lines selected
F ₀	24 crosses	20 crosses	-
F ₁	15 crosses	10 crosses	-
F ₂	27 crosses	27 crosses	-
F ₃	21 crosses	96 progenies from 15 crosses	-

F ₄	84 progenies from 14 crosses+21crosses from Kaghan	66 progenies from 10 crosses	-
F ₅	60 progenies from 7crosses	48 progenies from 6 crosses	-
F ₆	42 progenies from 12 crosses	-	28 uniform lines were selected
Total	294 progenies of 141 crosses	267 progenies from 88 crosses	28 uniform lines were selected

10) PRELIMINARY YIELD TRIAL

Sixteen (16) test entries of chickpea Kabuli including 2 checks Noor 2013 and Noor 2019 were sown on 11-11-2019 at Faisalabad and 9-11-2019 at kallurkot during Rabi 2019-20 having set I and set II under irrigated condition. Row to row and plant spacing was kept 30 cm and 15 cm respectively. Row length was 4 m. RCBD design with three replications was used. The plot size was kept 4.8 m². Harvesting was done on 18-05-2020. Yield performance of chickpea promising lines in preliminary yield trial (Set-I) were shown in table 16 and set II results shown in table 17.

Table 16 YIELD DATA OF PRELIMINARY YIELD TRIAL 2019-20 Set-I

Sr.#	Entries	Faisalabad	KallurKot	Av. Yield (Kg/ha)
1	PCK-19004	1450	2076	1763
2	PCK-19002	1305	1854	1579
3	PCK-19003	1047	1941	1494
4	NOOR 2019	1283	1677	1480
5	PCK-19008	896	1965	1430
6	NOOR 2013	1092	1670	1381
7	PCK-19001	1515	1160	1337
8	PCK-19010	1184	1385	1285
9	PCK-19007	914	1528	1221
10	PCK-19014	861	1528	1195
11	PCK-19006	876	1472	1174
12	PCK-19012	934	1257	1096
13	PCK-19009	665	1479	1072
14	PCK-19005	1012	993	1003
15	PCK-19011	674	1326	1000
16	PCK-19013	368	875	622
LSD (0.05)		25.93	36.48	62.41
CV %		7.53	6.16	6.85

During first fortnight of February 99 mm rainfall received frequently which badly effected flowering and pod formation. 135 mm rainfall received during February 2020. Similarly from sowing to harvesting 227.4 mm rainfall received at Pulses Research Institute Faisalabad which badly affected the chickpea yield.

On an average, entries PCK-19004(1763 kg/ha) and PCK-19002 (1579 kg/ha) over yielded the check Noor 2019 (1480 kg/ha). However maximum average yield was given by PCK-19004 with 2076 kg/ha followed by PCK-19003 (1941 kg/ha) at kallurkot.

Table-17 YIELD DATA OF PRELIMINARY YIELD TRIAL (SET-2)

Sr.#	Entries	Faisalabad	KallurKot	Av. Yield (Kg/ha)
1	PCK-19017	1243	1576	1410
2	PCK-19024	1122	1493	1307

3	Noor-2019	1052	1500	1276
4	PCK-19015	1057	1444	1250
5	PCK-19023	826	1660	1243
6	PCK-19018	1097	1333	1215
7	PCK-19016	1104	1319	1212
8	PCK-19026	771	1458	1114
9	PCK-19028	656	1479	1068
10	PCK-19021	958	1153	1056
11	Noor-2013	1048	1055	1051
12	PCK-19027	701	1375	1038
13	PCK-19020	622	1354	988
14	PCK-19022	628	1319	974
15	PCK-19019	656	1215	936
16	PCK-19025	521	1243	882
LSD (0.05)		23.57	36.48	30.03
CV %		8.47	6.16	7.32

On average basis in set II entries PCK-19017 (1410 kg/ha) and PCK-19024 (1307 kg/ha) over yielded the check varieties Noor 2013 (1051 Kg/ha) and (Noor 2019 (1276 kg/ha). Maximum yields of 1660 kg/ha and 1576 kg/ha were given the entries PCK-19023 and PCK-19017 at KallurKot.

11) ADVANCE YIELD TRIAL (Set-I)

Fourteen lines/entries of chickpea Kabuli including two checks Noor 2013 and Noor 2019 were planted on 11-11-2019 at Faisalabad and on 9-11-2019 at Kallurkot. Row to row and plant to plant spacing was 30 cm and 15 cm respectively. Row length was 4 m. Test entries were sown in plots of 4.8 m² according to RCB design with 3 replications under irrigated condition. Harvesting was done on 18-05-2020 at Faisalabad and on 21-05-2020 at KallurKot. Yield results of set I were shown in table 18.

Table-18 YIELD DATA OF ADVANCE YIELD TRIAL (SET-1)

Sr.#	Entries	Faisalabad	KallurKot	Av. Yield (Kg/ha)
1	PCK 18021	1295	1715	1505
2	PCK 18023	833	1955	1394
3	PCK 18007	854	1774	1314
4	PCK 18022	1163	1375	1269
5	PCK18005	851	1403	1127
6	NOOR 2019	848	1396	1122
7	PCK 18006	885	1278	1082
8	PCK18004	760	1319	1040
9	PCK 18028	701	1375	1038
10	NOOR 2013	839	1236	1037
11	PCK 18002	624	1278	951
12	PCK 18025	656	1167	912
13	PCK 18009	462	1305	883
14	PCK18003	531	1194	863
LSD (0.05)		25.09	26.38	25.74
CV %		7.28	4.77	6.03

On average, entries PCK-18021 (1505 kg/ha) and PCK-18021 (1394 kg/ha) over yielded the check varieties Noor 2013 (1037 kg/ha) and Noor 2019 (1122 kg/ha). However maximum yield was given by PCK-18023 with 1955 kg/ha followed by PCK-18007(1774 kg/ha) at kallurkot.

In advanced yield trial set II, Fourteen test entries of chickpea Kabuli including two checks Noor 2013 and Noor 2019 were planted on 11-11-2019 at Faisalabad and 9-11-2019 at KallurKot during Rabi 2019-20. Row to row and plant spacing was 30 cm and 15 cm respectively. Row length was 4 m. Test entries were sown in plots of 4.8 m² according to RCB design with 3 replications under irrigated condition. Yield data of set II shown in table 19.

Table-19 YIELD DATA OF ADVANCE YIELD TRIAL (SET-2)

Sr.#	Entries	Faisalabad	KallurKot	Av. Yield (Kg/ha)
	NOOR 2019	1295	2048	1672
	PCK 18016	986	2354	1670
	PCK 18020	1052	2104	1578
	NOOR 2013	1073	1986	1529
	PCK 18015	1108	1875	1492
	PCK 8005	806	2028	1417
	PCK 18017	1226	1542	1384
	PCK18008	1042	1611	1326
	PCK 18019	826	1701	1264
	PCK 18001	497	1965	1231
	PCK 18013	639	1819	1229
	PCK18010	562	1805	1184
	PCK 18012	507	1674	1090
	PCK 18014	479	1458	969
	LSD (0.05)	25.80	23.87	24.84
	CV %	7.62	3.28	10.09

On an average the Check Noor 2019 (1672 kg/ha) surpassed all the entries. However maximum yield was given by PCK-18016 with 2354 kg/ha followed by PCK-18020 (2104 kg/ha) at kallurkot. During first fortnight of February 99 mm rainfall received frequently which badly effected flowering and pod formation. 135 mm rainfall received during February 2020. Similarly from sowing to harvesting 227.4 mm rainfall received at Pulses Research Institute Faisalabad which badly affected the chickpea yield.

12) COOPERATIVE YIELD TRIAL

This study was designed to evaluate the promising advanced lines developed by different research organizations working on Chickpea Kabuli. The 20 entries including one check were sown in plots of 4.8 m² according to RCBD with 3 replications. . Row to row and plant to plant spacing was 30 cm and 15 cm respectively. Row length was 4 m. Yield data shown in table 20.

Table 20 COMPILED YIELD DATA OF CHICKPEA KABULI COOPERATIVE YIELD TRIAL

Sr No	Varieties /Lines	Code	Locations										Av. Yield (Kg/ha)
			PRI, FSD (Normal)	PRI FSD Zero Irrigation	PRI FSD One Irrigation	NIAB	RARI	BAR Fateh Jang	AZRI BHAKKAR	GBRS Kallurkot (Barani)	GBRS kallurkot (Irrigated)	Rakhutra	
1	TGK1504	J	931	632	962	1003	2208	723	1794	1069	2083	198	1160
2	BRC408	F	552	524	757	867	2687	684	1611	1347	1819	326	1117
3	PCK-16027	B	810	531	625	878	2083	681	1633	1507	2055	260	1106
4	NOOR2019	T	854	597	924	985	1910	719	1751	1042	1923	333	1104
5	TGK1503	R	861	479	757	909	2431	733	1618	896	1979	201	1086
6	CH73/13	C	806	639	861	985	2118	686	1635	1062	1795	260	1085
7	PCK-16010	A	783	694	680	1029	1528	671	1764	1368	1729	201	1082
8	PCK17002	H	479	406	465	899	2500	663	1758	1680	1604	365	1082
9	CH74/13	K	719	365	670	929	2243	710	1844	1472	1465	306	1072
10	PCK17001	G	809	517	687	868	2187	693	1666	618	2035	458	1054
11	CH69/09	E	758	441	719	887	1806	696	1550	1354	1951	271	1043
12	CH51/12	D	736	424	545	866	2194	699	1375	1389	2014	187	1043
13	TGK1508	I	600	893	802	879	2083	707	1610	1229	1274	333	1041
14	CH72/13	L	854	611	715	912	1944	660	1554	875	1899	340	1036
15	CH47/13	Q	753	413	809	910	1937	716	1646	972	1941	201	1030
16	NOOR2013	S	658	545	663	892	1826	681	1522	1417	1764	229	1020
17	PCK17018	M	649	319	469	852	2292	683	1436	1510	1743	187	1014
18	PCK17030	O	540	368	490	876	1465	676	1719	1660	2014	312	1012
19	PCK17024	N	490	223	587	915	2326	703	1217	1406	1736	208	981
20	CH56/12	P	549	515	715	898	1701	729	1681	868	1736	212	960
	LSD(0.05)		20.74	17.92	22.5	26.07	206.17	6.59	26.81	21.44	20.7	27.19	39.60
	CV %		7.24	9.65	8.06	7.29	25.37	2.42	5.80	4.93	2.99	5.70	7.95

Keeping in view the overall performance, three entries viz TGK1504 (1160 kg/ha), BRC408 (1117 kg/ha) and PCK16027 (1106 kg/ha) showed better performance. Highest yield potential was recorded with a grain yield of 2687 kg/ha by BRC 408 at Bahawalpur followed by (2500 kg/ha) by PCK-17002 at the same location. During first fortnight of February 99 mm rainfall received frequently which badly effected flowering and pod formation. 135 mm rainfall received during February 2020. Similarly from sowing to harvesting 227.4 mm rainfall received at Pulses Research Institute Faisalabad which badly affected the chickpea yield.

13) RESPONSE OF ADVANCE LINES IN IRRIGATED AND RAINFED CONDITION

This study was designed to evaluate the promising advanced lines under rainfed and irrigated conditions (zero and one irrigation). The twenty test entries including two checks were sown in plots of 4.8 m² according to RCBD with 3 replications at PRI, Faisalabad 11-11-2019 and 9-11-2019 at GBRSS, Kallur Kot. Row to row and plant to plant spacing was 30 cm and 15 cm respectively. Row length was 4 m. Yield data shown in table 21.

