

ANNUAL TECHNICAL REPORT 2018-19



**ARID ZONE RESEARCH INSTITUTE,
BHAKKAR**

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Breeding Division

1. WHEAT:

1.1 Variety Development:

Spot examination of high yielding disease and terminal heat stress tolerant and bold seeded wheat advance line TWS12464 was successfully carried out by Experts Sub-Committee AARI/PSC, Punjab on 22-03-2019.

1.2 Collection and Maintenance of Wheat Germplasm 2018-19

Introduction, collection, evaluation, maintenance and improvement of plant genetic resources play crucial role in the evolution of crop varieties. Four hundred and eighty one strains/varieties collected from various research organizations were laid out in observational plots to identify cultivars having high yield potential coupled with desirable attributes. Gross plot size was kept 1.8m x 0.6m maintaining row to row distance 0.3m. Sowing was carried out on 22-11-2018 with the help of dibbler to ensure uniform plant population and geometry. All the agronomic practices were carried out as and when required. One hundred and seventy lines were rejected due to disease incidence (yellow rust) and poor performance. The experiment was harvested on 16-05-2019. Data regarding days to 50% heading, spikes per plant, plant height, diseases incidence, average grain weight per spike and grain yield per plant were recorded accordingly. Maximum and minimum range values of characters; days to 50% heading, days to maturity, tillers per plant, plant height, grain weight per ear, 1000 grain weight and grain yield per plant were 95-130, 136-182, 5-25, 65-140, 1-5, 35-52g and 3-50g respectively.

1.3 Wheat Hybridization Programme 2018-19

Two hundred and fifty eight promising strains/varieties with special reference to desirable attributes were planted in paired rows plot having length 1.5m and maintaining row to row distance 0.30m among the parental lines. Sowing was done on 14-11-2018 and harvesting was carried out on 29-04-2019. One hundred and fifty crosses were attempted among promising varieties/strains with basic objective to combine desirable attributes in single genotype. Seed of one hundred and forty successful crosses was harvested for study of F₁ progenies during the next crop season 2019-20.

1.4 Evaluation of Segregating Generations

1.4.1 F₁ Generations

Ninety eight F₀ seeds (Crosses) were planted alongwith their parents for evaluation of F₁ populations. The plot size was kept 1.8m x 0.3m by maintaining plant to plant distance 0.15m and row to row distance 0.30m. Sowing was carried out on 22-11-2018 and harvesting was carried out on 18-05-2019. All the agronomic practices were carried out as and when required. The seed was obtained from eighty desirable disease resistant F₁ populations' alongwith parents to raise F₂ generations during the next crop year 2019-20.

1.4.2 F₂ Segregating Generations

Quantum of genetic variability existing in F₂ generations is a basic tool of a plant breeder for his successful breeding programme. Sixty five segregating populations were studied

alongwith parental lines during the year 2018-19. The plot size was kept 3.5m x 1.8m having row to row distance 0.30m. The sowing was done on 23-11-2018. Segregation was observed in all populations .Six hundred single plant selections from seventy five segregating populations were made on the basis of visual performance and disease incidence in field condition on 29-04-2019 to raise F₃ generations during crop season 2019-20.

1.4.3 F₃ Segregating Generations

Fifty four segregating populations being the descendants of F₂ progenies were planted to raise F₃ populations. Sowing was done on 26-11-2018 and gross plot size was maintained 3.5m x 1.2m. Selections of desirable plants were made from 08-05-2019 to 13-05-2019. Five hundred and fifty single plant selections from eighty three segregating populations were made on the basis of visual performance and disease incidence in field condition on 18-05-2019 to raise F₄ generations during crop season 2019-20.

1.4.4 F₄ Segregating Generations

Twenty segregating populations connected through the ancestry line of F₃ populations of previous year were planted. The plot size of each progeny was 3.5m x 1.2m. Space planting was done by maintaining plant to plant and row to row 0.15m and 0.30m distance on 26-11-2018. The segregation was observed in most of the populations and four hundred and seventy single plants were selected on the basis of plant height, spikes per plant, av. grain weight per spike and grain yield per plant to raise F₅ generation during crop season 2019-20.

1.4.5 F₅ Segregating Generations

Twenty three segregating progenies being the descendants of F₄ generations selected as single plant progenies of previous year were laid out. The plot size for each progeny was maintained 3.5m x 1.2m. Sowing was carried out on 26-11-2018 with the help of dibbler as per planting geometry of row to row distance and plant to plant distance 0.30m and 0.15m respectively. Two seeds per hole were sown and single baby plant was ensured after germination through thinning operation. Six hundred and fifty single plants were selected on visual observation from field and five hundred and fifty were finally selected in the laboratory on the basis of plant height, spikes per plant, and average grain weight per spike and grain yield per plant to raise F₆ generation during next sowing season 2019-20.

1.4.6 F₆ Segregating Generations

Eighty four populations collected from ancestry line of F₅ generations of previous year were planted. Plot size for each progeny was kept 3.5m x 1.2m. The sowing was carried out on 26-11-2018 with the help of dibbler as per planting geometry of row to row distance and plant to plant distance 0.30m and 0.15m respectively. Two seeds per hole were sown and single baby plant was maintained after germination through thinning operation. Thirty eight uniform populations were selected on the basis of field observation and twenty were finally selected in the laboratory on the basis of grain yield per plant alongwith allied attributes to incorporate in preliminary wheat yield trials during sowing season 2019-20.

1.4.7 F₇ Segregating Generations

Nine populations connected from ancestry line of F₆ generations of previous year were laid out. The plot size for each progeny was 3.5m x 1.2m. The sowing was carried out on 26-11-2018 with the help of dibbler as per planting geometry of row to row and plant to plant distance of 0.30m and 0.15m respectively. Two seeds per hole were sown and single baby plant was maintained after germination through thinning operation. Three uniform populations were selected on the basis of field observation and two were finally selected in the laboratory on the basis of grain yield per plant to include in preliminary wheat yield trial during Rabi crop season 2019-20.

1.5 Replicated Wheat Yield Trials 2018-19

1.5.1 Preliminary Wheat Yield Trial (A₁) 2018-19

A preliminary wheat yield trial-A₁ comprising twenty entries viz; TW1802, TW1809, TW1817, TW1813, TW1806, TW1815, TW1810, TW1804, TW1818, TW1801, TW1808, TW1803, TW1807, Fakhar-e-Bkr, Anaj, TW1805, TW1811, TW1812, TW1816 and TW1814 was laid out in hot irrigated dry climate of arid zone. The trial was laid out according to randomized complete block design with three replications. The sowing was done on 07-11-2018 with gross plot size 5.0m × 1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 06-05-2019. And yield data were recorded as given in Table-1.1.

Table 1.1 Grain yield data of preliminary wheat yield trial (A₁) 2018-19

S. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)	S. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	TW1802	5581	11	TW1808	4808
2	TW1809	5489	12	TW1803	4764
3	TW1817	5457	13	TW1807	4725
4	TW1813	5456	14	Fakhar-e-Bhakkar	4586
5	TW1806	5367	15	Anaj-2017	4311
6	TW1815	5283	16	TW1805	4161
7	TW1810	5156	17	TW1811	4089
8	TW1804	5119	18	TW1812	3947
9	TW1818	5008	19	TW1816	3883
10	TW1801	4861	20	TW1814	3781

LSD_{0.05} = 644 Kg/ha. CV(%) = 8.13

Statistical analysis of yield data revealed that the differences among the means of entries were highly significant as given in the Table-1.1. The strain TW1802 was top yielder with yield figure 5581 kg ha⁻¹ followed by TW1809 having grain yield value 5489 kg ha⁻¹. Check varieties F-Bhakkar and Anaj depicted grain yield 4586 and 4311 kg ha⁻¹ respectively. The strain TW1814 gave the lowest yield with mean yield value 3781 kg ha⁻¹. Seed of four top yielding and disease tolerant genotypes (TW1802, TW1809, TW1817 & TW1813) with high agronomic score was reserved for layout of regular yield trial in crop year 2019-20.

1.5.2 Preliminary Wheat Yield Trial (A₂) 2018-19

A preliminary wheat yield trial-A₂ comprising twenty entries viz; TWS1889, TWS1833, TWS1826, TW1819, TWS1834, TWS1824, TWS1836, TWS1829, TWS1830, TWS1827, TWS1823, Fakhar-e-Bhakkar, TWS1825, TWS1831, TWS1822, TW1820, Anaaj-17, TW1821, TWS1835 and TWS1828 was conducted in hot irrigated dry climate of arid zone. The trial was laid out according to randomized complete block design with three replications having plot size 5.0m x 1.2m. The sowing was done on 07-11-2018. All the cultural practices were carried out as and when required. The trial was harvested on 08-05-2019. The grain yield data were recorded as given in Table-1.2

Table 1.2: Yield data of preliminary wheat yield trial (A₂) 2018-19

Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	TWS1889	5553	11	TWS1827	4475
2	TWS1833	5133	12	TWS1823	4192
3	TWS1826	5047	13	Fakhar-e-Bhakkar	4122
4	TW1819	5006	14	TWS1825	4094
5	TWS1834	4964	15	TWS1831	4083
6	TWS1824	4939	16	TWS1822	4022
7	TWS1836	4914	17	TW1820	3978
8	TWS1829	4714	18	Anaaj-2017	3919
9	TWS1830	4539	19	TW1821	3847
10	TWS1828	4514	20	TWS1835	3728
LSD _{0.05} = 549 kg / ha		CV (%) = 7.40			

It was revealed from the analysis of variance (Table 1.2) that the differences among the means of entries were highly significant. The strain TWS1889 gave maximum grain yield 5553 kg ha⁻¹ followed by TWS1833 and TWS1826 having grain yield values of 5133, and 5047 kg ha⁻¹ respectively. Check varieties F-Bhakkar and Anaj-2017 gave the yield values of 4122 and 3919 kg ha⁻¹ respectively. The strain TWS1835 gave the lowest yield with mean yield value of 3728 kg ha⁻¹. Seed of five top yielding and disease tolerant with high agronomic score genotypes (TWS1889, TWS1833, TWS1826, TWS1819 & TWS1834) was reserved for layout of regular yield trial in rabi crop season 2019-20.

1.5.3 Preliminary Wheat Yield Trial (A₃) 2018-19

A preliminary wheat yield trial-A₃ comprising twenty entries viz; TWS1837, TWS1859, TWS1846, TWS1881, TWS1839, TWS1843, TWS1840, Fakhar-e-Bkr, Anaaj-17, TWS1860, TWS1841, TWS1845, TWS1867, TWS1891, TWS1838, TWS1892, TWS1882, TWS1866, TWS1844 and TWS1842 was conducted in irrigated condition. Trial was laid out according to randomized complete block design with three replications having plot size 5.0m x 1.2m. The sowing was done on 07-11-2018. All the cultural practices were carried out as and when required. The trial was harvested on 08-05-2019. The grain yield data were recorded as shown in Table1.3

Table 1.3: Yield data of preliminary wheat yield trial (A₃) 2018-19

Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	TWS1837	5597	11	TWS1841	3997
2	TWS1859	5547	12	TWS1845	3964
3	TWS1846	5531	13	TWS1867	3936
4	TWS1881	5506	14	TWS1891	3919
5	TWS1839	5497	15	TWS1838	3903
6	TWS1843	5161	16	TWS1892	3883
7	TWS1840	5147	17	TWS1882	3853
8	Fakhar-e-Bhakkar	4875	18	TWS1866	3789
9	Anaaj-17	4161	19	TWS1844	3775
10	TWS1860	4144	20	TWS1842	3581
		LSD _{0.05} = 909 kg ha ⁻¹	CV (%) = 12		

It was revealed from the analysis of variance (Table1.3) that the differences among the means of entries were highly significant. The strain TWS1837 gave maximum grain yield 5597 kg ha⁻¹ followed by TWS1859 and TWS1846 having grain yield values 5547 and 5531 kg ha⁻¹ respectively. Check varieties F-Bhakkar and Anaj-2017 gave the yield values 4875 and 4161 kg ha⁻¹ respectively. The strain TWS1842 depicted the lowest yield with mean yield value of 3581 kg ha⁻¹. Seed of five top yielding and disease tolerant with high agronomic score genotypes (TWS1837, TWS1859, TWS1846, TWS1881 & TWS1839) was reserved for layout of regular yield trial 2019-20.

