IJBPAS, April, 2017, 6(4): 777-787

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

# AARI CANOLA: PAKISTAN'S FIRST EVER CANOLA QUALITY AND SHORT DURATION MUSTARD (*Brassica juncea* L.) CULTIVAR RESILIENT TO CLIMATE CHANGE

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**Received 1st Nov. 2016; Revised 2nd Dec. 2016; Accepted 1st Feb. 2017; Available online 1st April 2017**

## ABSTRACT

Climate change is the crucial global issue and directly effects on crop production leading towards food security. The relative importance of climate change for food security is very much, especially in developing countries like Pakistan. Pakistan spends approximately US$ 2.50 billion annually on the import of edible oil, which is a huge burden on the economy of the country. Development of canola quality and short duration mustard cultivar is a dire need to combat the upcoming food and health intimidations for this region. The newly developed canola quality *Brassica juncea* cultivar AARI canola (ZBJ-06012) at Oilseeds Research Institute, Faisalabad, Pakistan is an outcome of hybridization (ZBJ-97004 x J90-43001) during 1999-2000 and has been developed through the pedigree method of plant breeding. Homozygous progenies of 6012 from F6 were bulked in 2005-06 for yield evaluation. Its performance was evaluated in Station Yield Trials, Zonal Yield Trials, Micro Yield Trials and National Uniform Mustard Yield Trials. It has proved its worth in all yield trials and its performance is better than the existing non-canola mustard varieties. AARI canola exhibited 3152 kg/ha seed yield potential in NUMYT 2010-11 at Pioneer Seed Farms, Sahiwal, Pakistan. It produced 13 % higher yield as compared to check in Micro Yield Trials carried out during 2009-10. The new strain showed tolerance against diseases especially Alternaria blight, Powdery mildew, Downy mildew and White rust and also escapes

the aphid attack due to early maturity. Agronomic studies revealed that this variety needs no special production technology package and fit in a better way with the existing agronomic practices. AARI canola is suitable for both irrigated and rainfed regions of the Punjab, Pakistan.

**Keywords: *B. juncea*, food security, drought tolerance, short duration, genetic variability.**

## INTRODUCTION

Food security is the outcome of food system processes all along the food chain. Climate change is affecting food security through impacting the conditions in which agricultural activities are conducted. Plants, animals, and ecosystems are adapted to the prevailing climatic conditions in every part of the world. With the change in climatic conditions, the plants and animals are effecting less or more in term of quality and production [1]. Food security has remained the foremost objective of the Government of Pakistan. Therefore, the policymakers spend substantial time on designing sound food policy leading to food security. Various factors have an impact on food security including agronomic, institutional, political factors, in addition to climatic factors. Climate change is considered the most crucial factor influencing food security. Food security includes different dimensions, namely production, distribution, and accessibility. Considering food production dimension, the studies show the substantial impact of temperature and rainfall on food production [2]. *Brassica juncea* (Indian mustard) belongs to the family *Brassicaceae*. It is a major oilseed crop of the subcontinent. It is a rich source of protein with well-proportioned amino-gram [3]. *B. juncea* is more adaptable oilseed crop than *Brassica napus* in arid areas. It has more vigorous seedling growth, faster ground covering ability, better tolerance to heat and drought along with better resistance to the blackleg fungus, Leptosphaeri amaculans than *B. napus* [4,5]. *B. juncea* silique are non-shattering and seeds potentially contain a higher percentage of oil plus protein because of the thinner seed coat. The potential benefits of developing canola quality B. juncea are recognized by a number of northern hemisphere countries [4]. All over the world, Mustard oil is consumed for both edible and non-edible purposes [6]. Palm oil promotes heart disease by raising blood cholesterol [7]. Fewer contents of Erucic acid are helpful in cardiac problems. Recently, *B. juncea* has been explored for its biodiesel potential [8].

Pakistan is facing severe scarcity of edible oil due to its increasing demand and production gap, thus, edible oil production

does not match with growing demand of population [9]. Consequently, a huge volume of foreign exchange is spent every year on its import to gratify the requirement [10]. During the year 2013-14, the local production of 0.573 million tonnes against the 3.20 million tonnes total need of edible oil and imported 2.627 million tonnes of edible oil worth US$ 2.50 billion [11]. The Oilseeds Research Institute, Faisalabad (Pakistan) is the only research institute in Pakistan working on the development of canola quality varieties in summer mustard. The breeding program is aiming to develop canola quality (double low) *B. juncea* cultivars which are non-shattering, high yielding, early maturing and disease tolerant with good drought/heat tolerant traits. The key objective is to develop canola quality mustard genotypes, which are early maturing than rapeseed and non-canola mustard cultivars along with comparable or enhanced yields.