Table 21 YIELD DATA OF ADVANCE LINES UNDER IRRIGATED AND RAINFED CONDITION

Sr. No.	Locations						
	Entries	PRI,FSD (Kg/ha)	GBRSS,K.KT (Kg/ ha)	Av.Yield (Kg/ha)	PRI,FSD (Kg/ha)	GBRSS,K.KOT (Kg/ha)	Av. Yield (Kg/ha)
		Zero Irrigation			One Irrigation		
1	PCK-1610	694	1368	1031	1054	1729	1392
2	PCK-16027	531	1507	1019	625	2055	1340
3	CH73/13	639	1062	850	861	1795	1328
4	CH51/12	424	1389	906	545	2014	1280
5	CH69/09	441	1354	897	719	1951	1335
6	BRC408	524	1347	936	757	1819	1288
7	PCK-17001	517	618	568	687	2035	1361
8	PCK-17002	406	1680	1043	465	1604	1035
9	TGK 1508	493	1229	861	802	1274	1038
10	TGK 1504	632	1069	850	962	2083	1522
11	CH74/13	365	1472	919	670	1465	1068
12	CH72/13	611	875	743	715	1899	1307
13	PCK17018	319	1510	914	469	1743	1106
14	PCK17024	223	1406	814	587	1736	1161
15	PCK17030	368	1660	1014	490	2014	1252
16	CH52/12	515	868	692	715	1736	1226
17	CH47/13	413	972	693	809	1941	1375
18	TGK-1503	479	896	688	757	1979	1368
19	NOOR2013	545	1417	981	663	1764	1214
20	NOOR2019	597	1042	820	924	1923	1423
	LSD (0.05)	23.80	23.17	24.24	25.20	23.87	
	CV %	7.62	3.28	10.09	7.62	3.28	

On average basis maximum yield was produced by PCK-16010 (1392 Kg/ha) followed TGK-1504(1522 Kg/ha) in irrigated condition. On average basis in rainfed condition, PCK-17002(1043 Kg/ha) followed by PCK-16010 (1031 Kg/ha) gave maximum yield. The maximum yield was given by TGK-1504 (2083Kg/ha) followed by PCK-16027 (2055 Kg/ha) in irrigated condition.

14) NATIONAL UNIFORM YIELD TRIAL

Sixteen entries including one check were received from coordinator pulses NARC, Islamabad and sown on 11-11-2019 as per instructions at PRI, Faisalabad in RCB design having three replications with plot size of 4m×1.8m and it was harvested on 19-5-2020. Yield results were shown in table 22.

Table-22 consolidated results of chickpea Kabuli in national uniform yield trial

Entry Name	Institute	Blight Rating	Locations										Av. Yield (Kg/ha)
			1	2	3	4	5	6	7	8	9	10	
BRC-408	RARI BHW	9	976	1283	1090	250	760	1656	1989	852	2438	2049	1334
15KCC-112	BARI Chakwal	7	969	1175	824	476	711	1563	2314	968	2604	1354	1296
15FCK 16	Fatah jang	5	924	1007	1008	482	742	1424	2175	932	2479	1336	1291
TGK-1504	Bhakkar	9	965	1659	1251	601	667	1146	1698	922	2389	1250	1255
TGK-1508	Bhakkar	5	872	1779	740	488	742	1316	1918	906	2493	1285	1254
NCK-1801	NARC	3	861	827	1038	499	660	1184	1731	1106	2479	2000	1238

CH64/11	NIAB	9	908	831	795	556	768	1611	1501	911	2479	2014	1237
CH66/10	NIAB	9	753	1265	831	576	779	1368	1933	863	2438	1563	1237
PCK-15001	PRI,FSD	9	667	1595	872	588	723	1000	1740	888	2410	1806	1229
CH47/12	NIAB	9	917	1701	769	507	730	1576	1054	999	2111	1736	1210
NOOR2013	PRI,FSD	9	674	1398	840	522	726	927	1874	931	2729	1458	1208
14FCK02	Fathjang	7	764	792	847	431	784	1358	1978	1008	2306	1354	1162
CH48/12	NIAB	9	665	1278	949	388	698	1236	1546	885	2583	1007	1123
TGK-1503	Bhakkar	9	1250	1423	738	239	679	785	1174	978	2646	1285	1120
PCK-15019	PRI,FSD	3	750	906	986	194	714	899	2097	1105	2326	1076	1105
CH53/12	NIAB	9	931	1061	918	455	731	1253	749	933	2160	1285	1048
LOCATIONS													
1	2	3	4	5	6	7	8	9	10				
PRI,AARI FSD	ARS KARAK	AZRI BHAKKAR	AZRC D.I.KHAN	BARS FATEHJANG	GRS KALURKOT	NARC ISLAMABAD	NIAB FSD	QAARI LARKANA	RARI BAHAWALP UR				

On an average performance the entry BRC408 gave maximum yield 1334 kg/ha followed by entry 15KCC-112(1296 Kg/ha). Maximum yield 2604 kg/ha was obtained from entry 15KCC-112 at RARI, Bahawalpur. During first fortnight of February 99 mm rainfall received frequently which badly effected flowering and pod formation. 135 mm rainfall received during February 2020. Similarly from sowing to harvesting 227.4 mm rainfall received at Pulses Research Institute Faisalabad which badly affected the chickpea yield.

15) PRE-BASIC AND BASIC SEED PRODUCTION

Single plants selected during 2017-18, were sown as single plant progenies rows during 2018-19 in 4 m long and 30 cm apart. True to type progeny rows were harvested separately and these selected progenies were sown in blocks during 2019-20. Genetically true to types, disease free and healthy progeny blocks were selected, harvested and bulked as BNS during 2018-19. This BNS was sown as basic seed production during 2019-20. The single plants were selected for next year progeny rows at Faisalabad. Pre basic and BNS seed produced are given in table 23.

Table-23 PRE BASIC AND BNS SEED PRODUCTION

S.NO.	VARITIES	Quantity produced kg		
		BNS	Pre basic	Total kg
1	Noor 2009	-	528	528
2	Noor 2013	60	552	612
3	Noor 2019	160	1858	2018

LENTIL (*Lens culinaris* Medik) 2n = 14

17) MAINTENANCE AND EVALUATION OF GERMPLASM

The gene pool accessions comprising 278 genotypes of local and exotic origin were planted on 30-10-2019 in an augmented design at Faisalabad for maintenance and evaluation. Five checks i.e Masoor-93, Markaz-2009, Pb .Masoor -2009, Pb.Masoor-19 and Pb.Masoor-2020 were used. Each entry was planted in 4 m long row by keeping inter and intra row distance of 30cm and 10cm respectively. All entries were planted and characterized for different traits. It was harvested on 4-4-2020. Range of different traits is shown in table 23.

Table-23: Characterization of 278 genotypes

Traits	Group 1		Group 2		Group 3	
	Range	No. of Entries	Range	No. of Entries	Range	No. of Entries
Days to 50 % Flowering	72-90	99	91-100	132	101-108	47
Days to 90% Maturity	135-142	117	143-150	89	151-160	72
Plant Height (cm)	20-25	35	26-31	177	32 -40	66
1st Pod Height (cm)	10-14	138	15-20	99	21 -23	41
No of Primary Branches / Plant	6-10	127	11-14	116	15 -18	35
No. of Secondary Branches/Plant	10-15	95	16-20	143	21-26	40
No. of Pods / Plant	50-150	78	151-250	111	250 -280	89
No. of Seeds / Pod	1	29	2	241	Above 2	8
Seed Yield/Plant (g)	2.5-3.5	99	3.6-4.5	145	4.6 -5.0	34
1000 grain weight (g)	15-20	49	21-25	136	26 -29	93

18) HYBRIDIZATION AND STUDY OF FILIAL GENERATIONS

For creation of genetic variability 20 lentil genotypes possessing greater genetic diversity like wider adaptability, high yield potential, early maturing and resistant to diseases were planted on 30-10-2019 in Paired Plot Design. Fresh cross combination was attempted by tackling 100-150 flowers in each combination. The 20 crosses combinations which set seed were harvested on 7-4-2020 for raising F₁ generation during next crop season.

Parental sources of high yield = 5(Pb. Masoor 2009, P.Masoor-2019, LPP-12161, PLL-11513 and I-36203)

Parental Resistant to Rust and Wilt = 4 (V-17501, V-13502, V- 13516 & ICARDA- 36103)

Sr.No.	CROSSES			Sr.No.	CROSSES		
1	Pb.M-19	X	LPP-12161	11	Pb.M-09	X	PLL-11513
2	Pb.M-19	X	PLL-11508	12	Pb.M-09	X	PLL-13516
3	Pb.M-19	X	PLL-11513	13	Pb.M-09	X	PLL-13502
4	Pb.M-19	X	PLL-18503	14	LPP-12161	X	PLL-11508
5	Pb.M-19	X	PLL-18509	15	LPP-12161	X	PLL-11513
6	Pb.M-19	X	I-36106	16	LPP-12161	X	I-31217
7	Pb.M-19	X	PLL-13502	17	LPP-12161	X	PLL-13502
8	Pb.M-09	X	PLL-17502	18	LPP-12161	X	I-36106
9	Pb.M-09	X	LPP-12161	19	LPP-12161	X	PLL-13516
10	Pb.M-09	X	PLL-11508	20	PLL-11513	X	PLL-13502

Different filial generations were shown below.

Filial generation	Crosses/progenies Studied	Crosses/progenies Harvested	Uniform lines selected
F ₁	20	20	-
F ₂	20	20	-
F ₃	12	12/214	-
F ₄	14	14/160	-
F ₅	15/152	11/89	-
F ₆	24/107	-	28

19) PRELIMINARY YIELD TRIAL

The objective of this trial was to select high yielding lines for advanced yield trial. It consists of 14 Entries including two checks Pb. Masoor-2009 & Pb. Masoor-2019. It was planted at Faisalabad. It was laid out in RCBD design in plot size 4m× 1.2m having three repeats. It kept row to row distance of 30 cm and plant-to-plant spacing of 10 cm. It was harvested on 6-4-2020.

Table-24: RESULTS OF PRELIMINARY YIELD TRIAL.

Rank	Entries	Av. Yield (kg/ha)
1	19511	1806
2	Pb.M-19	1346
3	19505	1280
4	19512	1272
5	19508	1173
6	19504	1172
7	19501	1098
8	19502	1092
9	19510	1015
10	19503	1010
11	19506	958
12	Pb.M-09	918
13	19509	875
14	19507	778
	CV %	10.67
	LSD (0.05)	279

The genotype V-19511 produced highest yield of 1806 kg/ha as compared to check Pb.Masoor-2019 which produced yield of 1346 kg/ha.

20) ADVANCE YIELD TRIAL

The objective of this trial was to select high yielding lines for Micro Yield Trial. It consists of 14 entries including two checks Pb. Masoor-2009 & Pb. Masoor-2019. It was planted at Faisalabad, Kallurkot and Sahowali. It was laid out in RCBD design in plot size 4m×1.2 m having three repeats. It kept row-to-row distance of 30cm and plant-to-plant spacing of 10 cm. The results depicted in table 25.

Table-25: ADVANCE YIELD TRIAL

Rank	Entries	Yield kg/ha			
		Faisalabad	K.KOT	Sahowali	Mean
1	PLL-18506	1068	1944	382	1131
2	PLL-18503	1093	1979	201	1091
3	PLL-18510	1035	1889	243	1056
4	PLL-18509	1279	1455	431	1055
5	PLL-18504	1064	1896	188	1049
6	PLL-18505	1023	1510	278	937
7	Pb.M-19	1015	1396	319	910
8	Pb.M-09	1003	1444	243	897
9	PLL-18511	1038	1316	299	884
10	PLL-18512	494	1628	451	858
11	PLL-18508	1083	1104	292	826
12	PLL-18502	497	1451	958	802
13	PLL-18501	588	1479	313	793
14	PLL-18507	1055	1201	118	791
	CV%	7.5			
	LSD%	67.45			

The genotype V-18506 and V-18503 produced highest yield of 1131 kg/ha and 1091kg/ha respectively as compared to check Pb.M-19 which produced yield of 910 kg/ha.

21) MICRO YIELD TRIAL

The aim of this experiment was to evaluate advance lines in different agro-ecological zones to test their adaptability. It has 14 entries including two checks Pb. Masoor-2009 & Pb. Masoor-2019 was

laid out in RCBD design with three repeats in plot size 4m× 1.2m. The results are well represented in table 26.