1.6 Regular Wheat Yield Trials (B-1) 2018-19

A regular wheat yield trial-B₁ comprising twenty entries viz; TWS1849, TWS1868, TWS1853, TWS1861, TWS1857, TWS1847, TWS1850, TWS1855, TWS1851, Fakhar-e-Bkr, TWS1854, Annaj, TWS1862, TWS1863, TWS1858, TWS1864, TWS1865, TWS1856, TWS1852 and TWS1848 was conducted in hot irrigated dry climate. The trial was laid out according to randomized complete block design with three replications. The sowing was done on 08-11-2018 with gross plot size 5.0m x 1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 13-05-2019. The grain yield data were recorded as presented in Table1.4.

Table 1.4: Yield data of regular wheat yield trial-B1 2018-19

Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	TWS1849	5375	11	TWS1854	4433
2	TWS1868	5214	12	Annaj-17	4400
3	TWS1853	5125	13	TWS1862	4361
4	TWS1861	5058	14	TWS1863	4117
5	TWS1857	5019	15	TWS1858	4011
6	TWS1847	4925	16	TWS1864	4000
7	TWS1850	4733	17	TWS1865	3892
8	TWS1855	4650	18	TWS1856	3875
9	TWS1851	4600	19	TWS1852	3825
10	Fakhar-e-Bhakkar	4575	20	TWS1848	3700
LSD _{0.05} = 1035 kg / ha CV (%) = 14					

It was evident from the statistical analysis of the yield data given in the above Table 1.4 that the differences among the means of varieties/strains were significant. It was observed that the strain TWS1849 gave maximum grain yield 5375 kg ha⁻¹, followed by TWS1868 with grain yield 5214 kg ha⁻¹. However the check entries Fakhar-e-Bhakkar and Anaj-2017 gave grain yield 4575 and 4400 kg ha⁻¹ respectively. Seed of four top yielding and disease tolerant with high agronomic score genotypes (TWS1849, TWS1868, TWS1853 & TWS1861) was reserved for layout of adaptation yield trial 2019-20.

1.6.1 Regular Wheat Yield Trials (B-2) 2018-19

A regular wheat yield trial-B₂ comprising twenty entries viz; TWS1884, TWS1875, TWS1874, TWS1883, TWS1872, TWS1879, TWS1873, TWS1871, Fakhar-e-Bkr, Annaj, TWS1877, TWS1885, TWS1876, TWS1870, TWS1878, TWS1886, TWS1887, TWS1869, TWS1711 and TWS1880 was conducted in hot irrigated dry climate. The trial was laid out according to randomized complete block design with three replications. The sowing was done on 08-11-2018 with gross plot size 5.0m x 1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 13-05-2019. The grain yield data were recorded as presented in Table 1.5.

Table1.5: Yield data of regular wheat yield trial-B2 2018-19

Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	TWS1884	5333	11	TWS1877	4633
2	TWS1875	5308	12	TWS1885	4608
3	TWS1874	5217	13	TWS1876	4533
4	TWS1883	5200	14	TWS1870	3883
5	TWS1872	5133	15	TWS1878	3867
6	TWS1879	5108	16	TWS1886	3725
7	TWS1873	5083	17	TWS1887	3717
8	TWS1871	4825	18	TWS1869	3708
9	Fakhar-e-Bhakkar	4736	19	TWS1711	3681
10	Annaj-17	4675	20	TWS1880	3631
LSD _{0.05} = 977 kg / ha CV (%) =13					

It was evident from statistical analysis of the yield data given in the above Table 1.5 that the differences among the means of varieties/strains were highly significant. It was observed that the strain TWS1884 gave maximum grain yield 5333 kg ha⁻¹, followed by TWS1875 with grain yield 5308 kg ha⁻¹. However the check entries Fakhare-Bhakkhar and Anaj-2017 gave grain yield 4736 and 4675 kg ha⁻¹ respectively. Seed of five top yielding and disease tolerant with high agronomic score genotypes (TWS1884, TWS1875, TWS1874, TWS1883 & TWS1872) was reserved for layout of adaptation yield trial 2019-20.

1.6.2 Regular Wheat Yield Trials (B-3) 2018-19

A regular wheat yield trial (B₃) comprising twenty entries viz; TWS17041, TWS17048, TWS17064, TWS16297, TWS17043, TWS17069, TWS17062, TWS17042, TW1706, Fakhare-Bkr, TWS17049, TWS17073, TW1701, Anaaj-17, TW1714, TWS17060, TW1707, TWS17061, TWS16284, TW1702 was conducted in hot irrigated dry climate. This trial was laid out according to randomized complete block design with three replications. Sowing was done on 08-11-2018 with gross plot size 5.0m x 1.2m. All the cultural practices were carried out as and when required. This trial was harvested on 13-05-2019. However threshing was carried out on 30-05-2019 and grain yield data were recorded as presented in Table 1.6

Table-1.6: Yield data of regular wheat yield trial-B3 2018-19

Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	TWS17041	5092	11	TWS17049	4353
2	TWS17048	5056	12	TWS17073	4325
3	TWS17064	4942	13	TW1701	4272
4	TWS16297	4767	14	Anaaj	4261
5	TWS17043	4650	15	TW1714	4239
6	TWS17069	4600	16	TWS17060	4194
7	TWS17062	4592	17	TW1707	4175
8	TWS17042	4550	18	TWS17061	4086
9	TW1706	4528	19	TWS16284	4086
10	Fakhare-Bhakkhar	4461	20	TW1702	3744
LSD _{0.05} = 654 kg / ha CV (%) =9					

It was evident from statistical analysis of the yield data given in the above Table-6 that the differences among the means of varieties/strains were significant. It was observed that the strain TWS17041 gave maximum grain yield 5092 kg ha⁻¹, followed by TWS17048 with grain yield 5056 kg ha⁻¹. However the check entries Fakhare-Bhakkhar and Anaj-2017 gave grain yield 4461 and 4261 kg ha⁻¹ respectively. Seed of five top yielding and disease tolerant with high agronomic score genotypes (TWS17041, TWS17048, TWS17064, TWS16297 & TWS17043) was reserved for layout of adaptation yield trial 2019-20.

1.7 Wheat Adaptation Yield Trial 2018-19

A wheat adaptation yield trial was conducted at three locations AZRI, Bhakkar (Two different planting times as Timely Planting and Late Planting), Adaptive Research Station, Karor (Timely planting) and Gram Research Substation, Kallur kot). This trial had sixteen entries viz: TWS16164, TWS1637, TWS16263, TWS15110, TWS16274, TWS16296, TWS16279, TWS16260, Gold-16, TWS16263, TWS16313, TWS16261, TWS16324, TWS16299, Fakhar-e-Bkr and TWS16285 was sown according to randomized complete block design with three replications. The plot size was kept 5m x 1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 15-05-2019. Grain yield data were recorded as given in Table 1.7

Table 1.7: Grain yield data of wheat Adaptation yield trial 2018-1

Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)				Mean
		(AZRI, T.P)	(AZRI, L.P)	(ARS, Karor)	(GRSS, K.KOT)	
1	TWS16164	5359	3828	4800	5100	4772
2	TWS1637	4921	3601	5233	5250	4751
3	TWS16263	5706	3996	4083	4217	4500
4	TWS15110	5507	4007	3908	4167	4397
5	TWS16274	4971	3957	4033	4550	4378
6	TWS16296	5098	3636	3892	4550	4294
7	TWS16279	4717	3553	4442	4217	4232
8	TWS16260	5475	3634	3792	3850	4188
9	Gold-16	5275	3065	3892	4375	4152
10	TWS16263	4712	3543	3800	4517	4143
11	TWS16313	4881	3568	3742	4342	4133
12	TWS16261	5046	3600	3875	3858	4095
13	TWS16324	4317	3412	3497	5133	4090
14	TWS16299	4908	3440	3633	3950	3983
15	Fakhar-e-Bkr	3733	3015	4467	3867	3770
16	TWS16285	4523	3253	3033	3683	3623
		LSD _{0.05} =796 CV%=10	LSD _{0.05} =546 CV%=9	LSD _{0.05} =850 CV%=13	LSD _{0.05} =809 CV%=11	

Wheat adaptation yield trial depicted highly significant differences among entries at all locations. Genotype TWS16164 was top yielder having av. mean grain yield 4772 kg ha⁻¹ followed by strains TWS1637 and TWS16263 with mean grain yield figure 4751 kg ha⁻¹ 4500 kg per ha respectively. However check varieties Gold-16 and Fakhar-e-Bhakkar expressed av. grain yield 4152 and 3623 kg ha⁻¹ respectively. Seed of four top yielding and disease tolerant with high agronomic score genotypes (TWS15110, TWS1637, TWS16164 and TWS16263) was reserved for incorporation in Punjab Uniform Wheat Yield trial 2019-20.

1.8 Punjab Uniform Wheat Yield Trials 2018-19 (Provincial level testing)

Punjab uniform wheat yield trial was coordinated by WRI FSD. It was conducted all over the Punjab at different locations during crop season 2018-19. Trial was laid out according to alpha lattice design with two replications. Arid Zone research Institute Bhakkar offered four advanced lines for testing at provincial level and cooperated in conducting this trial at three different locations (AZRI Bhakkar, GRSS, Kallur kot and ARS Karor). These trials were laid out during third week of November 2018. Plot size was 5.0m x 1.2m. All the cultural practices were carried out as and when required. The trial was harvested and threshed during the month of April/May 2019. Grain yield and other requisite data were recorded and sent to Wheat Research Institute Faisalabad for compilation. Mean grain yield data of advance lines of this institute and check entries at twenty eight locations presented in Table: 1.8.

Table 1.8- Grain yield data of Punjab uniform wheat yield trial 2018-19

Sr. No.	Ranking	Genotypes	Grain Yield (Kg/ha) (Av. 28 locations) Irrigated
1	1	TWS15145	4890
2	6	TWS15105	4528
3	7	TWS15159	4524
4	20	TWS15137	4406
5	38	FSD-08	4065
6	44	JOUHAR-16	3768

It was evident from Table 1.8 that two advance lines TWS15145 and TWS15105 of this institute performed better in all over Punjab basis (Av. 28 locations) with grand mean grain yield 4890 and 4528 kg ha⁻¹ respectively. However, provincial checks FSD-08 and Jouhar-16 gave mean grain yield 4065 and 3768 kg ha⁻¹ respectively. Seed of four outperforming and disease tolerant with high agronomic score genotypes (TWS15105, TWS15137, TWS15145 and TWS15159) was reserved for incorporation in National Uniform Wheat Yield trial 2019-20.

1.9 National Uniform Wheat Yield Trial (AZRI, BKR) 2018-19

National uniform wheat yield trial was coordinated by Wheat Coordinator PARC Islamabad. It was conducted all over the Punjab at different locations during crop season 2018-19. Trial comprising 50 test and three check entries was laid out according to alpha lattice design with two replications in all over country. Arid Zone research Institute Bhakkar offered four advanced lines (TWS1334, TWS1335, TWS1432 and TWS1578) for testing at national level and cooperated in conducting this trial at three different locations (AZRI Bhakkar, GRSS, Kallur kot and ARS Karore). This trial was laid out during third week of November 2018. Gross plot size was 5.0m x 1.8m. All the cultural practices were carried out as and when required. The trial was harvested and threshed during the month of April/May 2019 with net plot size 5.0x1.2. Grain yield and other requisite data were recorded and sent to National Wheat Coordinator PARC Islamabad for compilation. Mean grain yield data of advance lines of this institute and test entries (Av. 20 locations in Punjab and Av. 30 locations in all over Pakistan) is presented in Table: 1.9 as given below.

Table 1.9: Grain yield data of National Uniform Wheat Yield Trial (AZRI, BKR) 2018-19.

(Grain yield kg/ha)					
Punjab (Av.20 locations)			Pakistan (Av.30 locations)		
Ranking	Genotypes	Grain Yield (Kg/ha)	Ranking	Genotypes	Grain Yield (Kg/ha)
3	TWS-1335	4656.2	4	TWS-1335	4716.0
5	TWS-1334	4621.0	5	TWS-1334	4690.1
7	TWS-1432	4501.2	7	TWS-1432	4647.2
10	FSD-08	4470.7	8	FSD-08	4626.8
12	PAK-13	4423.8	17	TWS-1578	4533.9
32	TWS-1578	4274.0	31	PAK-13	4399.3

It was evident from Table 1.9 that three advance lines TWS1335, TWS1334 and TWS-1432 of this institute performed better in all over Punjab basis (20 locations) with grand mean grain yield 4656.2, 4621.0 and 4501.2 kg ha⁻¹ respectively. However, two national check varieties Faisalabad-08 and Pakistan-13 gave mean grain yield 4470.7 and 4274.0 kg ha⁻¹ respectively on provincial basis.