## MATERIAL AND METHOD

**Crossing and filial generation development:** ZBJ-97004 was a locally adapted Mustard line and J-90-43001 was an exotic Mustard line with Canadian origin having low Erucic acid (1.5 %) and Glucosinolates (< 30 µ moles/g of the oil-free meal) were grown at Oilseeds Research Institute, Faisalabad, Pakistan during 1999-2000. At flowering stage, ZBJ-97004 was crossed as the female parent with J-90-43001. The $F_1$ plants were grown and self-pollinated at flowering during 2000-01. From $F_2$ generation, 95 single plants having the early maturity and good plant vigour were harvested separately during 2001-02, out of these 95 single plant were selected, 45 high yielding plants were used to grow $F_3$ progeny rows on the basis of canola quality characteristics during 2002-03. 56 plants were harvested separately from the selected rows on the basis of plant health and yield. Out of these selected plants, 36 single plants were further grown to have plant to progeny rows of $F_4$ during 2003-04. 40 desirable single plants were harvested from the selected rows. The $F_5$ was raised from 25 plants to row progenies having low Erucic acid and Glucosinolates during 2004-05. The 20 progeny rows were further selected to grow $F_6$. Ten superior rows of $F_6$ were selected for further study during 2005-06. The oil contents of elite strains were determined by Nuclear Magnetic Resonance (Model MQA 7005). Erucic acid and Glucosinolates of elite strains were determined by Gas Chromatograph (Model varian-3900 GC) and UV/Visible

Spectrophotometer (PD-303 UV) respectively.

**Evaluation and yield testing:** The lines with canola quality were evaluated in replicated station yield trials for two years during 2006 to 2008. The stability and performance of elite line (ZBJ-06012) was evaluated against varied climatic conditions throughout the province by Zonal Varietal Trials and Micro Yield Trials during 2008 to 2010. The stability and performance in broader aspect to combat the changing climatic conditions was also checked throughout the country by National Uniform Mustard Yield Trials for two years during 2010 -11. The candidate variety ZBJ-06012 has been tested under different agro-climatic zones of the Punjab (Pakistan) both in irrigated and rainfed areas during 2011 to 2014. In the broader perspective, it was also evaluated in National Uniform Mustard Yield Trials conducted throughout Pakistan. The performance of candidate variety was consistently better in Station Yield Trial, Zonal Varietal Trails and Micro Yield Trials conducted in Punjab. Though the conducting time of National Uniform Mustard Yield Trial was contrary to its sowing requirement, even then it performed at par to the check varieties. Randomized complete block design (RCBD) with four replications was followed at all locations. Each plot consisted of 4 rows with 6 meter in length. Seeds were planted with the help of a Hand Seed Drill and 45cm distance between the rows was maintained. Recommended dose of NPK were applied. Complete plot was harvested at maturity for yield evaluation.

**Agronomic studies:** ZBJ-06012 was evaluated for defining best package of production technology with different sowing dates starting from 1$^{st}$ September to 16$^{th}$ October with fifteen days of interval in each sowing date. The fertilizer response was also tested with different doses of Nitrogen and Phosphorus.

**Disease Incidence:** The data on infestation of diseases (Alternaria blight, Powdery mildew, Downy mildew and White rust) was recorded at Plant Protection Research Institute (PPRI), Faisalabad (Pakistan) during 2009-10 and 2010-11. The candidate variety ZBJ-06012 was compared with check variety Raya Anmol using KJ-159 as Spreader line.

**Statistical Analysis:** Statistx 8.1, computer statistical software package, was used to calculate and analyze variance for different measured traits. At 5% probability level, differences among means were tested by applying least significant difference test.

**Variety Approval:** In 2016, candidate variety ZBJ-06012 (AARI Canola) has been approved by Punjab seed Council (Pakistan) for general cultivation due its unique canola characteristics, short maturity duration and high seed production. The BNS and Pre-basic seed has been produced from a uniform and stable lot at Oilseeds Research Institute, Faisalabad (Pakistan).