Table-26: MICRO YIELD TRIAL

S.NO.	Entries	FSD (irrigated)	K. KOT	Chakwal (Barani)	Fateh jung	Av. Yield (kg/ha)
1	17503	1448	1632	827	997	1226
2	17505	1213	1764	833	972	1195
3	Pb.M-09	1267	1510	778	914	1117
4	17513	1187	1490	688	942	1076
5	17515	1439	1229	701	932	1075
6	Pb.M-19	1317	1333	736	889	1068
7	17502	1397	1160	639	1003	1049
8	17512	1078	1243	729	951	1000
9	17510	1027	1441	479	966	978
10	17509	1243	1153	535	968	974
11	17504	1201	1153	549	991	973
12	17501	962	1125	542	1015	911
13	17523	953	1094	556	926	882
14	17525	1165	861	521	919	866
	CV %	10.78	11.82	18.87	12.94	
	LSD (0.05)	240.56	189	209	200.91	

The genotype 17503 and 17505 produced highest yield of 1226 kg/ha and 1195 kg/ha respectively as compared to check Pb.M-09 which produced yield of 1117 kg/ha.

22) NATIONAL UNIFORM YIELD TRIAL

The trial received from Coordinator (Pulses) NARC, Islamabad. The experiment planted on 31-10-2019 at Faisalabad and data were recorded according to the instructions received along with the seed. It was laid out in RCBD design in plot size 4m×1.2 m having three repeats. It kept row-to-row distance of 30cm and plant-to-plant spacing of 10 cm. This Institute contributed three advance lines (V-16502, V-16508 & V-16510) in National Uniform Yield Trial. It was harvested on 6-4-2020. The results were shown in table 29.

Table-29 Consolidated Results of Lentil National Uniform Yield Trial (kg/ha)

Entry No.	Entry name	Source	LOCATIONS							Mean kg/ha
			RRI	AZRI	AZRC	BARI	BARS	NARC	NIAB	
1	Markaz-09	Check	1138	1761	614	757	1026	895	1920	1159
2	LS-18-2	PRP, NARC, Islamabad	1376	1451	421	667	969	989	1670	1078
3	15CL-307	BARI, Chakwal	1194	1687	690	632	1055	769	1431	1065
4	NLS-19-3	PRP, NARC, Islamabad	1151	1852	117	639	1078	1058	1510	1058
5	NLS-19-2	PRP, NARC, Islamabad	1014	1273	507	736	1103	911	1774	1045
6	LS-18-1	PRP, NARC, Islamabad	1503	1243	288	611	1114	921	1580	1037
7	Pb.M-19	Check	1140	1913	263	424	1061	879	1552	1033
8	NLS 19-4	PRP, NARC, Islamabad	1156	1726	132	646	1031	936	1587	1030
9	NLH-11220	NIAB, Fsd	1269	1451	422	639	1040	739	1618	1026
10	LHM-17014	NIAB, Faisalabad	1395	1017	307	674	1021	711	1993	1017
11	NLH-11229	NIAB, Fsd	1282	1250	749	535	1038	773	1403	1004
12	V-16510	PRI, Fsd	1420	890	369	507	1070	818	1837	987
13	LHM-17015	NIAB, Fsd	1217	1263	178	521	1002	723	1854	965
14	V-16508	PRI, Fsd	699	1629	186	681	1044	839	1670	964
15	15CL-305	BARI, Chakwal	1358	1515	197	590	1065	718	1292	962
16	NLH-11211	NIAB, Faisalabad	976	1347	410	507	995	761	1625	946
17	V-16502	PRI, Fsd	986	1151	103	625	976	823	1931	942
18	NLH-17026	NIAB, Fsd	1028	1028	448	701	1069	721	1556	936
19	NLH-12187	NIAB, Fsd	990	1364	269	653	1034	771	1427	930
20	LHM17020	NIAB, Fsd	1083	1124	213	500	982	743	1750	914
21	NLS-19-1	PRP, NARC, Islamabad	837	559	240	486	1086	730	722	666
	Location Means		1153	1357	339	606	1041	820	1605	

Coefficient of variation=21.8% Genotypes (G), Location (L) and G x L interactions are highly significant (P<0.01)

In national uniform yield trial the check Markaz-09 surpassed all the testing advanced lines of all research institutes.

23) DETERMINATION OF PROPER SOWING DATE TO OVERCOME THE CLIMATIC CHANGE

The aim of this experiment was to find out proper sowing time for new lines. It has 8 entries including two checks Pb.Masoor-19 & Pb. Masoor-2009 was laid out in split Plot Design with three repeats in plot size 4m x 1.2m.

Table-30: YIELD DATA ON SOWING DATES TO OVERCOME THE CLIMATIC CHANGE

Rank	Genotype	SD1 (10 Oct)	SD 2 (25 Oct)	SD 3 (10 Nov)	SD 4 (25 Nov)	Av. yield (kg/ha)
1	V-11508	779	1074	770	758	845
2	V-16508	945	540	803	770	765
3	V-16502	781	697	526	488	623
4	V-11513	984	1031	845	790	912
5	V-16510	885	958	702	694	810
6	V-13502	118	959	662	696	609
7	Pb.M-19	743	1152	1017	836	937
8	Pb.M-09	1003	911	827	831	893
		780	915	769	733	
CV for replications x sowing				11.67%		
CV for replications x sowing x entries				14.55%		

The sowing date 2 that was last week of October was the best sowing time for lentil crop to get maximum yield.

24) PRE-BASIC / BASIC SEED PRODUCTION

The single plants were selected during 2015-16 and sown during 2016-17 as single plant progeny rows in 4 meters long and 30 centimeters apart. The true to type progeny rows were harvested separately. Seed of selected progeny rows was sown in blocks during 2017-18. The genetically true to types, disease free and healthy progeny blocks were selected, harvested and bulked as BNS which was used for pre basic seed production during 2019-20. The diseased and off type plants were rouged out before flowering every year.

Table-31: Seed quantity of BNS and Pre-basic seed

Sr. #	Varieties	Quantity kg	
		BNS	Pre-basic
1	Pb. Masoor-2009	10	1160
2	Pb.Masoor-2019	10	81
3	Pb.Masoor-2020	12	84

DRY PEAS (*Pisum sativum* L.) 2n = 14.

24) MAINTENANCE AND EVALUATION OF GERMPLASM

The gene pool accessions comprising of 103 genotypes of local origin were planted on 14-11-2019 in an augmented design with plot size 4m×0.6m at Faisalabad for maintenance and evaluation. Four checks Meteor, Climax, Pea 09 & No. 267 were used. Each block was planted in 4 m long row by keeping inter and intra row distance of 30 cm and 15 cm respectively. It harvested on 4-4-2020 on their superiority for different traits i.e. highest yield potential and disease resistance for further utilization in the crossing program. The Range of data was shown in table 33.

Table 33 RANGE OF PARAMETERS OF DRY PEAS GERMPLASM GENOTYPES

Trait	Range (Average of five plants)	
	Minimum	Maximum
Plant height (cm)	27	97
Number of primary branches/ plant	1	4
Number of pods/plant	12	41
Pod length (cm)	5	8
Number of clusters/plant	6	21
Number of seeds/pod	3	7

25) HYBRIDIZATION AND STUDY OF FILIAL GENERATIONS

For creation of genetic variability 30 cross combinations possessing greater genetic diversity like wider adaptability, high yield potential, early maturing, resistant to diseases and cold tolerance were planted on 14-11-2019 in paired plot design. Fresh cross combinations were attempted by tackling 25-30 flowers in each combination. The 30 crosses combinations which set seed were harvested for raising F₁ generation during next crop season. Parental lines were planted in paired (female and male) 4 meter long and 30 cm apart rows to facilitate crossing. Cross combinations were harvested on 4-4-2020. Parents selected for new crossing scheme shown in table 34.

Table-34 list of successful cross combinations

S #	High Yielding		Powdery mildew resistant	S #	High Yielding		Powdery mildew resistant
1	T-07	×	Drypeas-2018	16	T-2	×	Drypeas-2018
2		×	I-26	17		×	I-26
3		×	T-28	18		×	T-28
4		×	Meteor	19		×	Meteor
5		×	Climax	20		×	Climax
6	I-41	×	Drypeas-2018	21	T-18	×	Drypeas-2018
7		×	I-26	22			I-26
8		×	T-28	23			T-28
9		×	Meteor	24			Meteor
10		×	Climax	25			Climax
11	T-11	×	Drypeas-2018	26	NO-267	×	Drypeas-2018
12		×	I-26	27		×	I-26
13			T-28	28		×	T-28
14		×	METEOR	29		×	Meteor
15		×	Climax	30		×	Climax

Table-35 LIST OF PARENTAL GENOTYPES ALONG WITH THEIR SALIENT CHARACTERS

Sr. #	Variety/Line	Salient Characters
1	T-07	High yielder
2	I-41	High yielder
3	T-11	High yielder
4	T-2	High yielder
5	T-18	High yielder
6	NO.267	High yielder
7	Drypeas-2018	Powdery mildew resistant
8	I-26	Powdery mildew resistant
9	T-28	Powdery mildew resistant
10	Meteor	Powdery mildew resistant
11	Climax	Powdery mildew resistant

Different segregating populations of crosses / plant progenies studied;

Table 36 LIST OF DIFFERENT SEGREGATING POPULATIONS OF CROSSES / PLANT PROGENIES

Filial generation	Crosses/progenies studied	Crosses/progenies harvested	Uniform lines selected
F1	18	18	-
F2	18/200	18/190	
F3	18/190	18/83	-
F4	23/83	16/80	-
F5	16/140	08/90	
F ₆	08/90	-	14

26) PRELIMINARY YIELD TRIAL

The objective of this trial was to select high yielding lines for advanced yield trial. It consists of 16 entries including two checks No. 267 and Pea 09. It was planted on 14-11-2019 at Faisalabad. It was laid out in RCBD design in plot size 4m× 1.2 m having three repeats. It kept row to row distance of 30 cm and plant to plant spacing of 15 cm. It was harvested on 4-4-2020. The results were shown in table 37.

Table-37 YIELD DATA OF PRELIMINARY YIELD TRIAL

Ranking	Entries	Faisalabad	Kallurkot	Av. Yield (Kg/ha)
1	DP-19006	3262	1444	2353
2	DP-19012	2396	1007	1701
3	DP-19013	2303	910	1607
4	DP-19007	1735	1222	1478
5	DP-19010	1734	1222	1478
6	DP-19001	1994	924	1459
7	DP-19008	1711	1194	1453
8	DP-19005	1949	851	1400
9	DP-19011	1733	924	1328
10	DP-19002	1679	958	1319
11	DP-19004	1574	958	1266
12	NO.267(C)	1974	538	1256
13	DP-19009	1123	1017	1070
14	DP-19003	1475	556	1015

15	DP-19014	1199	667	933
16	PEA 2009(C)	363	521	442
	LSD (0.05)	830	921	
	C.V %	16	18	

The genotype 19006 gave maximum average yield of 2353 kg/ha as compared to check NO.267 having yields of 1256 kg/ha.

27) ADVANCE YIELD TRIAL

The objective of this trial was to select high yielding lines for micro yield trial. It consists of 14 entries including two checks dry pea 2018 and Meteor. It was planted on 14-11-2019 at Faisalabad. It was laid out in RCBD design in plot size 4m× 1.2 m having three repeats. It kept row to distance 30 cm and plant to plant spacing of 15 cm. It was harvested on 4-4-2020. The results were shown in table 38.

Table-38 YIELD DATA OF ADVANCED YIELD TRIAL

Ranking	Entries	Faisalabad	Sialkot	Av. Yield (Kg/ha)
1.	Meteor(c)	1908	528	1218
2.	DP-18006	1944	347	1145
3.	DP-18011	1746	444	1095
4.	DP-18013	1786	389	1088
5.	Dry peas 2018 (c)	1754	417	1085
6.	DP-18001	1228	819	1024
7.	DP-18005	1587	444	1016
8.	DP-18004	1383	549	966
9.	DP-18010	1437	354	895
10.	DP-18003	1294	493	894
11.	DP-18007	1183	576	880
12.	DP-18002	1267	486	877
13.	DP-18012	1278	431	855
14.	DP-18008	1232	250	741
	LSD (0.05)	612	519	
	C.V %	14	17	

The check meteor surpassed the all testing entries in advanced yield trial of dry peas.

28) MICRO YIELD TRIAL

The objective of this trial was to select high yielding lines for DUS Studies. It consists of 12 entries including two checks drypeas 2018 and climax. It was planted on 14-11-2019 at Faisalabad. It was laid out in RCBD design in plot size 4m× 1.2 m having three repeats. It kept row to row distance of 30 cm and plant to plant spacing of 15 cm. It was harvested on 4-4-2020 at Faisalabad. The results were shown in table 39.