Similarly same three advance lines TWS1335, TWS1334 and TWS-1432 of this institute performed better in all over Pakistan basis (Av. 30 locations) with grand mean grain yield 4716.0, 4690.1 and 4647.2 kg ha⁻¹ respectively. However, two national check varieties Faisalabad-08 and Pakistan-13 gave mean grain yield 4626.8 and 4399.3 kg ha⁻¹ respectively. Seed of outperforming genotype TWS1335 was reserved for sowing of spot examination plot during 2019-20.

1.10 International Trials and Screening Nurseries

1.10.1 CIMMYT TRIALS

1.10.2 6th Wheat Yield Consortium Yield Trial 2018-19.

Sixth wheat yield consortium yield trial 2018-19 comprising thirty two entries was sown on 27-11-2018. Trial was laid out according to randomized complete block design with two replications. Plot size was kept 2.0m × 1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 17-05-2019. Eighteen high yielding and disease resistant genotypes were selected for inclusion in regular wheat yield trial 2019-20. Grain data were recorded as presented in Table-1.10.

Table 1.10: Yield data of 6th wheat yield consortium yield trial 2018-19 (CIMMYT)

Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	6 th WYCYT-17	4208	10	6 th WYCYT-9	3500
2	6 th WYCYT-48	4042	11	6 th WYCYT-23	3208
3	6 th WYCYT-44	3917	12	6 th WYCYT-46	3125
4	6 th WYCYT-33	3875	13	6 th WYCYT-41	3000
5	6 th WYCYT-22	3833	14	6 th WYCYT-1	2750
6	6 th WYCYT-6	3833	15	6 th WYCYT-42	2750
7	6 th WYCYT-21	3750	16	6 th WYCYT-4	2625
8	6 th WYCYT-15	3583	17	6 th WYCYT-12	2500
9	6 th WYCYT-2	3500	18	6 th WYCYT-51	2333

It was evident from the Table 1.10 that the variety/strain 6th WYCYT-17 gave maximum grain yield with mean yield value of 4208 kg ha⁻¹ followed by strain 6th WYCYT-48 with grain yield value of 4042 kg ha⁻¹. However the strain No. 6th WYCYT-51 gave minimum grain yield value of 2333 kg ha⁻¹. Seed of one top yielding and disease tolerant with high agronomic score genotype (6th WYCYT-17) was reserved for incorporation in regular wheat yield trial (B₂) 2019-20.

1.10.3 8TH Stress Adaptive Trait Yield Trial 2018-19 (CIMMYT)

Eighth stress adaptive trait yield trial 2018-19 comprising thirty three entries was sown on 28-11-2018. Trial was laid out according to randomized complete block design with two replications. The plot size was kept 2.0m × 1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 20-05-2019. Ten high yielding and disease resistant genotypes were selected for inclusion in regular wheat yield trial 2019-20. Grain data were recorded as presented in Table 1.11.

Table 1.11: Grain yield data of 8th Stress Adaptive Trait Yield Trial 2018-19

Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	8 th SATYT-9425	2250	6	8 th SATYT-9418	2133
2	8 th SATYT-9431	2249	7	8 th SATYT-9445	2067
3	8 th SATYT-9415	2183	8	8 th SATYT-9424	2023
4	8 th SATYT-9404	2233	9	8 th SATYT-9438	2002
5	8 th SATYT-9453	2233	10	8 th SATYT-9447	1982

It was evident from the Table 1.11 that the variety/strain 8th SATYT-9425 gave maximum grain yield with mean yield 2250 kg ha⁻¹ followed by strain 8th SATYT-9431 with grain yield 2249 kg ha⁻¹. However the strain No 8th SATYT-9447 showed minimum grain yield value of 1982 kg ha⁻¹. Seed of two top yielding and disease tolerant with high agronomic score genotypes (8th SATYT-25 & 8th SATYT-31) was reserved for incorporation in Preliminary Wheat Yield trial (A₃) 2019-20.

1.10.4 17th High Temperature Wheat Yield Trial 2018-19

Seventeenth high temperature wheat yield trial 2018-19 comprising fifty entries were sown on 28-11-2018. Trial was laid out according to randomized complete block design with two replications. The plot size was kept 2.0m ×1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 20-05-2019. Twenty three high yielding and disease resistant genotypes were selected for inclusion in regular wheat yield trial 2019-20. Grain data were recorded as presented in Table 1.12.

Table 1.12: Grain yield data of 17th High Temperature Wheat Yield Trial 2018-19

Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	17 th HTWYT-2	4417	13	17 th HTWYT-83	2583
2	17 th HTWYT-96	4292	14	17 th HTWYT-28	2542
3	17 th HTWYT-17	4083	15	17 th HTWYT-78	2542
4	17 th HTWYT-6	3583	16	17 th HTWYT-98	2458
5	17 th HTWYT-77	3542	17	17 th HTWYT-73	2083
6	17 th HTWYT-10	3417	18	17 th HTWYT-91	1958
7	17 th HTWYT-100	3333	19	17 th HTWYT-11	1917
8	17 th HTWYT-9	3208	20	17 th HTWYT-66	1833
9	17 th HTWYT-31	3083	21	17 th HTWYT-56	1792
10	17 th HTWYT-95	2958	22	17 th HTWYT-23	1583
11	17 th HTWYT-48	2750	23	17 th HTWYT-89	1542
12	17 th HTWYT-21	2667	-	-	-

It was evident from the Table 1.12 that the variety/strain 17th HTWYT-2 gave maximum grain yield 4417 kg ha⁻¹ followed by strain 17th HTWYT-96 with grain yield 4292 kg ha⁻¹. However the strain 17th HTWYT-89 displayed minimum grain yield 1542 kg ha⁻¹. Seed of two top yielding and disease tolerant with high agronomic score genotypes (17th HTWYT-302 & 17th HTWYT-396) was reserved for incorporation in Regular Wheat Yield trial (B₂) 2019-20.

1.10.5 26th Semi-Arid Wheat Yield Trial 2018-19 (CIMMYT)

Twenty sixth semi-arid wheat yield trial 2018-19 comprising fifty entries was laid out on 27-11-2018. Trial was laid out according to randomized complete block design with two replications. The plot size was kept 2.0m ×1.2m. All the cultural practices were carried out as and when required. The trial was harvested on 20-05-2019. Twenty two high yielding and disease resistant genotypes were selected for inclusion in regular wheat yield trial 2019-20. Grain data were recorded as presented in Table1.13.

Table 1.13: Yield data of 26th Semi-arid Wheat Yield Trial 2018-19 (CIMMYT)

Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	26 th SAWYT-337	5917	12	26 th SAWYT-344	3833
2	26 th SAWYT-306	5458	13	26 th SAWYT-338	3750
3	26 th SAWYT-375	4917	14	26 th SAWYT-373	3583
4	26 th SAWYT-306	4833	15	26 th SAWYT-321	3500
5	26 th SAWYT-400	4833	16	26 th SAWYT-315	3500
6	26 th SAWYT-309	4583	17	26 th SAWYT-359	3417
7	26 th SAWYT-303	4500	18	26 th SAWYT-357	3333
8	26 th SAWYT-348	4083	19	26 th SAWYT-314	3333
9	26 th SAWYT-367	4042	20	26 th SAWYT-370	3208
10	26 th SAWYT-336	3958	21	26 th SAWYT-389	3125
11	26 th SAWYT-347	3958	22	26 th SAWYT-356	2917

It was evident from the Table-13 that the variety/strain 26th SAWYT-382 gave maximum grain yield 5917 kg ha⁻¹ followed by strain 26th SAWYT-307 with grain yield value of 5458 kg ha⁻¹. However the strain coded as 26th SAWYT-356 gave minimum grain yield value of 2917 kg ha⁻¹. Seed of five top yielding and disease tolerant with high agronomic score genotypes (26th SAWYT-37, 26th SAWYT-375, 26th SAWYT-306, 26th SAWYT-309 & 26th SAWYT-303) was reserved for incorporation in Regular Wheat Yield trial (B₂) 2019-20.

1.10.6 39th Elite Selection Wheat Yield Trial 2018-19.

Thirty ninth elite selection wheat yield trial 2018-19 comprising fifty entries were laid out on 27-11-2018. Trial was laid out according to randomized complete block design with two replications. The plot size was kept 2m ×0.6m. All the cultural practices were carried out as and when required. Twenty two high yielding and disease resistant genotypes were selected for inclusion in regular wheat yield trial 2019-20. The trial was harvested on 20-05-2019. Grain yield data were recorded as presented in Table 1.14.

Table 1.14: 39th Elite Selection Wheat Yield Trial 2018-19.

Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)	Sr. No.	Varieties /Strains	Grain Yield (kg ha ⁻¹)
1	39 th ESWYT-108	5250	12	39 th ESWYT-180	4125
2	39 th ESWYT-127	5167	13	39 th ESWYT-175	4083
3	39 th ESWYT-102	5167	14	39 th ESWYT-133	4000
4	39 th ESWYT-103	5042	15	39 th ESWYT-122	4000
5	39 th ESWYT-104	4958	16	39 th ESWYT-118	3958
6	39 th ESWYT-157	4750	17	39 th ESWYT-113	3917
7	39 th ESWYT-152	4750	18	39 th ESWYT-153	3750
8	39 th ESWYT-111	4583	19	39 th ESWYT-121	3708
9	39 th ESWYT-112	4458	20	39 th ESWYT-170	3667
10	39 th ESWYT-131	4375	21	39 th ESWYT-163	3667
11	39 th ESWYT-110	4333	22	39 th ESWYT-123	3458

It was evident from the Table 1.14 that strain 39th ESWYT-108 gave maximum grain yield 5250 kg/ha followed by strain 39th ESWYT-127 with grain yield 5167 kg/ha. Seed of nine top yielding and disease tolerant with high agronomic score genotypes (39th ESWYT-27, 39th ESWYT-2, 39th ESWYT-3, 39th ESWYT-75, 39th ESWYT-57, 39th ESWYT-11, 39th ESWYT-12, 39th ESWYT-31 & 39th ESWYT-10) was reserved for incorporation in Regular Wheat Yield trial (B₂) 2019-20.

1.10.7 51st International Wheat Screening Nursery 2018-19

A 51st International Bread Wheat Screening Nursery 2018-19 comprising three hundred entries was laid out on 27-11-2018. The plot size was kept 2m × 0.3m. All the cultural practices were carried out as and when required. Twenty four high yielding and disease tolerant entries were selected for further evaluation. The trial was harvested on 22-05-2019. Grain yield per plot data were recorded as presented in Table 1.15.

Table 1.15: Yield data of 51st International Bread Wheat Screening Nursery (CIMMYT)

Sr. No.	Strains No	Grain Yield (kg ha ⁻¹)	Sr. No.	Strains No	Grain Yield (kg ha ⁻¹)
1	51 st IBWSN-1141	6167	13	51 st IBWSN-1007	4167
2	51 st IBWSN-1046	6166	14	51 st IBWSN-1265	3917
3	51 st IBWSN-1111	6083	15	51 st IBWSN-1058	3833
4	51 st IBWSN-1251	5917	16	51 st IBWSN-1012	3667
5	51 st IBWSN-1231	5917	17	51 st IBWSN-1045	3583
6	51 st IBWSN-1017	5667	18	51 st IBWSN-1296	3417
7	51 st IBWSN-1271	5500	19	51 st IBWSN-1085	3167
8	51 st IBWSN-1126	5000	20	51 st IBWSN-1004	3167
9	51 st IBWSN-1152	4917	21	51 st IBWSN-1295	3167
10	51 st IBWSN-1051	4917	22	51 st IBWSN-1113	3083
11	51 st IBWSN-1221	4500	23	51 st IBWSN-1284	2917
12	51 st IBWSN-1056	4333	24	51 st IBWSN-1086	1833

It was revealed from the Table 1.15 that the variety/strain 51st IBWSN-1141 gave maximum grain yield 6167 kg/ha followed by strain 51st IBWSN-1046 with grain yield 6166 kg/ha. However, the strain 51st IBWSN-1086 showed minimum grain yield 1833 kg/ha. Seed of eighteen top yielding and disease tolerant with high agronomic score genotypes (51st IBWSN-141, 51st IBWSN-46, 51st IBWSN-111, 51st IBWSN-251, 51st IBWSN-231, 51st IBWSN-17, 51st IBWSN-271, 51st IBWSN-126, 51st IBWSN-85, 51st IBWSN-51, 51st IBWSN-292, 51st IBWSN-56, 51st IBWSN-7, 51st IBWSN-265, 51st IBWSN-58, 51st IBWSN-12, 51st IBWSN-45 & 51st IBWSN-296) was reserved for incorporation in Preliminary Wheat Yield trial (A₂) 2019-20.