## RESULT AND DISCUSSION

**Station Yield Trials:** AARI canola (ZBJ-06012) was tested in Preliminary Yield Trial and Advanced Yield Trial at Oilseeds Research Institute, Faisalabad, Pakistan during 2006-07 to 2007-08. The yield data of these trials are presented in Table1.

**Table 1: Yield Performance of ZBJ-06012 in station yield trials at ORI Faisalabad, Pakistan**

| Variety/Line | Seed Yield in kg/ha | | | % Increase over check |
|---|---|---|---|---|
| | PYT (2006-07) | AYT (2007-08) | Avg. | |
| ZBJ-06012 | 2074 | 1602 | 1838 | 7% |
| Raya Anmol(C) | 1908 | 1528 | 1718 | - |
| LSD 5% | 67 | 103 | | |

The above data of station yield trials indicate that AARI canola (ZBJ-06012) yielded 7% higher seed yield than Raya Anmol (check variety). In any crop breeding program physical and genetic variability of breeding material has a dynamic role to develop high yielding and stable cultivar to combat the changing climatic conditions [12].

**Out Station Yield Trials:**

**Zonal Varietal Trials:** AARI canola (ZBJ-06012) was tested in Zonal Varietal Trial during 2008-09 at five locations (Oilseeds Research Institute, Faisalabad, Pioneer Seeds, Sahiwal, Oilseeds Research Station, Khanpur, Oilseeds Research Sub-station, Piplan and Regional Agricultural Research Institute, Bahawalpur). The yield data of these trials are presented in Table 2.

**Table 2: Yield performance of ZBJ-06012 in Zonal Varietal Trial during 2008-09**

| Variety/Line | Seed Yield in kg/ha | | | | | | % Increase |
|---|---|---|---|---|---|---|---|
| | Faisalabad | Sahiwal | Khanpur | Piplan | BWP | Average | |
| ZBJ-06012 | 1937 | 1736 | 2002 | 1169 | 1389 | 1647 | 4 % |
| Raya Anmol(C) | 1929 | 2162 | 1690 | 1042 | 1111 | 1587 | - |
| LSD 5% | 160 | NS | 372 | NS | NS | | |

The above data of zonal varietal trial reveal that ZBJ-06012 gave 4% higher yield than Raya Anmol (check variety).

**Micro Yield Trials**: AARI canola (ZBJ-06012) was tested in Micro Yield Trial during 2009-10 at five locations (Oilseeds Research Institute, Faisalabad, Oilseeds Research Station, Khanpur, Oilseeds Research Sub-station, Piplan, Agronomic Research Station, Karor and Arid Zone

Agricultural Research Institute, Bhakkar). The yield data of these trials are presented in Table 3. Seed yield stability under different agro-climatic conditions is an important factor in plant breeding programs. The goal of plant breeders to develop varieties, which are widely adapted to diversified climatic conditions. The seed yield of *Brassica juncea* grown in Pakistan is significantly influenced by environment [10,13]. The ZBJ-06012 proved its adaptability in yield performance at multi-location evaluation and hence introduced as a new variety for general cultivation in Punjab (Pakistan).

**Table 3: Yield performance of ZBJ-06012 in Micro Yield Trial, 2009-10.**

| Variety/Line | Seed Yield in kg/ha | | | | | | % Increase |
|---|---|---|---|---|---|---|---|
| | FSD | K/Pur | Piplan | Karor | Bhakkar | Average | |
| ZBJ-06012 | 1951 | 2562 | 1512 | 941 | 633 | 1520 | 13 % |
| Raya Anmol (C) | 1362 | 2469 | 1235 | 941 | 710 | 1343 | - |
| LSD 5% | 50 | 368 | NS | 77 | 51 | | |

On the basis of the mean seed yield of five locations, the seed yield of AARI canola (ZBJ-06012) gave 13 % higher yield than Raya Anmol (check variety).