Table-39 YIELD DATA OF MICRO YIELD TRIAL

Rank	Entries	Locations					Av. Yield (Kg/ha)
		FSD	CKWL	KAROR	SIALKOT	AGR. FSD	
1	DP-17020	2231	604	878	889	657	1052
2	DP-17006	2274	819	217	917	564	958
3	DP-17002	1979	819	640	743	477	932
4	DP-17008	1662	688	519	1125	639	926
5	Dry peas 2018(C)	1762	910	699	688	519	915
6	DP-17019	1648	771	524	882	657	896
7	DP-17021	1129	882	719	1014	565	862
8	DP-17003	2204	556	426	569	537	859
9	DP-17004	994	826	297	1056	546	744
10	DP-17001	1556	674	293	660	440	725
11	DP-17018	1459	604	228	701	611	721
12	Climax (C)	633	826	290	813	574	627
	LSD (0.05)	240	73	19	191	21	
	C.V %	11	7	9	11	4	

The genotype DP-17020 gave maximum average yield of 1052 kg/ha as compared to check dry peas 2018 having yield of 915 kg/ha. The PRI, Faisalabad contributed one entry to FSC & RD for further DUS studies.

MUNG BEAN (*Vigna radiate* L. Wilczek) 2n = 22

29) GERmplasm STUDIES

The gene pool accessions comprising 350 genotypes of local origin were planted on 29-7-2019 in an augmented design at Faisalabad for maintenance and evaluation. Checks including PRI.M.2018 and NM-16 were used in each block planted in 4 m long row by keeping inter and intra row distance of 30 cm and 10 cm respectively. Each line was evaluated and maintained for further utilization in the crossing program. It was harvested on 13-10-2019. The range of parameters was shown in table 40.

Table-40 RANGE OF PARAMETERS OF MUNG BEAN GERmplasm GENOTYPES

CHARACTERS	RANGE
Days to 50% flowering	28-50
Plant height (cm)	34-100
Pod length (cm)	5-18
No. of grains/pod	4-12
No. of pods per plant	20-82
No. of days to 90% maturity	56-88
1000 grain weight (g)	35-52

30) HYBRIDIZATION PROGRAMME AND STUDY OF FILIAL GENERATIONS

Twenty cross combinations having greater genetic diversity like wider adaptability earliness; bold grain size and resistance against root rot disease were sown on 29-7-2019 in paired plot design at Faisalabad. Parental lines was planted in paired (male and female) 4 meter long and 60 cm apart rows to facilitate crossing. The cross combinations were attempted by tackling 50-70 flowers in each cross combination and 12 successful cross combinations were harvested on 13-10-2019 for raising F₁ generation during next crop season. Twelve successful crosses scheme shown in table 36 and parental genotypes salient characters shown in table 41.

Table-41 LIST OF SUCCESSFUL CROSS COMBINATIONS

Sr.#	Cross Combination			Sr.#	Cross Combination		
1	MPP-15024	x	LS-442	7	PML-13006	x	MPP-15039
2	"	x	MPP-15002	8	"	x	PML-17004
3	"	x	PML-17004	9	PRI M-2018	x	MPP-15002
4	NM-11	x	LS-442	10	"	x	MPP-15003
5	"	x	MPP-15039	11	"	x	MPP-15039
6	"	x	MPP-15003	12	"	x	PML-17004

Table-42 LIST OF PARENTAL GENOTYPES ALONG WITH THEIR SALIENT CHARACTERS

Sr. #	Variety/Line	Salient Characters
1	MPP-15024	Early Maturing/disease tolerant
2	NM-11	High yielding/disease tolerant
3	PML-13006	Bold Seeded
4	PRI MUNG-18	Drought tolerant
5	LS-442	Extra-long pod
6	MPP-15002	Short duration/early maturing
7	MPP-15003	Short Duration/disease tolerant
8	MPP-15039	MYMV Resistant/Early maturing
9	PML-17004	Top bearing fruit/Erect type plant

Different filial generations were shown in table 43.

Table 43 LIST OF DIFFERENT FILIAL GENERATIONS

Filial generations	Crosses/progenies studied	Crosses/progenies selected/harvested	Uniform lines selected
F ₁	20	12	-
F ₂	18	18	-
F ₃	14/46	12/37	-
F ₄	06/35	5/34	-
F ₅	12/42	06/35	-
F ₆	14/30	12/25	08 uniform lines selected

31) PRELIMINARY YIELD TRIAL

The objective of this trial was to select high yielding lines for advanced yield trial. It was consists of 10 entries including check NM-2016. It was planted on 29-7-2019 at Faisalabad. It was laid out in RCBD design in plot size 4m× 1.2 m having three repeats. It kept row to row distance of 30cm and plant to plant spacing of 15 cm. It was harvested on 13-10-2019. The yield data is given in table 44.

Table-44 YIELD DATA OF PRELIMINARY YIELD TRIAL

S. #	Entries	Av. Yield (kg/ha)
1	PML-17004	1354
2	PML-17003	1263
3	PML-17006	1233
4	PML-17008	1104
5	PML-17007	1036
6	PML-17005	986
7	AZRI-06	826
8	PML-17001	816
9	NM-16	796
10	PML-17002	780
	L.S.D (0.05)	19.12
	C.V %	11.55

The genotype 17004 gave maximum average yield of 1354 kg/ha as compared to AZRI-06 having yields of 826 kg/ha.

32) ADVANCE YIELD TRIAL

In this trial, 09 entries were studied including two checks AZRI 06 & NM-2016. It was sown on 29-7-2019 at Faisalabad with plot size 4 m × 1.2m. It was laid out in RCBD design having three repeats. It kept row to row distance of 30 cm and plant to plant spacing of 15 cm. It was harvested on 13-10-2019. The yield data recorded were compiled in table 45.

Table-45 YIELD DATA OF ADVANCED YIELD TRIAL

S. #	Entries	Av. Yield (kg/ha)
1.	PML-16005	1230
2.	PML-16002	1086
3.	PML-16006	866
4.	PML-16004	842
5.	PML-16003	834
6.	PML-16001	796

7.	AZRI -2006	752
8.	PML-16007	718
9.	NM-16	694
	L.S.D (0.05)	19.55
	C.V %	14.14

The genotype 16005 gave maximum average yield of 1230 kg/ha as compared to AZRI-06 having yields of 752 kg/ha.

33) MICRO YIELD TRIAL

The objective of this experiment was to evaluate advance lines for DUS studies as well as national uniform yield trial. It had 09 entries including two checks AZRI-06 & NM-2016 was sown on 29-7-2019 in RCBD design with three repeats in plot size 4m× 1.2m. It was harvested on 13-10-2019. The yield data was compiled in table 46.

Table-46 YIELD DATA OF MICRO YIELD TRIAL

S. #	Entries	Av. Yield (kg/ha)
1.	PML-15002	1210
2.	PML-15005	1186
3.	PML-15001	1138
4.	PML-15007	1098
5.	PML-15004	1036
6.	PML-15003	1028
7.	AZRI -2006	966
8.	PML-15006	914
9.	NM-16	904
	L.S.D (0.05)	19.71
	C.V %	10.61

The genotype 15002 gave maximum average yield of 1210 kg/ha as compared to AZRI-06 having yields of 966 kg/ha.

34) NATIONAL UNIFORM YIELD TRIAL

Mung national uniform yield trial comprising of 17 entries received from Coordinator Pulses NARC, Islamabad was sown on 29-7-2019 at Faisalabad with a plot size of 4m × 1.2 m in three repeats in RCBD design. Pulses research institute contributed 03 entries. It was harvested on 13-10-2019. Results were shown in table 47.

Table-47 Consolidated results of Mung bean National Uniform Yield Trial

S. No.	Entry Name	Source	Locations*									
			PRI FSD	AZRI BKR	BARI CKWL	NIAB	AZRC	NIFA	NARC	BARS	AZRI	Av.Yield (kg/ha)
1	MH-13091	NIAB	403	979	660	1858	1074	608	1715	503	741	949
2	TM-1627	AZRI	492	938	639	1965	1182	660	1287	514	704	931
3	MSPS-119	NARC	614	629	639	2225	958	552	907	500	800	869
4	TM-1426	AZRI	436	840	583	1702	597	378	1715	253	688	835
5	GV-1	Mingora	457	763	632	1469	1327	729	966	438	641	825
6	NM-11	Check	521	631	660	2108	611	385	1140	451	791	811
7	13006	PRI, AARI	414	688	604	1360	1356	743	869	653	558	805
8	14005	PRI, AARI	522	727	674	1494	763	458	1226	628	737	803
9	14009	PRI, AARI	407	754	590	1256	979	563	1222	597	814	798
10	NCM-13	NARC	446	740	632	1900	871	510	894	455	527	775

11	MH-16053	NIAB	410	415	569	1823	1008	576	990	681	439	768
12	AZRI M. 18	Check	413	642	611	1490	705	431	1356	479	479	734
13	TM-1418	AZRI	447	488	625	1740	590	375	983	497	693	715
14	AZRC-E218	AZRC	756	342	632	1427	792	472	887	715	331	706
15	MH-16058	NIAB	563	646	639	1354	828	490	967	368	370	692
16	NCM-11-Z	NARC	458	571	688	1744	416	292	929	524	573	688
17	NIFA Mung-6	NIFA	403	721	618	1510	603	382	850	448	592	681
Location Means			480	667	629	1672	862	506	1112	531	616	

Coefficient of variation= 14.03% Genotypes (G) Location (L) and G x L interactions are highly significant (P<0.01)

***Locations:**

1 = AARI, Faisalabad 2 = AZRI, Bhakkar 3 = BARI, Chakwal 4 = NIAB, Faisalabad
5 = AZRC, DI Khan 6=NIFA Peshawar 7 = NARC, Islamabad 8= BARS, Fatehjang 9= AZRI, Umarmkot

The genotype MH-13091 gave maximum average yield of 949 kg/ha as compared to NM-11 having yields of 811 kg/ha.

35) PRE-BASIC / BASIC SEED PRODUCTION

The single plants were selected during 2016 and sown during 2017 as single plant progeny rows in 4 meters long and 30 centimeters apart. The true to type progeny rows were harvested separately. Seed of selected progeny rows was sown in blocks during 2018. The genetically true to types, disease free and healthy progeny blocks were selected, harvested and bulked as BNS which was used for pre basic seed production during 2019. The diseased and off type plants were rouged out before flowering every year. Seed quantity of following genotypes was produced as shown in table 48.

Table 48 LIST OF VARIETIES AND SEED QUANTITY

Varieties	Pre-basic seed (Kg)	Basic seed (Kg)
AZRI-2006	2200	2710
PRI Mung-2018	125	-
Total (Kg)	2325	2710

MASH BEAN (*Vigna mungo* L. Hepper) 2n = 22

36) GERmplasm STUDIES

The gene pool accessions comprising 300 genotypes of local origin were planted on 01-08-2019 in an augmented design at Faisalabad for maintenance and evaluation. It was planted in 2.5 m long row by keeping inter and intra row distance of 30 cm and 10 cm respectively. Each line was selected on their superiority for different traits i.e. highest yield potential and other morphological parameters for further utilization in the crossing program. It was harvested on 16-10-2019. The range of different traits shown in table 49.

Table-49 RANGE OF PARAMETERS OF MASH BEAN GERmplasm GENOTYPES

Trait	Range
Plant type	Spreading to erect
Plant height	24- 70 cm
No. of pods /plant	14-142
No. of seeds/ pod	4-6
1000-grain weight	26-45 g
Maturity days	82-117
Grain color	Black , brown and green
Grain yield/plant	3.0 – 14.8 g

37) HYBRIDIZATION PROGRAMME AND STUDY OF FILIAL GENERATIONS

Fifteen cross combinations having greater genetic diversity like wider adaptability earliness; bold grain size and resistance against root rot disease were sown on 01-8-2019 in paired plot design at Faisalabad. Parental lines were planted in paired (male and female) 4 meter long and 30 cm apart rows to facilitate crossing. The fifteen cross combination were attempted by tackling 50-70 flowers in each cross combination and fourteen successful were harvested on 28-10-2019 for raising F1 generation during next crop season shown in table 50.