1.10.8 Heat Yield Trial-70 (2018-19)

Heat Yield Trial-70 comprising seventy entries was laid out on 09-11-2019. Trial was laid out according to randomized complete block design with two replications. The plot size was kept 4m × 0.6m. All the cultural practices were carried out as and when required. Twenty four high yielding and disease resistant genotypes were selected for inclusion in

regular wheat yield trial 2019-20. The trial was harvested on 21-05-2019. Grain yield data were recorded as presented in Table 1.16.

Table 1.16: Heat Yield Trial-70 2018-19.

Sr. No.	Varieties /Strains	Grain Yield (g/plot)	Sr. No.	Varieties /Strains	Grain Yield (g/plot)
1	HYT-70-54	645	13	HYT-70-46	510
2	HYT-70-64	620	14	HYT-70-4	505
3	HYT-70-63	568	15	HYT-70-45	485
4	HYT-70-65	565	16	HYT-70-10	480
5	HYT-70-69	565	17	HYT-70-57	459
6	HYT-70-21	558	18	HYT-70-27	453
7	HYT-70-3	555	19	HYT-70-37	450
8	HYT-70-18	553	20	HYT-70-50	445
9	HYT-70-31	545	21	HYT-70-43	400
10	HYT-70-67	539	22	HYT-70-32	395
11	HYT-70-55	525	23	HYT-70-39	375
12	HYT-70-42	513	24	HYT-70-20	360

It was evident from the Table 1.16 that strain HYT-70-54 gave maximum grain yield 645 g/plot followed by strain HYT-70-64 with grain yield 620 g/plot. However, the strain HYT-70-20 produced minimum grain yield 360 g / plot. Seed of six top yielding and disease tolerant with high agronomic score genotypes (HYT-70-52, HYT-70-54, HYT-70-8, HYT-70-39, HYT-70-42 & HYT-70-50) was reserved for incorporation in Preliminary Wheat Yield trial (A₃) 2019-20.

1.11 ICARDA Trials

1.11.1 19th Heat Tolerance Spring Bread Wheat Observation Nursery 2018-19

A 19th Heat Tolerance Spring Bread Wheat Observation Nursery 2018-19 comprising two hundred entries was laid out on 27-11-2018. The plot size was kept 2m ×0.3m. All the cultural practices were carried out as and when required. Thirteen high yielding and disease tolerant entries were selected for further evaluation. The trial was harvested on 21-05-2019. Grain yield per plot data were recorded as presented in Table 1.17.

Table 1.17: Grain yield data of 19th Heat Tolerance Spring Bread Wheat Observation Nursery 2018-19 (ICARDA)

Sr. No.	Strains No	Grain Yield (kg ha ⁻¹)	Sr. No.	Strains No	Grain Yield (kg ha ⁻¹)
1	19 th HTSBW-ON-130	4250	8	19 th HTSBW-ON-110	3000
2	19 th HTSBW-ON-7	4083	9	19 th HTSBW-ON-179	2917
3	19 th HTSBW-ON-91	3833	10	19 th HTSBW-ON-30	2667
4	19 th HTSBW-ON-81	3750	11	19 th HTSBW-ON-182	2333
5	19 th HTSBW-ON-181	3750	12	19 th HTSBW-ON-27	1833
6	19 th HTSBW-ON-147	3167	13	19 th HTSBW-ON-183	1583
7	19 th HTSBW-ON-83	3083	-	-	-

It was revealed from the Table 1.17 that the variety/strain 19th HTSBW-ON-130 gave maximum grain yield 4250 kg/ha followed by strain 19th HTSBW-ON-7 with grain yield 4083 kg/ha. However, the strain 19th HTSBW-ON-183 showed minimum grain yield 1583 kg/ha. Seed of six top yielding and disease tolerant with high agronomic score genotypes (19th DSBWYT-ON-130, 19th DSBWYT-ON-7, 19th DSBWYT-ON-91, 19th DSBWYT-ON-81, 19th DSBWYT-ON-181 & 19th DSBWYT-ON-179) was reserved for incorporation in Preliminary Wheat Yield trial (A₃) 2019-20.

1.11.2 19th Dryland Spring Bread Wheat Yield Trial 2018-19

A 19th Dryland Spring Bread Wheat Yield Trial 2018-19 comprising fifty entries and two replications was laid out on 27-11-2018. The plot size was kept 2m ×0.6m. All the cultural practices were carried out as and when required. Seven high yielding and disease tolerant entries were selected for further evaluation. The trial was harvested on 21-05-2019. Grain yield per plot data were recorded as presented in Table 1.18.

Table 1.18: Yield data of 19th Dryland Spring Bread Wheat Yield Trial (ICARDA)

Sr. No.	Strains No	Grain Yield (kg ha ⁻¹)
1	19 th DSBWYT-6	3917
2	19 th DSBWYT-33	3833
3	19 th DSBWYT-35	3375
4	19 th DSBWYT-9	3333
5	19 th DSBWYT-22	2625
6	19 th DSBWYT-13	2375
7	19 th DSBWYT-38	1375

It was revealed from the Table 1.18 that the variety/strain 19th DSBWYT-6 gave maximum grain yield 3917 kg/ha followed by strain 19th DSBWYT-33 with grain yield 3833 kg/ha. However, the strain 19th DSBWYT-38 showed minimum grain yield 1375 kg/ha. Seed of four top yielding and disease tolerant with high agronomic score genotypes (19th DSBWYT-6, 19th DSBWYT-33, 19th DSBWYT-27 & 19th DSBWYT-9) was reserved for incorporation in Preliminary Wheat Yield trial (A₃) 2019-20.

1.2. CHICKPEA

1.2.1 Collection and Maintenance of Chickpea Germplasm

Germplasm is a gene complex reservoir for selection of parental material for better grain yield, drought and temperature stress tolerance, resistance to insect pests and diseases. It served as a source of elite breeding material which was utilized in breeding programme. 284 chickpea genotypes (Desi-168 & Kabuli-116) including four check varieties were planted in augmented design. Sowing was done on 25-10-2018. The data regarding days to 50% flowering, plant stand, root rot and wilt diseases reaction (RRW), plant height (cm), number of pods/plant, days to maturity and grain yield (kg/ha) were recorded. Trial was harvested on 19-04-2019.

Table 1.19 (a) Chickpea Desi (Irrigated)

Sr. No	Characters studied	Range
1	Days to 50% flowering	78-112
2	Plant height (cm)	50-78
3	Pods/plant	39-185
4	Days to maturity	163-171
5	Grain yield (g/plot)	265-980

Table 1.19 (b) Chickpea Desi (Irrigated)

Sr. No	Yield range (kg/ha)	Entries
1	4000-4949	16
2	3000-4000	68
3	2000-3000	65
4	1000-2000	12
5	0-1000	0
6	Abolished	7

Table 1.19 (c) Chickpea Desi (Rainfed)

Sr. No	Characters studied	Range
1	Days to 50% flowering	72-106
2	Plant height (cm)	30-65
3	No. of pods/plant	27-102
4	Days to maturity	148-158
5	Grain yield (g/plot)	30-695

Table 1.19 (d) Chickpea Desi (Rainfed)

Sr. No	Yield range (kg/ha)	Entries
1	3000-3510	5
2	2000-3000	44
3	1000-2000	69
4	0-1000	45
5	Abolished	5

Table 1.20 (a) Chickpea Kabuli (Irrigated)

Sr. No	Characters studied	Range
1	Days to 50% flowering	65-108
2	Plant height (cm)	43-77
3	No. of pods/plant	40-150
4	Days to maturity	160-166
5	Grain yield (g/plot)	113-615

Table 1.20 (b)

Sr. No	Yield range (kg/ha)	Entries
1	2045-3106	53
2	1035-1995	52
3	571-884	6
4	Abolished	5

Table 1.20 (c) Chickpea Kabuli (Rainfed)

Sr. No	Characters studied	Range
1	Days to 50% flowering	54-104
2	Plant height (cm)	24-51
3	No. of pods/plant	7-55
4	Days to maturity	144-159
5	Grain yield (g/plot)	70-590

Table 1.20 (d)

Sr. No	Yield range (kg/ha)	Entries
1	3000-3434	1
2	2000-3000	27
3	1000-2000	41
4	0-1000	27
5	Abolished	20

Total 168 entries of chickpea (Desi) Germplasm were studied in two different environmental conditions (i.e. irrigated and rainfed). In irrigated conditions, entry no. 98, coded as Q performed best and gave highest grain yield of 980 grams/plot, while the entry no. 148(CH18-D137) showed poorest performance and yields only 265 grams/plot. Total sixteen entries showed best performance in irrigated conditions and gave grain yield between 4000-5000 kg/ha. In rainfed conditions, only 5 entries reduced grain yields of 3000-3510 kg/ha. The entry no. 50 coded as GGP-1475 gave highest grain yield of 695 grams /plot and entry no. 143, coded as CH18-D120, gave lowest grain yield of 30 grams/plot in the rainfed conditions.

In chickpea (Kabuli) Genepool, total 116 entries were also studied in two different conditions i.e. irrigated and rainfed. In irrigated conditions, entry no.5, coded as GGP-19, performed best and gave highest grain yield of 615 grams/plot, while check variety, Noor-2016 showed poorest performance and gave grain yield 113 grams/plot. One entry showed best performance in irrigated conditions and gave grain yield of 3106 kg/ha. In rainfed conditions the entry COOP-17-Q gave highest grain yield of 680 grams /plot and

entry GGP-1 gave lowest grain yield 70 gram/plot. One entry crossed the limit of 3000 kg/ha in rainfed conditions.

1.2.2 Chickpea Hybridization Program

Six crosses among desirable parents were attempted to develop high yielding, good quality, insect pest and disease tolerant varieties. Seeds from successful crosses were collected for generation enhancement and further evaluation. Parentage of successful crosses is given in Table-2.2.

Table 1.21 List of Crosses

Sr. No.	Crosses	Characteristics	Successful pods
Kabuli Chickpea Crosses			
1	Noor-09 x TGK1606	High yielding × Bold seeded	11
2	Noor-13 x TGK1602	High yielding x Wilt tolerant	11
3	TGK1620 x TGK1731	High yielding × Bold seeded	10
Desi Chickpea Crosses			
4	TG1218 x Bittle-16	High yielding × Bold seeded	08
5	TG1305 x TG1410	High yielding × Drought tolerant	12
6	TG1415 x Bhakkar-11	High yielding × Bold seeded	06

1.2.3 Evaluation of Filial Generations

Chickpea segregating generations viz, 5F₁, 119F₂, 45F₃, 62F₄, 49F₅, 63F₆ and 32F₇ populations were studied. One hundred and ninety one single plants/ progenies were selected from F₂ to F₆ populations for further evaluation. Eighteen (Desi) and 9 (Kabuli) uniform lines were selected from F₇ for further evaluation in preliminary yield trials.

Table 1.22 (a) F₁ Generations

Sr. No	Crosses	Population
1	CH55/09 x TG12K07	Bulk population
2	CH40/08 x CH39/09	Bulk population
3	K002/10 x CH56/09	Bulk population
4	K-01216 x K-01211	Bulk population
5	CH28/07 x DCD	Bulk population

Table 1.22 (b) F₂ Generations

Sr. No	Crosses	Single plant/ progenies planted	Single plant/ progenies selected
1	CH104/06 x Bittle-2016	12	6
2	K09015 x CM1235/08	8	2
3	Noor-2013 x TG12K07	7	2
4	CH24/07 x CH104/06	20	2
5	D09027 x D-10008	5	1
6	CH39/08 Bhakkar-2011	6	
7	K0902 x Noor-13	8	3
8	CM-2008 x Noor-13	5	
9	K0039/10 x CH54/07	11	14
10	D09027 x D09013	37	9
Total			39

Table 1.22 (c) F₃ Generations

Sr. No	Crosses	Single plant/ progenies planted	Single plant/ progenies selected
1	FG0902 x K0065-09	7	4
2	K0039-09 x K0021-09	3	1
3	D096-09 x D072-09	4	3
4	D090-09 x Bhakkar-2011	6	5
5	Thal-2006 x Punjab-2008	3	1
6	K-004-10 X K012-10	2	1
7	K-005-10 X Noor-2009	4	3
8	Bhakkar-2011 X D-0097-10	6	5
9	08AG016 X D0075-10	5	4
10	Punjab-2008 X 1977	5	3
Total			30

Table 1.22 (d) F₄ Generation

Sr. No	Crosses	Single plant /progenies planted	Single plant /progenies selected
1	D098-09 × D084-09	10	7
2	01067 × CH20/02	8	6
3	Bhakkar-2011 × D084-09	7	5
4	K004-10 × Noor-91	13	10
5	Noor-91 × K0069-10	5	4
6	D084/09× D096-09	6	4
7	CH39/04 × CH87/02	8	6
8	Noor-91 × Noor-2009	5	3
Total			45

Table 1.22 (e) F₅ Generations

Sr. No	Cross	Single plant /progenies sown	Single plants/progenies selected
1	BKK02209× D094-09	4	4/2
2	K70008 × Noor-2009	4	4/2
3	Bhakkar2011× D094-09	5	6/1
4	Bhakkar-2011× D0097-10	6	4/2
5	Punjab-2008× BKK02209	5	4/1
6	K0069-10 × D0085-10	4	4/1
7	08AG016 × D0075-10	3	4/1
8	Bhakkar-2011 × Thal-2006	2	5/1
9	08AG004× D084-09	5	3/2
10	08AG004 × D0085-10	3	3/1
11	Punjab-2008 × Thal-2006	4	5/2
12	CH23/06 × CH20/02	4	3/1
Total			49/17 = 66

Table 1.22 (f) F₆ Generation

Sr. No	Crosses	Single plants / progenies sown	Single plants/progenies selected
1	D0096/10 x Bhakkar-2011	22	12
2	06AG015 x Bhakkar-2011	10	11
3	08AG015 x D0096/10	12	5
4	K0019/10 x K0031/10	9	4
5	K0019/10 x K0026/10	10	6
Total			38

Table 1.22 (g) F₇ Generation

Sr. No	Crosses	Single plant /progenies sown	Single plants/lines selected
1	CH87/02 x D096/09	4	4
2	CH20/02 x D084/09	5	4
3	CH23/06 x D084/06	6	5
4	93127 x D084/09	4	4
5	CH39/04 x D084/09	6	5
6	Punjab-2008 x 1977	4	4
7	1067 x D096/09	3	2
Total			38

1.2.4 Preliminary Yield Trial -Desi (Set-1)

Preliminary Yield trial comprising eighteen entries was laid out according to RCBD with three replications under both irrigated and rainfed conditions. The sowing was done on 19-10-2018 in rainfed and 24-10-2018 in irrigated conditions, respectively. The plot size was maintained as 4 x 1.2m. The trial was harvested in the mid of April, 2019.

Table 1.23 Yield data of preliminary yield trial –Desi (Set-I)

Sr. No.	Name of Entry	Yield(kg ha ⁻¹)		Av. Yield (kg/ha)
		Irrigated	Rainfed	
1	TG1809	2705	1783	2244
2	TG1806	1996	2033	2015
3	TG1814	2156	1842	1999
4	TG1808	2611	1350	1981
5	TG1812	2153	1509	1831
6	TG1801	2167	1344	1756
7	TG1813	1892	1597	1745
8	TG1805	1941	1536	1739
9	TG1811	2063	1380	1722
10	TG1802	1896	1467	1682
11	TG1803	1785	1533	1659
12	Bittle-2016	1600	1400	1500
13	TG1815	1507	1442	1475
14	Bhakkar-2011	1552	1381	1467

15	TG1807	1434	1356	1395
16	TG1810	948	1472	1210
17	TG1804	875	1445	1160
18	TG1816	892	1189	1041
		CV= 5.49 LSD _{0.5} = 162.75	CV= 4.34 LSD _{0.5} = 108.17	

It was concluded from statistical analysis of yield data depicted in the above Table-2.4.2 that the differences among the means of entries were significant. Entry named as TG1809 gave the highest yield 2244 kg ha⁻¹, followed by TG1806 and TG1814 with yield 2015 kg ha⁻¹ and 1999 kg ha⁻¹, respectively. The entry coded as TG1816 gave the lowest yield of 1041 kg/ha.

1.2.5 Preliminary Yield Trial-Desi (Set-II)

The trial comprising sixteen entries laid out in RCBD with three replications under irrigated and rainfed conditions. The sowing was completed under rainfed conditions on 19-10-2018 while under irrigated conditions on 22-10-2018. The plot size was maintained as 4 x 1.2m. The trial was harvested in the mid of April, 2019.

Table 1.24 Yield data of preliminary yield trial –Desi (Set-II)

Sr. No	Name of Entry	Yield(kg ha ⁻¹)		Av. Yield (kg ha ⁻¹)
		Irrigated	Rainfed	
1	TG1829	3542	1475	2509
2	TG1824	3274	1503	2389
3	TG1826	3236	1528	2382
4	TG1823	3208	1480	2344
5	TG1825	3059	1550	2305
6	TG1818	3205	1389	2297
7	TG1817	3007	1383	2195
8	TG1820	2990	1275	2133
9	Bhakkar-2011	2950	1300	2125
10	Bittle-2016	2900	1283	2092
11	TG1927	3076	1103	2090
12	TG1822	3049	1075	2062
13	TG1828	2816	1256	2036
14	TG1830	2743	1206	1975
15	TG1821	2677	1228	1953
16	TG1819	2663	1189	1926
		CV= 3.32 LSD _{0.5} = 167.47	CV= 5.00 LSD _{0.5} = 110.59	

It was observed from statistical analysis of yield data depicted in the above Table-1.24 that the differences among the means of entries were significant. Entry TG1829 gave the highest yield 2509 kg ha⁻¹, followed by TG1824 and TG1826 with yield 2389 and 2382 kg ha⁻¹, respectively. However, genotype TG1819 gave the lowest yield of 1926 kg ha⁻¹.

1.2.6 Preliminary Yield Trial-Kabuli

Preliminary Yield Trial Kabuli comprising ten entries was laid out according to RCBD with three replications under irrigated and rainfed conditions. The sowing was completed under rainfed and irrigated conditions on 19-10-2018 and 24-10-2018, respectively. The plot size was maintained as 4 x 1.2m. The trial was harvested in the mid of April, 2019.

Table 1.25 Yield data of preliminary yield trial-Kabuli

Sr. No	Name of entries	Yield(kg ha ⁻¹)		Av. Yield (kg ha ⁻¹)
		Irrigated	Rainfed	
1	TGK1809	2361	1406	1884
2	TGK1808	2049	1364	1707
3	TGK1801	2059	1181	1620
4	TGK1804	1959	1141	1550
5	TGK1807	1917	986	1452
6	Noor-2009	1802	1075	1439
7	Noor-2013	1639	1100	1370
8	TGK1803	1465	1253	1359
9	TGK1802	1493	1053	1273
10	TGK1805	1542	864	1203
		CV= 4.60 LSD _{0.5} = 144.41	CV= 5.94 LSD _{0.5} = 116.42	

It was observed from statistical analysis of yield data depicted in Table 1.25 that the differences among the means of entries were significant. Entry coded as TGK1809 gave the highest yield 1884 kg ha⁻¹, followed by TGK1808 and TGK1801 with yield 1707 and 1620 kg ha⁻¹, respectively. The entry TGK1805 gave the lowest yield of 1203 kg ha⁻¹.

1.2.7 Regular Chickpea Yield Trial-Desi

Chickpea Regular yield trial comprising sixteen entries was laid out according to RCBD with three replications both under irrigated and rainfed conditions. The sowing was done on 19-10-2018 and 22-10-2018 under rainfed and irrigated conditions, respectively. The plot size was maintained as 4 x 1.2 m. The trial was harvested in the mid April, 2019.

Table 1.26 Yield data of regular chickpea yield trial-Desi

Sr. No	Name of Entries	Yield (kg/ha)		Average (kg ha ⁻¹)
		Irrigated	Rainfed	
1	TG1703	3715	1561	2638
2	TG1702	3695	1183	2439
3	TG1707	3354	1516	2435
4	TG1715	3514	1333	2424
5	TG1716	3021	1794	2408
6	TG1717	3281	1386	2334
7	TG1708	3285	1372	2329
8	TG1710	3153	1450	2302
9	TG1714	3295	1233	2264

10	TG1713	2924	1583	2254
11	TG1712	3347	1150	2249
12	Bittle-2016	3000	1400	2200
13	TG1704	2937	1177	2057
14	TG1711	2757	1355	2056
15	Bhakkar-2011	2691	1347	2019
16	TG1718	2511	1500	2006
		CV= 3.45 LSD _{0.5} = 181.25	CV= 5.30 LSD _{0.5} = 123.38	

It was obvious from the Table 1.26 that the differences among the means of entries were significant. Entry TG1703 gave the highest yield 2638 kg/ha followed by TG1702 and TG1707 with yield 2439 and 2435 kg ha⁻¹ whereas check varieties Bittle-2016 and Bhakkar-2011 gave the yield 2200 and 2019 kg ha⁻¹, respectively. The TG1718 gave the lowest yield of 2006 kg ha⁻¹.

1.2.8 Regular chickpea yield trial-Kabuli

Chickpea regular yield trial comprising twelve entries was laid out according to RCBD with three replications under irrigated and rainfed conditions. The sowing was done on 19-10-2018 in rainfed and 24-10-2018 in irrigated conditions. The plot size was maintained as 4 x 1.2 m. The trial was harvested in the mid April, 2019

Table 1.27 Yield data of regular chickpea yield trial-Kabuli

Sr. No	Name of Entry	Yield (kg ha ⁻¹)		Average (kg ha ⁻¹)
		Irrigated	Rainfed	
1	TGK1767	1694	706	1200
2	TGK1768	1469	716	1093
3	TGK1765	1454	647	1051
4	TGK1762	1660	350	1005
5	TGK1766	1420	566	993
6	Noor-2009	2028	945	1487
7	Noor-2013	1785	1028	1407
8	TGK1761	1476	444	960
9	TGK1770	1260	467	864
10	TGK1764	1354	366	860
11	TGK1769	1146	519	833
12	TGK1763	1295	358	827
		CV= 4.55 LSD _{0.5} = 115.87	CV= 9.43 LSD _{0.5} = 94.615	

It was obvious from the Table 1.27 that the differences between the means of entries were significant. Entry coded as TGk1767 gave the highest yield 1200 kg ha⁻¹ followed by TGk1768 and TGK1765 with yield 1093 and 1051 kg ha⁻¹, respectively. The entry TGk1763 gave the lowest yield of 827 kg ha⁻¹.

1.2.9 Chickpea Micro Yield Trial - C (Desi).

Chickpea Micro Yield Trial comprising 13 entries was laid out according to RCBD with three replications at different locations viz AZRI (Two sets), GBRSS. Kalurkot, ARS. Karor and farmer's field Mankera.

Table 1.28 Yield data of chickpea micro yield trial

Sr. No	Entries	AZRI		Yield (kg ha^{-1})			
		Rainfed	Irrigated	ARS	KKOT	Mankera	Average
1	TG-1616	1469	883	1167	1644	1650	1363
2	TG-1621	1339	1572	1094	1478	1278	1352
3	BITTLE-2016	1472	1194	1083	1672	1311	1346
4	TG-1626	1425	892	972	1728	1508	1305
5	TG-1620	1508	1196	1111	1250	1456	1304
6	TG-1614	1508	1186	611	1650	1213	1234
7	BK-2011	1058	1079	944	1644	1433	1232
8	TG-1623	1358	1053	833	1617	1281	1228
9	Niab Chana-2016	1517	803	1222	1344	1183	1214
10	TG-1617	1394	1092	1206	1122	1183	1199
11	TG-1618	1267	789	889	1561	1319	1165
12	TG-1622	994	786	825	1739	1378	1144
13	TG-1613	1200	681	1094	906	1383	1053
LSD_{0.05}		174.77	138.21	35.27	184.27	191.20	
CV (%)		17.35	10.15	3.72	5.68	8.37	

It is obvious from the Table 1.28 that the differences between the means of entries were significant. The entry TG-1616 gave the highest average yield 1363 kg/ha followed by TG-1621 and TG-1626, yield 1352 and 1305 kg/ha whereas check varieties Bittle-2016 and NIAB Channa 2016 gave the yield 1346 and 1214kg/ha respectively.

1.2.10 Chickpea Cooperative Yield Trial-Desi (Set-I) PRI- Faisalabad

Chickpea trial comprising sixteen entries was laid out according to RCBD with three replications under irrigated and rainfed conditions. The plot size was kept as 4 × 1.2m. The sowing was done on 22-10-2018. All the cultural practices were same carried out and trial was harvested on 11-4-2019.