Table-50 LIST OF SUCCESSFUL CROSS COMBINATIONS

High yield Parents	X	ULCV Tolerant Parents
62027	X	Arooj-11
	X	Mash-97
	X	ES-1
AARIM-65	X	Arooj-11
	X	Mash-97
	X	ES-1
AARIM-121	X	Arooj-11
	X	Mash-97
	X	ES-1
17M011	X	Arooj-11
	X	Mash-97
	X	ES-1
US-221	X	Arooj-11
	X	Mash-97

Different segregating populations / plant progenies studied shown in table 51;

Table 51. Filial generations	Crosses/progenies selected/harvested
F ₁	21
F ₂	11
F ₃	6/18
F ₄	7/20
F ₅	6/16
F ₆	2/6

38) PRELIMINARY YIELD TRIAL

The objective of this trial was to select high yielding lines for advanced yield trial. It was consists of 14 entries including two checks Mash-97 & Arooj-11. It was laid out in RCBD design with plot size 4m× 1.2 m having three repeats. It kept row to row distance of 30 cm and plant to plant spacing of 10 cm. The spring sowing was done on 27-3-2019 and harvested on 18-6-19. Results can be seen in table 52.

Table-52 YIELD DATA OF PRELIMINARY YIELD TRIAL SPRING 2019

Rank #	Entries	Av. Yield Kg/ha Faisalabad
1.	19M005	1027
2.	19M012	938
3.	19M003	860
4.	19M006	857
5.	19M009	795
6.	19M001	792
7.	AROJ-11(check)	781
8.	MASH-97(check)	752
9.	19M011	732
10.	19M004	708
11.	19M010	697
12.	19M007	656
13.	19M008	533
14.	19M002	396
	C.V.%	9.1
	LSD (0.05)	26

The genotype 19M005 gave maximum average yield of 1027 kg/ha as compared to check variety Arooj-11 having yields of 781 kg/ha.

The preliminary yield trial Kharif-2019 consists of 14 entries including two checks Mash-97 & Arooj-11. It was laid out in RCBD design with plot size 4m× 1.2 m having three repeats. It kept row to row distance of 30 cm and plant to plant spacing of 10 cm. It was sown on 01-08-19 and harvested on 24-10-19. Results can be seen in table 53.

TABLE 53 YIELD DATA OF PRELIMINARY YIELD TRIAL KHARIF-2019

Rank #	Entries	Av. Yield Kg/ha Faisalabad
1.	19M011	656

2.	19M002	646
3.	19M001	592
4.	AROOJ-11(check)	581
5.	19M010	531
6.	19M012	498
7.	MASH-97(check)	492
8.	19M005	481
9.	19M009	415
10.	19M008	402
11.	19M004	390
12.	19M006	367
13.	19M007	325
14.	19M003	256
	C.V.%	12.2
	LSD (0.05)	28

The genotype 19M011 gave the highest yield 656kg/ha followed by genotype 19M002 which gave 646 kg/ha yield. Check variety Arooj-11 stood at 4th place gave 581 kg/ha yield.

39) ADVANCED YIELD TRIAL

This trial was sown in spring 2019, 12 entries studied including two checks Mash-97 & Arooj-11. It was laid out at Faisalabad with plot size 4 m × 1.2m having three repeats. The spring sowing was done on 27-3-2019 and harvested on 18-6-19. The yield data recorded were compiled in table 54.

TABLE 54 YIELD DATA OF ADVANCED YIELD TRIAL SPRING 2019

Rank #	Entries	Av. Yield Kg/ha Faisalabad
1.	18M008	1325
2.	18M005	1183
3.	18M009	1080
4.	AROOJ-11(check)	948
5.	18M013	842
6.	18M006	787
7.	18M011	776
8.	18M010	731
9.	18M007	639
10.	MASH-97(check)	565
11.	18M014	558
12.	18M004	553
	C.V.%	11.2
	LSD (0.05)	36

The genotype 18M008 gave maximum average yield of 1325 kg/ha as compared to AROOJ-11 having yields of 948 kg/ha.

In Kharif 2019 trial, 12 entries were studied including two checks Mash-97 & Arooj-11. It was laid out at Faisalabad with plot size 4 m × 1.2m having three repeats. It was sown on 01-08-19 and harvested on 24-10-19. The yield data recorded were compiled in table 55.

TABLE 55 YIELD DATA OF ADVANCED YIELD TRIAL KHARIF-2019

Rank #	Entries	Av. Yield Kg/ha Faisalabad
1.	17M008	652
2.	17M007	633
3.	17M012	600
4.	Mash-97 (Check)	585
5.	17M009	581
6.	Arooj-11 (Check)	579
7.	17M014	560
8.	17M011	525
9.	17M006	521
10.	17M010	517
11.	17M013	475
12	17M005	400
	C.V.%	13.7
	LSD (0.05)	24

The genotype 17M008 gave maximum average yield of 652 kg/ha as compared to Mash-97 having yields of 585 kg/ha.

40) MICRO YIELD TRIAL

The objective of this trial was to select high yielding genotypes. Spring sown consists of 16 entries including two checks Mash-97 & Arooj-11. It was laid out in RCBD design with plot size 4m× 1.2 m having three repeats. It kept row to row distance 30 cm and plant to plant spacing of 10 cm. The spring sowing was done on 27-3-2019 and harvested on 18-6-19. The results were shown in table 56.

TABLE 56 YIELD DATA OF MICRO YIELD TRIAL SPRING-2019

Rank	Entry	Faisalabad	Sahowali	Av. Yield Kg/ha
1.	16M008	1057	2569	1813
2.	16M006	1194	2292	1743
3.	17M008	924	2556	1740
4.	17M011	762	2535	1649
5.	17M005	1047	2223	1635
6.	17M006	967	2292	1630
7.	17M013	721	2396	1559
8.	17M009	875	2229	1552
9.	Arooj-11(check)	514	2500	1507
10.	17M014	690	2187	1439
11.	16M005	1199	1625	1412
12.	17M012	762	2021	1392
13.	17M007	957	1777	1367
14.	17M010	863	1840	1352
15.	16M004	1204	1215	1210
16.	Mash97 (check)	670	1598	1134
	C.V.%	10.8	18.2	
	LSD (0.05)	38	103	

The genotype 16M008 gave maximum average yield of 1813 kg/ha as compared to AROOJ-2011 having yields of 1507 kg/ha.

Kharif-2019 sown consists of 16 entries including two checks Mash-97 & Arooj-11. It was laid out in RCBD design in plot size 4m× 1.2 m having three repeats. It kept row to row distance of 30 cm and plant to plant spacing of 10 cm. It was sown on 01-08-19 and harvested on 25-10-19. The results were shown in table 57.

Table 57 YIELD DATA OF MICRO YIELD TRIAL

Rank #	Entry	Av. Yield Kg/ha
1.	17M009	623
2.	17M011	618
3.	17M012	613
4.	16M004	612
5.	17M014	574
6.	16M006	560
7.	AROOJ-2011	545
8.	17M006	543
9.	17M005	519
10.	16M008	481
11.	17M008	465
12.	Mash-97	464
13.	17M013	449
14.	17M010	394
15.	16M005	365
16.	17M007	357
	C.V.%	16.8
	LSD (0.05)	34

The genotype 17M009 gave maximum average yield of 623 kg/ha as compared to check variety Arooj-11 which gave 545 kg/ha yield.

41) PRE-BASIC / BASIC SEED PRODUCTION

The single plants were selected during 2016 and sown during 2017 as single plant progeny rows in 4 meters long and 30 centimeters apart. The true to type progeny rows were harvested separately. Seed of selected progeny rows was sown in blocks during 2018. The genetically true to types, disease free and healthy progeny blocks were selected, harvested and bulked as BNS which was used for pre basic seed production during 2019. The diseased and off type plants were rouged out before flowering every year. Seed of following genotypes was produced as shown in table 58.

Table 58 LIST OF VARIETIES AND SEED QUANTITY

S #	Entries/Lines	Pre-basic (Kg)	BNS (Kg)
1.	Arooj-2011	779	84

42) NATIONAL UNIFORM YIELD TRIAL

Mash national uniform yield trial comprising of 17 entries received from Coordinator Pulses NARC, Islamabad was sown on 01-08-2019 at PRI Faisalabad with a plot size of 4m × 1.2 m in three repeats in RCBD design. It was harvested on 25-10-19. Row to row distance of 30 cm and plant to plant spacing was 10 cm. It was sown at four different sites of Pakistan. Data was shown in table 59.

Table 59 Consolidated results of Mash National Uniform Yield Trial

S. No.	Genotype	Institution	Locations				Mean Kg/ha
			1	2	3	4	
1	14CM-705	BARI, Chakwal	513	1450	922	1054	985
2	14CM-708	BARI, Chakwal	502	1232	891	807	858
3	AG-30	PGRI, NARC	591	417	1230	1132	842
4	AG-29	PGRI, NARC	621	690	973	1014	825
5	16M004	PRI,AARI, FSD	579	426	1156	1022	796
6	AG-10	PGRI, NARC	583	663	1024	902	793
7	AG-34	PGRI, NARC	477	588	809	1255	782
8	AZRC-Mash-2	AZRC, DI KHAN	489	600	899	1053	760
9	Mash -NARC-13	Check	689	380	1172	777	755
10	AG-7	PGRI, NARC	449	435	1298	830	753
11	NMS-16-15	PRP, NARC	655	678	708	778	704
12	16M006	PRI,AARI, FSD	471	599	1050	655	694
13	NMS-16-14	PRP, NARC	421	333	1155	851	690
14	17M013	PRI,AARI, FSD	680	443	723	781	657
15	NMS-16-16	PRP,NARC	632	885	502	554	643
16	AZRC –Mash-1	AZRC, DI khan	508	179	972	856	629
17	Arooj-Mash	Check	499	429	456	933	579
Mean			551	613	938	897	750
LSD (0.05)			139.48	109.58	97.09	227.16	-
CV %			18.32	12.92	7.49	18.30	-

Coefficient of variation=14.66%

Genotypes (G), Location (L) and G x L interactions are highly significant (P<0.01)

1	2	3	4
PRI, AARI Faisalabad	AZRI Umer Kot Sindh	AZRC D.I.Khan	NARC Islamabad

The genotype 14CM-705 gave the highest average yield 985 kg/ha. PRI Faisalabad genotype 16M004 stood at 5th place and gave 796 kg/ha yield. Check variety Mash-NARC-13 stood at 9th place with average yield of 755 kg/ha.

COW PEAS (*Vigna sinensis L.*) 2n = 22

43) GERMPLASM STUDIES

The gene pool accessions comprising of 60 genotypes of local origin were planted in an augmented design at Faisalabad for maintenance and evaluation. It was planted on 24-7-2019 by keeping inter and intra row distance of 60 cm and 20 cm respectively. Each line was selected on their superiority for different traits i.e. highest yield potential and disease resistance for further utilization in the crossing program. It was harvested on 15.11.2019. The range of traits was given in table 60.

Table-60 RANGE OF PARAMETERS OF COWPEAS GERMPLASM GENOTYPES

Trait	Range
Plant type	Erect to spreading
Flower color	White and Purple
Leaf color	Light green to dark green
No. of pods /plant	20-98
No. of seeds/ pod	4-19
Days to Flower initiation	45-70
Maturity days	105-132
100-grain weight (g)	11-34

44) HYBRIDIZATION PROGRAMME AND STUDY OF FILIAL GENERATIONS

Twelve cross combinations having greater genetic diversity like wider adaptability earliness; bold grain size and resistance against root rot disease were sown in paired plot design at Faisalabad. Parental lines were planted on 24-7-19 in paired (male and female) 4 meter long and 60 cm apart rows to facilitate crossing. The cross combinations were attempted by tackling 50-60 flowers in each cross combination and successful cross combinations were harvested on 10-11-2019 for raising F1 generation during next crop season. List of successful cross combinations were given in table 61 and parents characteristics shown in table 62.