Table 1.29 Cooperative Yield Trial-Desi (Set-I) PRI- Faisalabad

Sr. No	Code	Yield (kg ha^{-1})			
		AZRI, BKR Irrigated	AZRI, BKR Rainfed	Mankera (farmer field)	Average
1	D-16004	896	1924	1735	1518
2	D-16032	882	1819	1603	1435
3	D-16003	1066	1424	1561	1350
4	TG1415	604	1625	1733	1321
5	Bittle-2016	837	1021	2036	1298
6	CH09/12	858	1000	1833	1230
7	D-16011	1021	1569	853	1148
8	D-16017	691	1639	1071	1134

9	TG1221	674	1458	1253	1128
10	CH12/12	934	694	1668	1099
11	Punjab-2008	951	865	1375	1064
12	TG1218	795	948	1356	1033
13	TGX228	733	1566	750	1016
14	CH44/12	799	1118	1029	982
15	D-16007	667	1115	1056	946
16	CH40/12	566	799	885	750
LSD _{0.05}		165.71	248.92	112.89	
CV (%)		12.26	11.60	4.97	

It is evident from the Table 1.29 that the differences among the means of yield value of entries were significant. The entry D-16004 gave the maximum average yield 1518 kg ha⁻¹ followed by D-16032 with yield 1435 kg ha⁻¹ while lowest yield of 750 kg ha⁻¹ was given by advance line CH40/12. The trial sown under irrigated & rainfed conditions.

1.2.11 Cooperative Yield Trial-Desi (Set-II) PRI- Faisalabad

Chickpea trial comprising sixteen entries was laid out according to RCBD with three replications. The plot size was kept as 4 × 1.2m. The sowing was done on 22-10-2018. All the cultural practices were same carried out and trial was harvested on 11-4-2019.

Table 1.30 Cooperative Yield Trial-Desi (Set-II) PRI- Faisalabad

Sr. No	Name of entries	Yield (kg ha ⁻¹)			Average (kg ha ⁻¹)
		AZRI, BKR Irrigated	AZRI, BKR Rainfed	Mankera (farmer field)	
1	Punjab-2008	1986	1219	504	1570
2	CH13/12	2343	1139	774	1419
3	TG1410	2274	1132	656	1354
4	D-16029	2260	910	853	1341
5	TG1424	2278	951	740	1323
6	D-16020	2056	1125	743	1308
7	D-16033	2427	757	674	1286
8	CH30/12	2288	1031	507	1275
9	Bittle-2016	1792	1049	697	1179
10	TG1421	1844	1000	447	1097
11	CH11/12	1833	712	593	1046
12	TGX220	1567	1038	451	1019
13	D-16019	1493	809	714	1005
14	CH10/12	1663	875	467	1002
15	TG1305	1760	580	651	997
	D-16015	1368	667	553	863
		145.69	159.55	78.713	
		4.48	10.21	7.53	

It is evident from the Table 1.30 that the differences among the means of yield value of entries were significant. Punjab-2008 gave the maximum average yield 1570 kg ha⁻¹ followed by CH13/12 with yield 1419 kg ha⁻¹ while lowest yield of 997 kg ha⁻¹ was given by advance line TG1305.

1.2.12 Chickpea Cooperative Yield Trial-Kabuli, PRI, Faisalabad

Chickpea trial comprising sixteen entries was laid out according to RCBD with three replications. The plot size was kept as 4 x 1.2m. The sowing was done on 22-10-2018. Trial was harvested on 18-4-2019.

Table 1.31 Yield data of chickpea cooperative yield trial-Kabuli

Sr. No	Name of Entry	Yield (kg ha ⁻¹)
1	K-15001	1413
2	CH66/10	1410
3	CH51/12	1215
4	TG12K01	1143
5	K-15012	1010
6	CH47/12	941
7	K-15018	927
8	CH48/12	913
9	CH69/09	882
10	K-15019	871
11	K-15014	799
12	CH56/12	792
13	Noor-2013	757
14	K-15010	628
15	CH53/12	597
16	CH54/12	462
LSD _{0.05} = 131.61		CV (%) = 8.56

It is evident from the Table 1.31 that the differences among the means of yield value of entries were significant. Entry coded as K-15001 gave the maximum yield 1413 kg/ha followed by CH66/10 with yield 1410 kg/ha while lowest yield 462 kg/ha was given by entry coded as CH54/12.

1.2.13 Chickpea National Uniform Yield Trial (Desi)

Chickpea National Uniform Yield Trial consisting of 24 entries was laid out according to RCBD with three replications. The sowing was done on 29-10-2018 at AZRI, Bhakkar with a plot size of 4 x 1.2 m and harvesting was done on 23-04-2019. Arid Zone Research Institute, Bhakkar contributed nine advance lines for the chickpea National Uniform yield Trial (Desi) 2018-19.

Consolidated yield data showed that the differences among the means of entries were highly significant. Test entry TG-1410, contributed by AZRI, Bhakkar got top position at all 11 locations, it exhibited the mean yield of 1934 kg/ha this entry was also tolerant for blight. Other entry of AZRI, Bhakkar TG-1424 stood at fifth having mean grain yield of 1747 kg ha⁻¹ and this entry showed as highly resistant against Blight, followed by test entry TG-1305 of AZRI, Bhakkar having grain yield 1732 kg ha⁻¹.

Table 1.32 Consolidated results of Chickpea (Desi) National Uniform yield Trail 2018-19

No.	Genotype	Locations											Mean	Blight
		PRI, AARI Faisalabad	ARS Karak	AZRI Bhakkar	AZRI Bahwalpur	AZRC D.I.Khan	BARI Chakwal	GRS K.Kot	NARC Islamabad	NIAB Faisalabad	NIFA Peshawar	QAARI Larkana		
1	TG-1410	1969	1221	2861	1412	1144	1320	2090	2621	1827	3160	1646	1934	3
2	D-15024	1704	1042	1857	1279	1337	1313	2129	3238	1177	3263	1611	1814	5
3	D-14005	2451	1193	2222	824	1428	1396	1709	3170	1564	2639	1291	1808	3
4	CH-32/10	1708	931	2055	1617	1346	1160	2132	2809	1581	2813	1562	1792	1
5	TG-1424	1711	1160	2101	1057	1600	1125	2202	2906	1521	2292	1541	1747	1
6	TG-1305	1613	1229	2400	1290	1258	1132	1736	3245	1388	2486	1277	1732	7
7	CH-10/11	1381	1423	2059	1089	1389	1222	1976	3113	1083	2569	1222	1684	3
8	CH-29/11	1536	1298	2330	1341	1176	1250	2146	2756	1735	1771	1090	1675	3
9	D-15033	1852	1035	2264	1060	1454	1160	1729	2862	1244	2500	1243	1673	5
10	D-13011	1449	1236	2219	1136	1494	1202	1716	2991	1277	2431	1215	1669	5
11	TG-1218	1371	1167	2417	1315	1087	1236	1538	2771	1472	2708	1257	1667	5
12	TG1221	1785	1132	2337	1463	1331	1271	1667	2148	1983	1875	1229	1656	3
13	CH-35/10	1565	1230	2552	1851	1356	1222	2000	2204	1344	1632	1201	1651	3
14	D-13036	1856	1042	1962	1303	1190	1271	2028	3001	1165	2118	1153	1644	5
15	TG-1415	1736	1042	1792	1394	1173	1132	2208	2312	1315	2501	1437	1640	3
16	D13012	1830	1160	1906	1295	1092	1236	1892	2400	1704	2188	1222	1630	3
17	TG228	1654	958	2167	1396	1296	1410	1979	2624	1152	2153	1090	1625	3
18	TGX-220	1364	930	2274	1310	1359	1187	2125	2810	1169	2153	1180	1624	3
19	CH-39/11	1377	1021	2108	1478	1182	1076	2049	2715	1353	2083	1396	1622	5
20	BRC-448	1585	1049	2406	1233	1288	1278	1868	2427	1377	2051	1243	1619	5
21	Bittle-2016	1892	1233	2125	1193	1341	1201	1431	2288	1417	2260	1132	1592	5
22	D-15030	1498	1125	2205	1301	1027	1201	1785	3326	903	1874	1145	1581	7
23	SL-05-053	1052	1480	1889	951	1577	1236	1715	2733	1108	2326	1187	1569	5
24	TG-1421	1703	1090	2389	1425	1175	1327	1486	2428	1202	1911	1069	1564	3
Location Mean		1652	1143	2204	1292	1296	1232	1889	2746	1378	2323	1277	-	-
LSD 0.05		181	286	199	88	113	214	90	501	340	89	99	-	-
CV (%)		7.98	18.26	6.58	4.98	6.34	12.69	3.46	13.32	18.03	2.80	5.64	-	-

Coefficient of variation=10.28% Genotypes (G), Location (L) and G x L interactions are highly significant (P<0.01)

***Disease score** 9=Highly susceptible 7=Susceptible 5=Moderately Tolerant 3= Tolerant 1= Resistant

1.2.14 Chickpea National Uniform Yield Trial (Kabuli)

Chickpea trial comprising sixteen coded entries was laid out according to RCBD with three replications. The sowing was done on 29-10-2018 at AZRI, Bhakkar with a plot size of 4 x 1.2 m and harvesting was done on 23-04-2019. (Table1.33). Arid Zone Research Institute, Bhakkar contributed one advance lines for the Chickpea National Uniform yield Trial (Kabuli) 2018-19. Consolidated yield data showed that the differences among the means of entries were highly significant. Test entry TG-12k01 contributed by AZRI, Bhakkar exhibited mean grain yield 1485 kg ha⁻¹

Table 1.33 Consolidated results of Chickpea (Kabuli) National Uniform yield Trail 2018-19

No.	Genotype	Locations										
		PRI, AARI Faisalabad	AZRI Bhakkar	AZRC D.I.Khan	BARI Chakwal	GRS KalurKot	NARC Islamabad	NIAB Faisalabad	QAARI, Larkana	RARI, Bahawalpur	Mean	Blight
1	Noor-013	1469	1417	615	1410	1702	1156	1115	1729	3993	1623	5
2	K-14006	1300	1552	637	1292	1257	1837	1244	1556	3924	1622	7
3	CH 64/11	1555	1726	280	1354	1042	1549	1101	1479	4028	1568	7
4	CH-54/07	836	1851	486	1340	1556	1532	1021	1722	3715	1562	5
5	K-14004	1305	1722	678	1354	1174	1694	1370	1542	3056	1544	3
6	CH-68/08	954	1622	651	1354	1466	1551	1175	1583	3472	1536	3
7	K-14003	1165	1844	762	1257	1278	1701	1376	1514	2778	1519	3
8	K-14001	1035	1389	553	1326	1306	1953	1203	1493	3333	1510	7
9	15-KCC-106	1145	1333	703	1444	1167	1972	1072	1535	3125	1500	5
10	CM877/10	1038	1615	585	1271	1180	1268	1257	1458	3750	1491	5
11	TG-12k01	1133	1441	651	1438	1299	1624	901	1750	3125	1485	7
12	CM-1235/08	1023	1524	628	1382	1313	1545	660	1528	3542	1460	7
13	14FCK02	1321	1364	594	1424	938	857	988	1542	2917	1327	3
14	NCK-1801	481	781	660	1507	1028	1820	289	1667	1979	1135	3
15	QG-5	478	809	239	1194	820	1505	458	1813	2847	1129	5
16	QG-2	427	840	501	1042	569	1544	652	1823	2222	1069	5
Mean		1042	1427	577	1337	1193	1569	993	1608	3238	1443	-
LSD 0.05		90	121	57	120	79	684	244	35	322	-	-
CV (%)		6.20	6.11	7.12	6.49	4.79	31.47	17.71	1.56	7.17	-	-

Coefficient of variation=13.74% Genotypes (G), Location (L) and G x L interactions are highly significant (P<0.01)

Disease score** 9=Highly susceptible 7=Susceptible 5=Moderately Tolerant 3= Tolerant 1= Resistant

1.2.15 Chickpea Advance Yield Trial (Desi)- NIAB, Faisalabad

This trial comprising 18 test entries was laid out according to RCBD with three replications. The trial was sown on 22-10-18 with the plot size of 4 x 1.2m. The trial was harvested in the mid April, 2019

Table 1.34 Data of Advance Yield Trial (Desi) NIAB, Faisalabad

Sr. No	Name of Entry	Yield (kg ha ⁻¹)	Sr. No	Name of Entry	Yield (kg ha ⁻¹)
1	CH39/13	927	10	CH22/13	750
2	CH18/13	913	11	CH16/13	733
3	CH21/13	906	12	CH15/13	722
4	Bhakkar-2011	885	13	CH28/13	698
5	Bittle-2016	879	14	CM21/11	653
6	CH26/13	819	15	CH36/13	632
7	CH40/13	806	16	CH30/13	628
8	CH38/13	761	17	CH32/13	580
9	CH09/13	754	18	CH07/13	535
LSD _{0.05} = 96.74		CV (%) = 7.73			

It was obvious from the Table-1.34 that the differences between the means of entries were significant. The entry CH39/13 gave the highest yield 927 kg ha⁻¹ followed by CH18/13, CH21/13 with yield 913, and 906 whereas check varieties Bhakkar-2011 and Bittle-2016 gave the yield 885 and 879 kg ha⁻¹, respectively. The entry CH07/13 gave the lowest yield of 535 kg ha⁻¹.