Table-61 LIST OF SUCCESSFUL CROSS COMBINATIONS

Sr.#	Cross Combination		
1	CP-017	x	CP-002
2	CP-030	x	CP-034
3	CP-072	x	CP-034
4	CP-072	x	CP-037
5	CP-020	x	CP-034
6	CP-020	x	CP-037

Table-62 LIST OF PARENTAL GENOTYPES ALONG WITH THEIR SALIENT CHARACTERS

Sr. #	Variety/Line	Salient Characters
1	CP-002	Erect type
2	CP-017	High yielder
3	CP-020	Virus resistant
4	CP-030	Virus resistant
5	CP-034	High yielder
6	CP-037	High yielder
7	CP-072	Virus resistant

Different segregating populations of crosses / plant progenies studied shown in table 63;

Table 63 LIST OF DIFFERENT SEGREGATING POPULATIONS OF CROSSES / PLANT PROGENIES

Filial generations	Crosses/progenies studied	Crosses/progenies selected/harvested
F ₁	5	20
F ₂	3	3/40

45) PRELIMINARY YIELD TRIAL

The objective of this trial was to select high yielding lines for advanced yield trial. It was consists of 10 entries including one check S. A. dandy. It was sown on 24-7-2019. It was laid out in RCBD design in plot size 5 m x 3.0 m having three repeats. It kept row to row distance of 60 cm and plant to plant spacing of 20 cm. It was harvested on 15-11-19. Results were shown in table 64.

Table 64 YIELD DATA OF PRELIMINARY YIELD TRIAL

Rank	Entry	Av. Yield kg/ha
1.	CP-020	915
2.	CP-017 (CHECK)	776
3.	CP-003	769
4.	CP-014	680
5.	CP-018	598
6.	CP-047	527
7.	CP-024	488
8.	CP-009	478
9.	CP-050	364
10.	CP-019	344
	C.V.%	16.8
	LSD (0.05)	34

In this trial the entry CP-020 gave the highest average yield i.e. 915 kg/ha followed by entry CP-017 (check) with average yields of 776 kg/ha.

46) ADVANCE YIELD TRIAL

In this trial, 10 entries were studied including one check S.A. Dandy. It was laid out in RCBD design in plot size 5m x 3.0 m having three repeats. It kept row to row distance of 60 cm and plant to plant spacing of 20 cm. It was sown on 24-7-2019 and harvested on 15-11-2019. The results were shown in table 65.

Table-65 YIELD DATA OF ADVANCED YIELD TRIAL

Rank	Entry	Av. Yield kg/ha
1.	CP-037	808
2.	CP-101	751
3.	CP-034	720
4.	CP-017 (CHECK)	676
5.	CP-040	576

6.	CP-008	543
7.	CP-030	517
8.	CP-072	488
9.	CP-001	422
10.	CP-060	306
	C.V.%	14.1
	LSD (0.05)	37

In this trial the entry CP-037 gave the highest average yield i.e. 808 kg/ha followed by entry CP-101 with average yields of 751 kg /ha.

47) MICRO YIELD TRIAL

In this trial, 10 entries were studied including one check S.A. Dandy. It was laid out in RCBD design in plot size 5m x 3.0m having three repeats. It kept row to row distance of 60 cm and plant to plant spacing of 20 cm. It was sown on 24-7-2019 and harvested on 15-11-2019. Results were shown in table 66.

Table-66 YIELD DATA OF MICRO YIELD TRIAL

Rank	Entry	Location			Av. Yield kg/ha
		Faisalabad	Kallurkot	Sahowali	
1	CP-070	626	570	403	533
2	CP-076	539	285	354	393
3	CP-002	718	477	347	514
4	CP-075	577	555	347	493
5	CP-085	540	481	229	417
6	CP-029	359	192	208	253
7	CP-096	533	659	174	455
8	CP-100	525	429	146	367
9	CP-077	405	500	139	348
10	CP-017 (CHECK)	623	459	97	393
	C.V.%	12.8	17.8	10.8	
	LSD (0.05)	39	35	51	

In this trial, entry CP-070 gave the highest average yield i.e. 533 kg /ha followed by entry CP-002 with average yield of 514 kg/ha and entry CP-075 with average yield of 493 kg/ha.

PLANT PATHOLOGY

48) SCREENING OF CHICKPEA (DESI AND KABULI) ADVANCE LINES AGAINST ASCOCHYTA BLIGHT

The aim of study was to identify lines of chickpea resistant/ tolerant to blight (*Ascochyta rabiei* Pass. Lab.) The experiment comprises of 204 lines of both kabuli and desi was conducted under tunnel condition. Trail was sown on 14-10-2019. The disease was induced artificially in the tunnel. Spore suspension was sprayed on the test lines at 3 days interval till the initiation of disease. Fresh tap water was sprayed daily to provide required humidity. It consists of plot size 3m×0.3m. Two checks (k-15012 and AUG-424) were sown after two lines in Kabuli and desi respectively. The incidence of the disease was recorded using International Standard Scale 1-9 (ICARDA). It was harvested on 28-4-2020.

Out of 104 varieties/lines of chickpea (Desi) only 05 showed Moderately Resistant response. Out of 100 varieties/lines of chickpea (Kabuli) only 03 showed Moderately Resistant

49) SCREENING OF CHICKPEA LINES AGAINST WILT AND ROOT ROT DISEASES

One hundred and four Desi and one hundred Kabuli chickpea lines were screened against wilt and root rot diseases in sick field. It was sown on 14-10-2019. Each variety/line was sown in 3 m long row and 30 cm apart. Highly susceptible line (AUG-424) was sown after every two test entries as check. It was harvested on 28-4-2020. The data of disease incidence was recorded from seedling stage to maturity using international standard scale (ICARDA). All the tested lines of chickpea (Kabuli) and (Desi) showed susceptible to highly susceptible response against wilt and root rot diseases.

50) SCREENING OF LENTIL GERMPASM AGAINST WILT AND ROOT ROT DISEASES

Forty four lines of lentil were screened against wilt and root rot diseases in sick field. It was sown on 14-10-2019. Each variety was planted in 3 m long and 30 cm row apart. Highly susceptible check M-85 was planted after every two-test entries as check. The disease incidence was recorded from seedling to maturity. It was harvested on 28-4-2020.

Out of 44 lines 07 lines were found Resistant, 22 lines showed moderately resistant and all other showed as susceptible to highly susceptible.

51) SCREENING OF MUNGBEAN (*Vignaradiata* (L.) Wilczek) PROMISING LINES/ VARIETIES FOR RESISTANCE/ TOLERANCE TO MUNGBEAN YELLOW MOSAIC VIRUS (MYMV) AND URDBEAN LEAF CRINKLE VIRUS (ULCV)

Ten lines of Mung bean were evaluated against Mungbean Yellow Mosaic Virus (MYMV) and Urdbean Leaf Crinkle Virus (ULCV). Trail was sown on 19-07-2019. The test entries were planted in 3 meter long and 30 cm apart single rows. Mung Kabuli was sown as spreader after every two-test entries. It was harvested on 28-10-2019. The data of disease incidence was recorded from seedling stage to maturity using international standard scale (ICARDA). Out of 10 lines/Entries, 09 lines showed resistant response and 01 line was found moderately resistant against Mungbean Yellow Mosaic Virus (MYMV). whereas all varieties showed moderately susceptible to susceptible response against Urdbaen Leaf Crinkle Virus (ULCV).

52) SCREENING OF MASH (*Vigna mungo* (L.) Hepper) LINES/ VARIETIES FOR RESISTANCE/ TOLERANCE TO URDBEAN LEAF CRINKLE VIRUS (ULCV) AND MUNGBEAN YELLOW MOSAIC VIRUS(MYMV)

Seventy lines of Mash bean were evaluated against Mungbean Yellow Mosaic Virus (MYMV) and Urdbean Leaf Crinkle Virus (ULCV) trial was sown on 19-07-2019. The test entries were planted in 3 meter long and 30 cm apart single rows. Kandari Mash was used as spreader after every two test entries. Trail was harvested on 28-10-2019. The data of disease incidence was recorded from seedling stage to maturity using international standard scale (ICARDA).

Out of 70 lines/Entries, 66 lines showed resistant response against Mungbean Yellow Mosaic Virus (MYMV). Whereas 37 lines showed resistant and 01 line was moderately resistant response against Urdbean Leaf Crinkle Virus (ULCV).

53) SCREENING OF COWPEAS (*Vigna sinensis*) PROMISING LINES FOR RESISTANCE/ TOLERANCE TO COWPEA YELLOW MOSAIC VIRUS (CYMV)

Ten lines of Cowpeas were screened against cowpea yellow mosaic virus (CYMV). Trail was sown on 19-07-2019. The test entries were planted in 3 meter long and 30 cm apart single rows. The disease incidence was recorded from seedling to maturity. Desi Arvan was used as spreader after every two test entries. It was harvested on 28-10-2019. The data of disease incidence was recorded from seedling stage to maturity using international standard scale (ICARDA). Out of 10 lines/Entries all lines were found highly resistant Against COWPEA YELLOW MOSAIC VIRUS (CYMV).

54) Screening of Mungbean (*Vigna radiata* (L.) Wilczek) Lines for Resistance/ Tolerance to *Cercospora* leaf spot

Ten lines of Mungbean lines were evaluated against *Cercospora* leaf spot. Trail was sown on 19-07-2019. The test entries were planted in 3 meter long and 30 cm apart single rows. Line 14003 was used as spreader after every two-test entries. It was harvested on 23-10-2019. The severity of disease was recorded by using scale 0-9 (C.D.MAYEE & V.V DATAR, 1986) in natural conditions. Due to unfavorable weather conditions *Cercospora* leaf spot did not appeared. So, the trial will be repeated in the next Kharif season.

55) MANAGEMENT OF CERCOSPORA LEAF SPOT (*Cercospora canescens*) in MUNG BEAN (*Vigna radiata* (L.) Wilczek) BY USING SYSTEMIC AND NON-SYSTEMIC FUNGICIDES

The aim of study was to see the effect of using systemic and non-systemic fungicides for the management of *Cercospora* leaf spot (*Cercospora canescens*) in Mungbean. Trail was sown on 19-07-2019. Line 14003 was used in this trial. It was harvested on 23-10-2019. Total seven treatments were used including water as a control treatment in table 67.

Sr #	Table 67. Treatments	% Decrease/control
1	T1 (Curzate)	16.67%
2	T2 (score)	30%
3	T3 (Revis)	6.67%
4	T4 (Evito)	16.67%
5	T5 (Redomil gold)	16.67%
6	T6 (Topsin M)	46.67%
7	T7 (Water)	0.00%

The efficacy of six fungicides was tested against Cercospora leaf spot of Mungbean. Out of which Topsin M gave 46.67% decrease over control

BACTERIOLOGICAL STUDIES

56) RESPONSE OF CHICKPEA AND MUNGBEAN TO RHIZOBIUM AND PGPR CO-INOCULATION

Microbes play an important role in agricultural management because they help to fix the nitrogen by nitrogen fixation which helps the plants to absorb nitrogen easily and they also help to decompose the dead and organic matter which is also very useful for plants. Some soil bacteria and fungi form relationships with plant roots that provide important nutrients like nitrogen or phosphorus. Therefore, this trial was conducted to identify the best suited rhizobium PGPR co-inoculation for optimum chickpea and mung bean production. The following treatments as given in Table 1 were tested during 2019-20. Recommended dose (25-60 N, P kg/ha) of fertilizers were added to the soil prior to sowing. Rhizobium as well as PGPR culture as per treatment were applied to seed before sowing. Data for number of nodules at flowering stage and yield at maturity were recorded. Pre sowing and post-harvest soil samples were collected for their physico- chemical analysis.

Results showed (Table 68) that in case of chickpea maximum no. of nodules were found in T₁ (33.7) where rhizobium sp. of bacteria was used and minimum in control (22.3) where seed was not inoculated with inoculum. Similarly maximum grain yield (996 kg/ha) was found in T₂ and minimum grain yield (615 kg/ha) in T₁ (control) where seed was not treated with inoculum.

Treatments		No. of nodules per plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	22.3	615
T2	Rhizobium Sp. For Chick pea	33.7	996
T3	Azotobacter (PGPR1)	28.7	954
T4	Bacillus (PGPR2)	29.3	840
T5	Rhizobium + PGPR1	26.3	802
T6	Rhizobium + PGPR2	30.0	785

Data given in Table 69 revealed that in case of mung bean maximum number of nodules (25.7) were observed in T₂ and minimum in T₁ (16.0). Similarly maximum grain yield (1486 kg/ha) was found in T₂ and minimum grain yield (1111 kg/ha) in T₁ (control) where seed was not inoculated. The results showed that grain yield was increased and grain quality was also improved in treatments inoculated with inoculum as compared to control.