1.2.16 Chickpea Advance Yield Trial (Kabuli)-NARC, Islamabad

This trial comprising 25 test entries was laid out according to (RCBD) with three replications. The trial was sown on 22-10-18 with a plot size of 4 x 1.2m. The trial was harvested in the mid April, 2019

Table 1.35 Data of Advance Yield Trial (Kabuli)-NARC, Islamabad

Sr. No	Name of Entry	Yield (kg ha ⁻¹)	Sr. No	Name of Entry	Yield (kg ha ⁻¹)
1	NCSK1601	1989	14	NCSK1805	677
2	NCS1608	1240	15	ILC482	666
3	NCSK1801	1229	16	NCSK1804	646
4	Noor-13	1229	17	NCSB1812	635
5	NCSK1715	1177	18	NCSK1808	625
6	NCSK1803	1177	19	NCSK1606	604
7	NCSK1802	1156	20	NCSK1807	594
8	NCSK1716	1063	21	NCSB1722	500
9	NCSB1724	1052	22	NCSK1714	490
10	NCSK1607	854	23	NCSB1811	489
11	NCSK1711	813	24	NCSK1810	416
12	NCSK1809	812	25	NCSB1723	333
13	NCSK1806	729			
LSD _{0.05} = 280.09		CV (%) = 16			

It is obvious from the Table 1.35 that the differences between the means of entries were significant. The entry NCSK1691 gave the highest yield 1989 kg ha⁻¹ followed by NCS1608, with yield 1240 kg ha⁻¹ whereas check variety Noor-2013 gave yield 1229 kg ha⁻¹, while NCSB 1723 gave the lowest yield value of 333 kg ha⁻¹.

1.3 Mungbean

1.3.1 Variety Approved

One Mungbean candidate variety was evolved and got approved in the name of AZRI Mung 2018 as commercial variety for general cultivation from Provincial Seed Council on 09.05.2018.

1.3.2 Collection, Maintenance & Characterization of Mungbean Genepool

One hundred & fifty entries were characterized and maintained in Germplasm to select the desirable parents for Hybridization programme. The sowing was done on 11.5.2018 with plot size 5 x 0.6m. Data regarding agronomic parameters, diseases and yield were recorded.

Table 1.36 Characteristic of Mungbean Germplasm

Sr. No	Characters	Range
1	Days to 50% flowering	34-50
2	Plant height (cm)	35-68
3	Pod length (cm)	2.30-8.7
4	No. of Pods Plant ⁻¹	22-48
5	Days to maturity	70-85
6	Seed yield (kgha ⁻¹)	315-2880

1.3.3 Hybridization

Hybridization was carried out to create the genetic variability to get the desirable recombinant by testing in filial generation. Eight crosses were attempted and seed from successful cross combatants were collected for further study in segregating generations. Mungbean segregating generation comprised 184 populations were studied in hot dry irrigated climate of Arid Zone. 137 single plant/ progenies were selected from F₃- F₆ population for generation enhancement on the basis of plant type, number of pods, pod length, 100 grain weight and disease incidence. Twelve uniform lines were selected from F₇ for assessing yield potential in preliminary yield Trials.

Table 1.37 Cross combinations

Sr. No	Cross combinations	Characteristics
1	NM-16 x AZRI-Mung-06	High yielding x Yellow mosaic resistant
2	AZRI-Mung-06 x 13 TM-04	Yellow mosaic resistant x high yielding
3	NM-2011 x AZRI-Mung-2018	Bold seeded, early maturing x high yielding
4	TM-1706 x TM-1711	High yielding x bold seeded
5	AZRI Mung-2018 x NM-2016	High yielding x Yellow mosaic resistant, bold seeded
6	TM1627 x NM-2016	High yielding x bold seeded & high yielding
7	AZRI Mung-2018 x AZRI-Mung-06	High yielding, heat tolerant x bold seeded & high yielding
8	NM-11 x TM1627	Bold seeded, Yellow mosaic resistant x high yielding, bold seeded

1.3.4 Preliminary Yield Trial

The objective of the trials was to evaluate the best lines for maximum yield potential and disease tolerance. Two preliminary yield trials (PYT-I & PYT-II) comprised of twenty eight entries including two check AZRI Mung 2006 & NM-2011 were laid out according to RCBD. Sowing was done on 11.05.2018 by keeping plot size 5 x 1.2m. Twenty two entries surpass the

both check varieties. The test entry TM-1803 gave the highest yield 1595 kg/ ha followed by TM-1806 with yield of 1250 kg/ha. The check varieties AZRI Mung 2006 and NM-2011 gave the yield 886 & 856 kg ha⁻¹ respectively. While in set II TM-1423 gave the maximum yield of 948 kg ha⁻¹ followed by TM-1813 having yield 894 kg ha⁻¹.AZRI Mung 2006 & NM-2011 gave yield 453 & 478 kg ha⁻¹ accordingly.

Table 1.38 Mungbean Preliminary Yield Trial (Set-I)

S. No	Genotype	Yield (kg/ha)	S. No	Genotype	Yield (kg/ha)
1	TM 1803	1295	7	TM 1426	911
2	TM 1806	1250	8	TM 1804	906
3	TM 1802	969	9	TM 1801	897
4	TM 1807	947	10	AZRI-Mung-06	886
5	TM 1810	944	11	NM-2011	856
6	TM 1808	917	12	TM 1811	850
LSD _{0.05}				101	
CV (%)				6.55	

Table 1.39 Mungbean Preliminary Yield Trial (Set-II)

S. No	Genotype	Yield (kg/ha)	S. No	Genotype	Yield (kg/ha)
1	TM 1423	948	9	TM 1815	728
2	TM 1813	894	10	TM 1816	711
3	TM 1821	853	11	TM 1825	705
4	TM 1814	850	12	TM 1817	650
5	TM 1424	756	13	TM 1820	530
6	TM 1822	755	14	NM-2011	478
7	TM 1818	739	15	AZRI-Mung-2006	453
8	TM 1812	728	16	TM 1819	414
LSD _{0.05}				83	
CV (%)				7.09	

1.3.5. Mungbean Regular yield Trial

Regular yield trial consisted of twelve test entries was evaluated included two check varieties in RCBD. The strain TM-1706 expressed the higher yield potential of 1328 kg ha⁻¹ followed by TM-1711 with maximum yield of 1200 kg ha⁻¹. While the check varieties NM-2016 and AZRI Mung-2006 gave the yield 1000 & 917 kg ha⁻¹ respectively

Table 1.40 Mungbean Regular Yield Trial

S. No	Genotype	Yield (kg/ha)	S. No	Genotype	Yield (kg/ha)
1	TM 1706	1328	7	NM-2016	1000
2	TM 1711	1200	8	TM 1418	986
3	TM 1710	1122	9	TM 1713	942
4	TM 1727	1072	10	TM 1701	928
5	TM 1720	1030	11	AZRI-Mung-2006	917
6	TM 1719	1003	12	TM 1714	889
LSD _{0.05}				80	
CV (%)				4.96	

1.3.6 Mungbean Micro yield Trial

Regional yield trial consisted of sixteen entries was conducted at three different agro-ecological locations of hot dry irrigated climate of Arid Zone. Seven entries gave the higher yield than both check varieties. TM-1627 gave the higher yield potential 724 kg ha⁻¹ followed by TM-1615 with 713 kg ha⁻¹. However, check variety AZRI-Mung 2006 and NM-2016 gave the yield 538 and 493 kg ha⁻¹ respectively.

Table 1.41 Mungbean Micro yield Trial

S. No	Genotype	Yield (kg/ha)	S. No	Genotype	Yield (kg/ha)
1	TM 1706	1328	7	NM-2016	1000
2	TM 1711	1200	8	TM 1418	986
3	TM 1710	1122	9	TM 1713	942
4	TM 1727	1072	10	TM 1701	928
5	TM 1720	1030	11	AZRI-Mung-2006	917
6	TM 1719	1003	12	TM 1714	889
LSD _{0.05} = 80 CV(%) 4.96					

1.3.7 National Uniform Mungbean Yield Trial

National yield trial comprising 17 entries was laid out according to RCBD. Two advance line TM-1418, TM-1426 & TM-1627 were contributed in the national uniform yield trial. The test entries TM-1627 of Arid Zone Research Institute Bhakkar attained the 2nd position at national level with yield value of 931 kg/ ha. While TM-1426 & TM-1418 gave the 835 & 715 kg ha⁻¹. However, check varieties NM-11 and AZRI Mung 2018 gave 734 & 811 kg ha⁻¹ respectively.

Table 1.42 Consolidated Results of Mungbean National Uniform Yield Trial- across the country
Grain Yield (kg/ha)

E. No.	Entry name	Source	Locations*									MEAN
			1	2	3	4	5	6	7	8	9	
1	AZRC-E2-18	AZRC-D. I Khan	756	342	632	1427	792	472	887	715	331	706
2	MH-16053	NIAB, FSD	410	415	569	1823	1008	576	990	681	439	768
3	13006	PRI, AARI, FSD	414	688	604	1360	1356	743	869	653	558	805
4	14005	PRI, AARI, FSD	522	727	674	1494	763	458	1226	628	737	803
5	14009	PRI, AARI, FSD	407	754	590	1256	979	563	1222	597	814	798
6	TM-1426	AZRI, Bhakkar	436	840	583	1702	597	378	1715	253	688	835
7	NCM-11-Z	PRP, CSI, NARC, ISB	458	571	688	1744	416	292	929	524	573	688
8	TM-1627	AZRI, Bhakkar	492	938	639	1965	1182	660	1287	514	704	931
9	MH-13091	NIAB, FSD	403	979	660	1858	1074	608	1715	503	741	949
10	MSPS-119	PRP, CSI, NARC, ISB	614	629	639	2225	958	552	907	500	800	869
11	TM-1418	AZRI, Bhakkar	447	488	625	1740	590	375	983	497	693	715
12	Azri Mung-18	Check	413	642	611	1490	705	431	1356	479	479	734
13	NCM-13	PRP, CSI, NARC, ISB	446	740	632	1900	871	510	894	455	527	775
14	NM-11	Check	521	631	660	2108	611	385	1140	451	791	811
15	NIFA Mung-6	NIFA, Tarnab, Peshawar	403	721	618	1510	603	382	850	448	592	681
16	GV-1	ARI, Mingora, Swat	457	763	632	1469	1327	729	966	438	641	825
17	MH-16058	NIAB, FSD	563	646	639	1354	828	490	967	368	370	692
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)

2 PLANT PROTECTION

2.1 Entomology

2.1.1 Integrated Pest Management Studies of Gram Pod Borer

Integrated Pest Management Studies of Gram Pod Borer trial was conducted according to RCBD keeping plot size of 31m x 136m. Bittle 2016 was used as test material. Pheromone traps data were recorded on daily basis. *Bacillus thuringiensis* and Lufenuron were sprayed at flowering and pod formation when the pest crossed ETL. Larval population data were recorded from pre flowering stage till pod formation on fortnightly basis. Yield and pod infestation data was also recorded at maturity.

Table 2.1 Effectiveness of Various Treatments To Incorporate Into IPM Studies of Gram Pod Borer

Treatments	Total Catches/ Season	Average Foliage damage (%)	Pod Damage (%)	Grains Damage (%)	Average Larval Population/ Plant	Grain Yield (kg/ha)	Yield increase over control (%)
T ₁ = Pheromone Traps	136 (A)	5.27bc	3.56b	3.49b	0.82bc	785.0ab	46.46
T ₂ = Light Traps	706 (A)	2.09a	0.71a	0.29a	0.13a	875.0a	63.25
T ₃ = Trichogramma cards	-	6.96c	7.92c	6.81b	0.92b	582.0c	8.58
T ₄ = <i>Bacillus thuringiensis</i>	-	4.56b	5.36bc	9.02c	0.72b	690.0b	28.73
T ₅ = T-Bird Perches	-	6.28c	7.28c	12.42c	1.03c	603.0bc	12.50
T ₆ = Hand Picking	1232 (L)	3.69ab	4.95b	5.34b	0.63b	689.0b	28.54
Cumulative impact of IPM		4.81	4.96	6.22	0.71	704	32.28
T ₇ = Farmer practice	0.00	10.58d	13.79d	15.18c	1.12c	536.0c	

Pest management with light traps involvement proved best with minimum damage to foliage, pods and grains. There was minimum larval population (0.13/plant), maximum grain yield of 875 kg/ha and maximum increase in yield 68.84 % over control followed by T₁ (pheromone traps), T₄ (*Bacillus thuringiensis*), T₆ (Handpicking), T₅ (T-Bird perches) and T₃ (release of *T. chilonis*). T₇ (Farmer practice) results were not satisfactory as it had maximum foliage damage 10.58 %, pod damage 13.79 % grain damage 15.18 % and larval population 1.12/plant. There was minimum grain yield of 536 kg ha⁻¹.

2.1.2 Evaluation Of New Chemistry Insecticides

Gram variety Bittle-2016 was sown according to RCBD with three replications. Treatments were applied when the pest population crossed ETL. The larval population was recorded pretreatment and post treatment after 3 and 7 days of pesticide application. The mortality of pest was calculated /analyzed statistically.

Table 2.2 Evaluation of New Chemistry Insecticides against *Helicoverpa* on Gram

Insecticides	Pretreatment Larval population/ Plant	Percent Larval Mortality		
		3 DAS	7 DAS	10 DAS
Emmamectin benzoate 1.9 EC	0.830	78.36	81.32	82.69
Chlorantaniliprol 200 SC	0.660	79.39	85.36	87.69
Spinosad 240 SC	0.530	65.98	71.85	76.15
Bacillus thuringiensis 0.6 WP	0.860	36.14	45.36	52.61
Lufenuron 50 EC	0.800	45.69	66.34	74.69
Spintoram 120 SC	0.920	65.69	77.26	79.52
Control	0.860	10.36	11.23	13.94
CV %	18.65	15.32	18.65	14.51

It was concluded that insecticides Chlorantaniliprol 200 SC and Emmamectin benzoate 1.9 EC proved better against other treatments with 87.69 and 82.69 % mortality after 10 days of insecticide application, respectively.

2.1.3 Population Dynamics Studies of Wheat Aphid

Wheat variety Fakhar-e-Bhakkhar was sown in November 2018. Five yellow moericke traps were installed on per acre basis under CRD. Aphid counts/ tray was recorded on weekly basis. Data were correlated with different wheat growth stages and meteorological factors as well.

Table 2.3 Population Dynamics Studies of Aphid By Using Yellow Moericke Traps

Crop Stage	Weeks 2018-19	Av. Aphid Population/Tray	Temperature °C	Humidity %
Stem Elongation	07-Feb	1.33	19.36	50.36
	14-Feb	6.83	21.41	49.34
Heading	21-Feb	41.16	22.69	52.69
	28-Feb	50.54	23.19	48.21
Dough	07-Mar	71.16	23.69	46.68
	14-Mar	296.66	24.25	51.36
Ripening	21-Mar	25.5	23.69	45.69
	28-Mar	2.65	25.65	40.68
	04-Apr	0.23	26.89	39.75

It was concluded that maximum aphid population 296.66/tray was recorded at Dough stage of wheat during the 2nd week of March with temperature 24.25 °C and Humidity 51.36 %. Where temperature had positive-significant correlation with the aphid population and humidity positive-non significant correlation.

2.1.4 Screening of Germplasm/Advance Lines of Gram

Mungbean germplasm screening trial was conducted at Arid Zone Research Institute, Bhakkar according to augmented design with plot size 4 m x 1.2 m. *Helicoverpa* eggs and larval population was recorded per 6 inches terminal shoot from 5 plants/plot on weekly basis from the time of pre flowering to pod formation stage.

Table 2.4 Screening of Germplasm/Advance Lines Of Gram against *Helicoverpa*

COMPARATIVELY RESISTANT LINES (Pod Borer Population less than 0.5/plant)	SUSCEPTIBLE LINES (Pod Borer Population 0.5-1.0/plant)	HIGHLY SUSCEPTIBLE LINES (Pod Borer Population 1.0-2.0/plant)
TG-1427	TG-1415	E-21-CNUYT-D
TG-1430	TG-1425	TG-1424
E-2-CNUYT-D	E-5-CNUYT-D	TG-1429
During 2019	TG-1426	E-15-CNUYT-K
	E-7-CNUYT-K	TG-1419
	TG-1410	E-17-CNUYT-D
TG-1614	TG-1401	E-18-CNUYT-K
TG-1622	E-11-CNUYT-K	E-19-CNUYT-D

Results showed that advance lines TG-1427, TG-1430, E-2-CNUYT-D and E-17-CNUYT-K found comparatively resistant against pod borer due to hardness of pod and hairiness of the plants. While advance lines TG-1415, TG-1425, E-5-CNUYT-D, TG-1426, E-7-CNUYT-K, TG-1410, TG-1401 and E-11-CNUYT-K found susceptible while rest of lines were highly susceptible with population 1-2/plant.

2.1.5 Population Dynamics Studies of Lepidopterous Insect/Pests

Two light traps were installed at research area of the institute. The moth catches /night were recorded daily. The data was correlated with meteorological factors.

Table 2.5 Population Dynamics Studies of Lepidopterous Insect/Pests By Using Light Traps

Sr. No.	Name of Insect/Pest species	Total captures /ha	Crop Specific Pest
1	American Bollworm (<i>Helicoverpa armigera</i>)	1723	Mungbean, Gram, Wheat, Vegetables, Cotton, Maize etc
2	Armyworm (<i>Spodoptera litura</i>)	3955	Mungbean, Gram, Wheat, Vegetables, Cotton etc
3	Cutworm (<i>Agrotis</i> Sp.)	1725	Seedlings of Mungbean, Gram, Wheat, Vegetables, Cotton etc
4	Whitefly (<i>Bemesia</i> sp.)	2875	Mungbean, Cotton etc

5	Termites (<i>Microtermes</i> Spp.)	1681	All crops, vegetables and ornamentals
6	Field Crickets (<i>Gryllus</i> Spp.)	124	-
7	Leaf Folder (<i>Cnaphalocrocis medinalis</i>)	495	-
8	Hairy Catterpillar (<i>Euproctis lunata</i>)	186	Oilseed and fodder crops
9	Aphids (<i>R. padi</i> , <i>S. graminum</i> , <i>S. avenae</i> , <i>M. rosae</i>)	12854	Wheat, Ornamentals
10	Leafminer (<i>Phyllocnistis citrella</i>)	394	Citrus, Vegetables
11	Till hawk moth (<i>Acherontia</i> Spp.)	79	Weeds, Ornamentals
12	Dung Beetle (<i>Onthophagus gazelle</i>)	728	-
13	Ground Beetle (<i>Calosoma</i> Spp.)	673	-
14	Green Bug (<i>Chinavia hilaris</i>)	349	Mungbean, Gram, Vegetables, Cotton
15	Stink Bug (<i>Halyomorpha halys</i>)	291	Mungbean, Gram, Vegetables, Cotton
16	Grey weevil (<i>Mylocerus virdidanus</i>)	112	Mungbean, Cotton
17	Others (ants, grasshopper, cockroach, damsfly, click beetle, earwig, water beetle etc)	3375	-
SOME BENEFICIAL FAUNA			
18	Lady Bird Beetle (<i>Coccinella septempunctata</i>)	174	-
19	Lacewing (<i>Chrysoperla Carnea</i>)	529	-
20	Preying mantis (<i>Mantis religiosa</i>)	55	-
21	Honey Bees (<i>Apis mellifera</i>)	38	-

Results showed that More than 26 insect species including 4 species of natural enemies were attracted through light traps. 32415 adult catches of insects were made during 2017-18 of which 16086 were important pests of gram, mungbean and other pulses. These pests were *Helicoverpa armigera*, *Spodoptera litura*, *Agrotis* Sp., *Bemisia tabaci*, *Microtermes* Spp., *Chinavia hilaris*, *Halyomorpha halys* and *Mylocerus virdidanus* with 1723, 3955, 1725, 6250, 1681, 349, 291, and 112 captures respectively, during different time periods and environmental conditions.

2.1.6 Screening of Germplasm/Advance Lines of Mungbean

Mungbean germplasm screening trial was conducted according to RCBD with three replications with plot size of 4 m x 1.2 m and AZRI Mung-2016 was used as check. Thrips population was recorded at weekly intervals from 6 cm length of 3 flowering shoots each taken from 5 random plants/plot. The pest population was analyzed statistically.

Table 2.6 Screening Of Germplasm/Advance Lines Of Mungbean against Thrips

S. No	Advance Lines	Average Thrips Population/plant at weekly intervals							Av. Population /season
		15-Jun-18	22-Jun-18	29-Jun-18	6-Jul-18	13-Jul-18	20-Jul-18	27-Jul-18	
1	09TM-11	0.09	0.20	0.30	0.41	0.10	0.65	0.15	0.27
2	13TM-04	0.00	0.00	0.14	0.12	0.23	0.63	0.36	0.21
3	13TM-14	0.00	0.00	0.00	0.11	0.14	0.36	0.25	0.12
4	TM-1418	0.12	0.10	0.60	0.63	0.95	1.25	0.95	0.66
5	TM-1426	0.23	0.20	0.50	0.52	0.24	0.98	1.24	0.56
6	TM-1501	0.12	0.30	0.40	0.24	0.64	0.47	0.64	0.40
7	TM-1502	0.00	0.20	0.23	0.14	0.74	1.26	1.26	0.55
8	NM-11	0.10	0.40	0.30	0.25	0.59	1.36	0.67	0.52
9	NM-16	0.16	0.30	0.80	0.56	0.42	1.75	1.58	0.80
10	AM-18	0.00	0.10	0.30	0.69	0.36	0.65	1.36	0.49
11	TM-1503	0.10	0.30	0.20	0.42	0.45	0.85	0.95	0.47
12	TM-1508	0.30	0.20	0.60	0.48	0.26	1.36	0.48	0.53
13	TM-1511	0.10	0.50	0.42	0.74	1.10	1.75	1.54	0.88
14	TM-1513	0.21	0.60	0.26	0.65	0.65	2.36	0.36	0.73
15	TM-1627	0.11	0.25	0.36	0.26	0.36	0.37	1.26	0.42
Temperature °C		38.5	37.5	38.2	40.6	41.7	41.7	42.3	
Humidity %		30.6	29.3	31.7	30.5	29.7	28.5	27.7	

It was concluded that advance lines 13TM-04, and AM-2018 were comparatively resistant against pod borer due to hairiness of the pods and leaves. While advance lines 09TM-11, TM-1426, TM-1627, TM-1503, and NM-2016 found vulnerable to pest while rest of lines were highly susceptible with population <5/plant.

2.1.7 Response of Espanola Bug on Mungbean

AZRI Mung-2016 was planted at 10 days intervals. Thrips was kept under control during the crop season. Espanola bug population was recorded from 15 random plants at weekly intervals from each sowing date, starting from blooming till maturity. The population recorded was correlated and meteorological factors as well.

Table 2.7 Response of Espinola Bug On Mungbean Planting at Different Time

Sowing Dates		Average Thrips Population/plant at fortnightly intervals						Average Pop./season	Yield kg/acre
		15-Jun-18	30-Jun-18	15-Jul-18	30-Jul-18	14-Aug-18	29-Aug-18		
SD 1	15-Apr-18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	201.00
SD 2	25-Apr-18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	305.00
SD 3	5-May-18	0.00	0.00	0.00	0.00	0.56	0.00	0.00	256.00
SD 4	15-May-18	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.14 321.00
SD 5	25-May-18	0.00	0.00	0.00	0.00	1.23	2.36	0.00	0.51 368.00
SD 6	4-Jun-18	0.00	0.00	0.00	0.23	2.26	1.23	0.68	0.63 184.00
SD 7	14-Jun-18	0.00	0.00	0.00	0.00	0.53	0.68	0.00	0.17 156.00
SD 8	24-Jun-18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 69.00
SD 9	4-Jul-18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 35.00
Temperature °C		39.54	40.25	41.68	40.36	39.64	38.64	35.48	
Humidity %		30.25	28.64	26.54	30.25	32.69	36.48	41.29	

It was concluded from the data given Table 2.7 that sowing dates of 25 April and 05 May were found least infestation with Espinosa bug. While sowing dates 15 April, 15 May, 25 May and 05 June were found medium infestation. However sowing dates 15 June, 25 June and 05 July had found maximum attack of Espanola bug. Thus it is recommended that sowing before 15 May will be ideal having maximum yield and minimum pod infestation. Temperature and humidity had negative and non significant correlation with population.

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