Treatments		No. of nodules per plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	16.0	1111
T2	Rhizobium Sp. For Chick pea	25.7	1486
T3	Azotobacter (PGPR1)	20.7	1148
T4	Bacillus (PGPR2)	20.3	1324
T5	Rhizobium + PGPR1	21.7	1278
T6	Rhizobium + PGPR2	22.0	1324

57) BIOFORTIFICATION OF PULSES (RABI AND KHARIF) BY ZINC AND IRON APPLICATION

The lack of micronutrients such as iron and zinc is a widespread nutrition and health problem in developing countries. Biofortification is the process of enriching the nutrient content of staple crops. Biofortification provides a sustainable solution to iron and zinc deficiency in food around the world. Reports have highlighted the current strategies for the biofortification of crops, including mineral fertilization, conventional breeding and transgenic approaches. Any approach which could increase root growth and result in a high transfer of Fe and Zn from the soil to the plant is crucial for biofortification.

Keeping in view these facts this study was planned to increase the yield, Zn and Fe concentration in chickpea (Desi and Kabuli), lentil (Rabi crops) and Kharif crops (Mung bean and Mash) . Recommended dose (25-60 N, P kg/ha) of fertilizer was applied to all treatments. Chickpea variety Bittal-2016 (Desi), Noor-2013 (Kabuli), lentil (Pb-Masoor-2020), PRI Mung-2018 (Mung bean) and Mash (Arooj-2011) were grown during 2019-20.

The following treatments as given in Table 70 were tested. Recommended dose (25-60 N, P kg/ha) of fertilizers were added to the soil prior to sowing. Treatments of Zinc and Iron were applied according to treatment plan. Data for number of nodules at flowering stage and yield at maturity were recorded. Pre sowing and post-harvest soil samples were collected for their physico-chemical analysis.

Table 70 Treatments

T1	Control (25-60-0)
T2	2.5 kg Zn/ ha
T3	5.0 kg Zn / ha
T4	2.5 kg Fe/ ha
T5	5.0 kg Fe / ha
T6	2.5 kg Zn + 2.5 kg Fe/ ha
T7	5 kg Zn + 5 kg Fe/ ha
T8	0.1 % ZnSO ₄ (Two sprays: one at flowering and one 15 days after first spray
T9	0.1 % FeSO ₄ (Two sprays: one at flowering and one 15 days after first spray
T10	0.1 % ZnSO ₄ +0.1 % FeSO ₄ (Two sprays: one at flowering and one 15 days after first spray

The results given in Table 71 revealed that in chickpea (Desi) maximum number of nodules were found in T₇ (51) where Zn and Fe were applied @ 5 kg/ha and minimum in T₁ (26) where only recommended dose of fertilizer was applied. The maximum grain yield (1236 kg/ha) was found in T₇ and minimum in T₁ (736 kg/ha).

Table 71. BIOFORTIFICATION OF CHICKPEA (DESI) BY ZINC AND IRON APPLICATION DURING 2019-20

Treatments		No. of nodules/plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	26.0	736
T2	2.5 kg Zn/ ha	32.3	792
T3	5.0 kg Zn/ ha	35.0	895
T4	2.5 kg Fe/ ha	36.7	889
T5	5.0 kg Fe/ ha	39.3	976
T6	2.5 kg Zn+2.5 kg Fe/ ha	45.0	1060
T7	5.0 kg Zn+5.0 kg Fe/ ha	51.0	1236
	0.1 % Zn (Two sprays: first at flowering and second 15 days after first spray)	32.0	835
T9	0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	31.7	876
T10	0.1% Zn+0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	30.0	914

In case of Kabuli gram (Table 72) maximum number of nodules were found in T₇ (35.3) where Zn and Fe were applied @ 5 kg/ha and minimum in T₁ (17.7) where only recommended dose of fertilizer was applied. The results in Table 5 showed that maximum grain yield (915 kg/ha) was found in T₇ and minimum in T₁ (490 kg/ha). Similar results were found in case of lentil crop (Table 6).

Treatments		No. of nodules/plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	17.7	490
T2	2.5 kg Zn/ ha	20.3	541
T3	5.0 kg Zn/ ha	20.7	722
T4	2.5 kg Fe/ ha	23.7	689
T5	5.0 kg Fe/ ha	27.7	690
T6	2.5 kg Zn+2.5 kg Fe/ ha	33.7	781
T7	5.0 kg Zn+5.0 kg Fe/ ha	35.3	915
T8	0.1 % Zn (Two sprays: first at flowering and second 15 days after first spray)	32.0	601
T9	0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	24.0	632
T10	0.1% Zn+0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	26.0	719

Treatments		No. of nodules/plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	8.7	513
T2	2.5 kg Zn/ ha	9.3	663
T3	5.0 kg Zn/ ha	10.0	705

T4	2.5 kg Fe/ ha	9.7	782
T5	5.0 kg Fe/ ha	10.0	851
T6	2.5 kg Zn+2.5 kg Fe/ ha	12.7	1004
T7	5.0 kg Zn+5.0 kg Fe/ ha	16.0	1081
T8	0.1 % Zn (Two sprays: first at flowering and second 15 days after first spray)	12.3	781
T9	0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	12.0	737
T10	0.1% Zn+0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	13.0	822

The results showed (Table 74) that in mung bean crop maximum number of nodules were found in T₇ (35.3) where Zn and Fe were applied @ 5 kg/ha and minimum in T₁ (18) where only recommended dose of fertilizer was applied. The results showed that maximum grain yield (976 kg/ha) was found in T₇ and minimum in T₁ (804 kg/ha).

Table 74. BIOFORTIFICATION OF MUNG BY ZINC AND IRON APPLICATION DURING 2019			
Treatments		No. of nodules/plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	18.0	804
T2	2.5 kg Zn/ ha	20.7	844
T3	5.0 kg Zn/ ha	23.3	865
T4	2.5 kg Fe/ ha	22.3	897
T5	5.0 kg Fe/ ha	25.3	902
T6	2.5 kg Zn+2.5 kg Fe/ ha	29.3	975
T7	5.0 kg Zn+5.0 kg Fe/ ha	35.3	976
T8	0.1 % Zn (Two sprays: first at flowering and second 15 days after first spray)	23.7	905
T9	0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	26.3	914
T10	0.1% Zn+0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	27.7	900

Similar results were found in case of mash genotypes (Table 75). Maximum no. of nodules (38.3) and grain yield (1000 kg/ha) was found in T₇ and minimum no. of nodules (20.7) and grain yield (657 kg/ha) in T₁. The results obtained so far showed that application of micronutrients (Zn and Fe) increased the number of nodules and crop yield.

Table 75. BIOFORTIFICATION OF MASH BY ZINC AND IRON APPLICATION DURING 2019			
Treatments		No. of nodules/plant	Grain yield (kg/ha)
T1	Control (25-60) N,P (Kg/ha)	20.7	657
T2	2.5 kg Zn/ ha	23.7	759

T3	5.0 kg Zn/ ha	26.3	750
T4	2.5 kg Fe/ ha	25.3	759
T5	5.0 kg Fe/ ha	28.3	796
T6	2.5 kg Zn+2.5 kg Fe/ ha	33.0	935
T7	5.0 kg Zn+5.0 kg Fe/ ha	38.3	1000
T8	0.1 % Zn (Two sprays: first at flowering and second 15 days after first spray)	26.7	843
T9	0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	29.3	759
T10	0.1% Zn+0.1 % Fe (Two sprays: first at flowering and second 15 days after first spray)	30.3	796

58) NUTRITIONAL QUALITY EVALUATION OF CHICKPEA (DESI AND KABULI), MUNG BEAN AND MASH BEAN DUE TO MICROBIAL INOCULATION

The experiment was conducted to improve the nutritional value of chickpea (Desi and Kabuli) through microbial inoculation. Recommended dose (25-60 N, P kg/ha) of fertilizer was applied to both inoculated and un-inoculated plots. Three varieties of Desi gram (Bittal-2016, Pb-2008 and D-10008) and Kabuli gram (Noor-2013, Noor-2009 and K-70005) were grown during 2019.

The results showed (Table 76) that inoculated Desi gram (Pb-2008) gave maximum no. of nodules (33.7) as compared to un-inoculated (27.3). Inoculated Desi gram (Bittal-2016) gave maximum grain yield (901 kg/ha) as compared to un-inoculated (735 kg/ha). In case of Kabuli gram inoculated K-70005 gave maximum no. of nodules (28.7) as compared to un-inoculated (22) and maximum grain yield (519 kg/ha) as compared to un-inoculated (441 kg/ha).

Name of Genotypes	No. of nodules/plant		Grain yield (kg/ha)	
	Un-inoculated	Inoculated	Un-inoculated	Inoculated
NOOR-2013	20.3	25.7	367	420
NOOR-2009	23.0	28.0	415	463
K-70005	22.0	28.7	441	519
BITTAL-2016	21.7	29.7	761	898
Pb-2008	27.3	33.7	735	901
D-10008	28.0	32.7	758	844

Six mung bean genotypes (Table 77) namely, Pri-Mung-2018, 14005, 15002, 15003, 15024, 15039, and six mash bean genotypes, Arooj 2011, Mash 97, 15 M 001, 15 M 002, 15 M 004 and 15 M 008 (Table 11) were tested.

The results showed (Table 10) that inoculated 15039 genotype of mung bean gave maximum no. of nodules (22.7) as compared to un-inoculated (18.6) and PRI Mung-2018 genotype of mung bean gave maximum grain yield (1102 kg/ha) as compared to un-inoculated (889 kg/ha).

Table 77. NUTRITIONAL QUALITY EVALUATION OF MUNGBEAN GENOTYPES DUE TO MICROBIAL INOCULATION DURING 2019				
Name of Genotypes	No. of nodules/plant		Grain yield (kg/ha)	
	Un-inoculated	Inoculated	Un-inoculated	Inoculated
PRI Mung-2018	16.5	19.4	889	1102
14005	17.6	22.2	778	944
15002	17.5	21.8	815	991
15003	17.8	20.7	796	870
15024	17.9	20.7	833	926
15039	18.6	22.7	824	907

In case of Mash bean mash bean (Table 78) inoculated Arooj 2011 gave maximum no. of nodules (31.3) as compared to un-inoculated (25) and inoculated Arooj 2011 gave maximum grain yield (971 kg/ha) as compared to un-inoculated (861 kg/ha). The results showed that inoculation of seed increased the number of nodules and grain yield in all six genotypes of both crops. The quality of grain was also improved by the inoculation as compared to control.

Table 78. NUTRITIONAL QUALITY EVALUATION OF MASH GENOTYPES DUE TO MICROBIAL INOCULATION DURING 2019				
Name of Genotypes	No. of nodules/plant		Grain yield (kg/ha)	
	Un-inoculated	Inoculated	Un-inoculated	Inoculated
15 M 001	18.3	29.3	620	732
15 M 002	19.0	28.7	750	843
15 M 004	20.7	30.3	704	833
15 M 008	19.3	29.0	676	796
Mash 97	20.7	29.7	769	889
Arooj 2011	25.0	31.3	861	971

ENTOMOLOGICAL STUDIES

59) EVALUATION OF DIFFERENT INSECTICIDES FOR MANAGEMENT OF SPINOLA BUG ON MUNG CROP

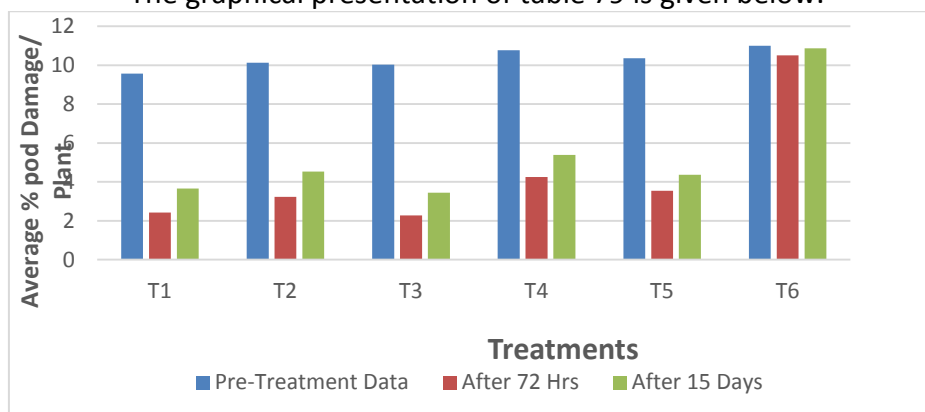
Experiment was laid out in Randomized Complete Block Design with six treatment including checks i.e. Novastar® 56 EC@5ml/liter, Confidor® 20% SL@2.5ml/liter ,Lesenta® 80% @ WG 0.6gm/litre , Advantage® 20 EC@5ml/litre, Sanitox® 40 EC @ 4ml/litre and untreated check/control having three replications each. Experiment was conducted in research area of Pulses Research Institute, AARI, Faisalabad. Data regarding spinola bug population was recorded from number of damaged and healthy pods per plant from randomly selected 5 plants from each plot before treatment and then after 3 and 15 days of treatment. Results revealed that after 3 days of application, all the insecticides caused % reduction ranging from (Minimum 60.44% to Maximum 77.22%) but after 15 days of application Lesenta® 80% WG (Imidacloprid+Fipronil) @0.6 gm/litre & Novastar® 56 EC (Bifenthrin+Abamectin) @ 5 ml/litre caused % reduction i.e., 65.51% & 61.74% respectively and shown in table 79.

Treatments	Dose/Acre (ml/gm)	Pre-treatment Pod Damage%/ Plant	Post-treatment Pod Damage%/Plant After		% Reduction In Pod Damage% after	
			72 Hrs	15 Day	72 Hrs	15 Days
T1 Nova-Star56EC (Abamectin+Bifenthrin)	500 ml	9.57	2.43	3.66	74.597 A	61.737 AB
T2 Confidor 200 SL (Imidacloprid)	250 ml	10.12	3.24	4.54	67.820 B	54.960 CD
T3 Lesenta 80 WG (Imidacloprid+Fipronil)	60 gm	10.02	2.28	3.45	77.223 A	65.507 A
T4 Advantage 20 EC (Carbosulfan)	500 ml	10.77	4.25	5.38	60.443 C	49.920 D
T5 Semitox 40 EC (Dimethoate)	400 ml	10.35	3.54	4.36	65.700 B	57.653 BC
T6 Control	-	11.00	10.5	10.86	5.117 D	1.863 E
LSD at 5%					3.31	5.23

The table 79 showed that Lesenta 80 WG (Imidacloprid+Fipronil) @ 60 gm/ac gave the maximum % reduction in Pod Damage (77.22% & 65.50%) after 72 hours and 15 days of spray application, while the minimum % reduction in Pod Damage (60.44% & 49.92%) was observed in plots treated with Advantage 20 EC (Carbosulfan)@ 500ml/acre after 72 hrs and 15 days of spray application.

Graph 1

The graphical presentation of table 79 is given below.



60) SCREENING OF DIFFERENT MUNG BEAN GENOTYPES AGAINST SPINOLA BUG UNDER NATURAL CONDITION

A study was carried out at area of pulses Research Institute Faisalabad during Kharif 2019. Ten mung bean advanced lines/varieties were evaluated against spinola bug and results shown in table 80.

Table: 80 SCREENING OF MUNG BEAN GENOTYPES AGAINST SPINOLA BUG

Variety/ Line	% Damage
PML-16001	21.24
PML-16002	15.71
PML-16003	18.86
PML-16004	38.00
PML-16005	16.00
PML-16006	12.50
PML-16007	21.00
PML-16008	32.00
PRI-MUNG-18	14.58
AZRI-2006	26.67

The table 67 On the basis of pod infestation in (%), the lowest infestation 14.58% was recorded on PRI-MUNG-18 & the highest infestation were recorded on PML-16004 i.e., 38%.

61) SCREENING OF DIFFERENT GENOTYPES OF MASH BEAN AGAINST WHITEFLY UNDER NATURAL CONDITION

A study was carried out at area of pulses Research Institute Faisalabad in Kharif 2019. Fifty mash bean advanced lines were evaluated against whitefly and results shown in table 81.




Table: 81 SCREENING OF GENOTYPES OF MASH BEAN AGAINST WHITEFLY



Variety/ Line	Av. /Leaf	Variety/ Line	Av. /Leaf
AARIM-3	0.75	AARIM-269	1.85
AARIM-7	1.50	AARIM-2	2.40
AARIM-8	1.00	6036-12	3.20
AARIM-15	2.40	6049-1	2.55
AARIM-26	1.35	6049-10	3.60

AARIM-28-1	0.30	6049-20	3.80
AARIM-28-2	0.60	6065-5	2.40
AARIM-30	2.50	6206	2.70
AARIM-31	0.20	6206-1	1.20
AARIM-34	4.95	07M003	0.85
AARIM-41	2.00	07M004	1.55
AARIM-354	2.50	07M005	1.10
AARIM-65	2.80	07M007	2.60
AARIM-113	2.85	07M008	3.80
AARIM-121	1.15	08M001	0.55
AARIM-124	1.00	08M002	2.65
AARIM-130	2.65	08M004	0.36
AARIM-160	1.60	08M006	0.45
AARIM-174	0.70	62027	0.75
AARIM-176	2.05	ES-1	1.50
AARIM-231	2.50	4M-716	2.05
AARIM-240	0.85	6036-21	1.00
AARIM-257	1.50	SPN-1	1.40
AARIM-263	1.10	SPN-2	4.40
SS-2	3.50	SS-1	7.60

The table 81 showed lowest whitefly population (Av. /Leaf) 0.20/ Leaf was recorded on advance line AARIM-31 and the highest whitefly population was found on SS-1 i.e., 7.60/Leaf.

62) PERFORMANCE OF DIFFERENT ADVANCED LINES OF DIFFERENT PULSES CROPS IN NATIONAL UNIFORM YIELD TRIAL

CROP	ADVANCED LINE	PLANT PICTURE	SALIENT CHARACTERS
Mung bean	15006		It has average yield of 892 kg/ha. It produces 20-48 pods/plant. It is short duration and top bunch bearing suitable for mechanical harvesting. It is moderately susceptible to urd bean mosaic virus.
Mash bean	16M004		It is high yielding. It produces 20-70 pods/plant. It is short duration and suitable for mechanical harvesting. It is tolerant to urd bean mosaic virus.
Chickpea	PCK-15001		It has high yield potential (1594 Kg/ha) and an average yield 1229 Kg/ha (NUYT-K-2019-20). It gained high yield potential (3472 Kg/ha) than Check Noor 2013(2604 Kg/ha) at Bahawalpur (CYT-2018-19) and Have medium seed size, attractive shape and color. It has 20.8% Protein while Check Noor 2013 has 19.69% Protein.

	PCK-15019		<p>It has yield Potential (2097Kg/ha) and an average yield 1105 Kg/ha (NUYT-K-2019-20).</p> <p>It gained high yield Potential (3645 Kg/ha) than the Check Noor2013 (2604Kg/ha) at Bahawalpur (CYT-2018-19). Medium seed size with attractive shape and color.</p> <p>Moderately resistant to Wilt and Blight.</p>
lentil	PLL-16510		<p>1-It has 1-6 pods/node</p> <p>2-high yielding</p> <p>3-It is moderately resistant to lentil Rust and Botrytis Grey Mold.</p>

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5	Dr. Muhammad Azhar Iqbal	Plant Pathologist	-do-
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LIST OF PUBLICATIONS 2019-20

Sr. No.	Name of Authors	Title	Year of Publication	Name of Journal with Vol. /Issue/Page no.
1	C.M. Rafiq, Muhammad Tariq Mahmood, Mushtaq Ahmad, Imtiaz Ali, Sadia Kaukab, Muhammad Shafiq, Muhammad Saleem	Detection of most diverse and high yielding strains of chickpea (<i>Cicer arietinum</i> L.)	2020	<i>Life Sci J.</i> 2020:17(3):88-93
2	C.M. Rafiq, Muhammad Amin, Amer Hussain, Amir Amin, Sadia Kaukab and Muhammad Shafiq	An innovative high yielding and powdery mildew resistant dry pea, rich source of protein	2020	<i>Life Sci J.</i> 2020:17(4):11-15
3	C. M. Rafiq, Sadia Kaukab, Aqsa Tahir, Masood Qadir, Busharat Hussain, Shakeel Ahmad Anwar, Muhammad Tariq Mahmood, Ali Aziz, Amir Hameed and Khalid Mehmood Mughal	Fusarium wilt's pathogenic studies and disease management	2020	Genetics an Molecular Research 19(1):gmr16039974
4	C. M. Rafiq, Sadia Kaukab, Aqsa Tahir, Masood Qadir, Busharat Hussain, Shakeel Ahmad Anwar, Muhammad Tariq Mahmood, Ali Aziz, Amir Hameed and Khalid Mehmood Mughal	Genetic studies for yield and related traits in micro and macrosperma exotic lentil genotypes	2020	Genetics an Molecular Research 19(1):gmr16039973
5	Iqbal, M.M; M.I.Zafar, T. Naz, A. Mahmood, M.A.Ali, S.M.Mehdi, S.Javed, M.A.Sarwar, S.A.Anwar, K.S.U.Khan, A.Khalid, M.Afzal,, G.Sarwar, M.I.Javed and M.Imtiaz	Safe Handling and Precautionary Measures during Pesticide Usage	2020	J. Environ. Agric. Sci. 22(2):58-64
6	Iqbal, M.M; I. Ahmad, S.M.A. Basra, A.B.Ijaz, Z. H. Tarar, M. Ansar, U. Iqbal, T. Naz, B. Fatima, M. Akram, A. Wasaya, A.Iqbal, S.A.Anwar, K.S.U.Khan, A. Khalid, A. Aziz and R. Mehmood	Induction of Heat Tolerance in Maize through Exogenous Application of Salicylic Acid, Ascorbic Acid and Hydrogen Peroxide in a Field Study	2020	Pakistan Journal of Agricultural Research 33(1):585-593
7	Ch. Muhammad Rafiq, Muhammad Tariq Mahmood, Mushtaq Ahmad, Imtiaz Ali, Muhammad Shafiq, Sadia kaukab	Fusarium wilts pathogenic studies and disease management, A review	2020	Genetics and Molecular Research (GMR)
8	Ch. Muhammad Rafiq, Muhammad Tariq Mahmood, Mushtaq Ahmad, Imtiaz Ali, Muhammad Saleem, Sadia kaukab	Detection of most diverse and high yielding chickpea genotypes	2020	Life Sciences Journal (LSJ)
9	Ch. Muhammad Rafiq, Muhammad Tariq Mahmood, Mushtaq Ahmad, Imtiaz Ali, Muhammad Shafiq, Irfan Rasool, Muhammad Saleem, Sadia kaukab	Differential Response of elite chickpea genotypes under moisture stress conditions	2020	Pakistan Journal of Agricultural Research
10	Imtiaz Ali, Muhammad Tariq Mahmood, Imran Akhtar, Akash Zafar, Abdul majeed, Wajiha Anum	Some direct and indirect selection indices for increased yield of peas (<i>Pisum sativum</i> L.)	2019	Journal of environmental and agricultural sciences (JEAS)
11	Muhammad Tariq Mahmood, Mushtaq Ahmad and Imtiaz Ali	Chickpea Blight: Former efforts on Pathogenecity and disease management	2019	Gomal University Journal of Research (GUJR)
12	Ch. Muhammad Rafiq, Muhammad	Screening of chickpea		Science Technology

	Tariq Mahmood, Mushtaq Ahmad, Imtiaz Ali, Muhammad Shafiq, Irfan Rasool, Abdul Latif, Muhammad Zubair	genotypes for yield stability across environments.	2019	and Development
13	Aziz ur Rehman, M. Ehsan Khan, Saida Kaukab, Sajjad Saeed, M. Aqeel, Gulfam Riasat, Ch. Muhammad Rafiq	Prospects of Mungbean as an Additional Crop in Rice Wheat System of Punjab Pakistan	2019	University J. of Agri. Res. 7 (3): 136-141. 2019