**National Uniform Mustard Yield Trials:** Traditionally, NUMYT for summer mustard is not being conducted in Pakistan, therefore, as an alternative, this candidate variety was evaluated in NUMYT of Rabi season (winter), during 2009 to 2011 in all over Pakistan at different Agro-climatic conditions coordinated by Oilseed coordinator, Pakistan Agricultural Research Council (PARC), Islamabad (Pakistan). Where ZBJ-06012 was performed at par with full season mustard varieties i.e. BARD-1 and Khanpur Raya. The yield data of ZBJ-06012 during 2009-10 and 2010-11 of NUMYT is shown in Table 4 and Table 5 respectively.

**Table 4: Yield performance of ZBJ-06012 in National Uniform Mustard Yield Trial, 2009-10.**

| Variety/Line | Seed Yield in kg/ha | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NARC | FSD | Pioneer | BWP | K/Pur | NIFA | DIK | Sakrand | Quetta | Avg. |
| ZBJ-06012 | 2539 | 2760 | 1018 | 555 | 1875 | 1927 | 2111 | 1473 | 416 | 1630 |
| BARD-1 (C) | 1903 | 2056 | 1058 | 986 | 2292 | 2479 | 2417 | 1973 | 446 | 1734 |
| LSD 5% | 317 | 131 | NS | 101 | 199 | 379 | 89 | 76 | 68 | |

**Table 5: Yield performance of ZBJ-06012 in National Uniform Mustard Yield Trial, 2010-11**

| Variety/Line | Seed Yield in kg/ha | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NARC | FSD | BWP | K/Pur | Pioneer | Kanzo | NIFA | Kohat | T/Jam | Avg. |
| ZBJ-06012 | 2063 | 3067 | 2708 | 1875 | 3152 | 2304 | 1306 | 963 | 1125 | 2063 |
| Khanpur Raya(C) | 1581 | 2352 | 3042 | 3208 | 3018 | 3407 | 2861 | 1387 | 1417 | 2475 |
| LSD 5% | 377 | 200 | 452 | 426 | 829 | - | 470 | 398 | NS | |

Maximum yield potential of AARI canola (ZBJ-06012) was recorded 3152 kg/ha in NUMYT 2010-11 at Pioneer Seed Farms, Sahiwal. It produced 13 % higher yield as

compared to check in Micro Yield Trials carried during 2009-10. Same procedure were adapted by Anwar *et al.,* [14], Mahmood *et al.,* [15] and Mahmood *et al.,* [16] for evaluation of their strains "Th-6", "Punjab Sarson" and "Faisal Canola" respectively.

**Agronomic studies:**

**Sowing Date Trial:** Response of ZBJ-06012 to different sowing dates was evaluated at Vegetable & Oilseeds Section (V&O), Agronomic Research Institute, Faisalabad (Pakistan) during 2010-11 & 2011-12. The average yield performance of ZBJ-06012 in sowing date trials was assessed from 1st September to 16th October with fifteen days' intervals (Table 6). Sharghi *et al*., [17] also described that late sowing date and interruption of irrigation at flowering stage significantly reduced the growth, yield and yield components of the Canola cultivar. The yield data showed that the highest mean yield 2605 kg/ha was recorded in treatment-3 (1st October).

**Table 6: Sowing date trial of ZBJ-06012**

| Sowing Date | Yield (kg/ha) | | Av. (kg/ha) |
|---|---|---|---|
| | 2010-11 | 2011-12 | |
| 1st September ($T_1$) | 1780 | 1940 | 1860 |
| 16th September ($T_2$) | 2472 | 2469 | 2471 |
| 1st October ($T_3$) | 2651 | 2558 | 2605 |
| 16th October ($T_4$) | 1882 | 2140 | 2011 |
| LSD 5% | 255 | 127 | |

**Fertilizer (NP) Response Trial:** Response of ZBJ-06012 with different levels of Nitrogen & Phosphorus was tested at Oilseeds Research Station (ORS), Khanpur and Vegetable & Oilseeds Section (V&O), Agronomic Research Institute, Faisalabad during 2012-13 & 2013-14. The data for seed yield was statistically significant (Table 7). On average basis maximum seed yield of 3276 kg/ha was produced by treatment No. 5 in which N:P was applied @ 75:75 kg/ha followed by treatment 4 with seed yield of 2979 kg/ha. Same procedure was adapted by various researchers [14-16].

**Table 7: Data of fertilizer (NP) response trial**

| Treatment | Nitrogen (kg/ha) | Phosphorus (kg/ha) | ORS | V&O | Avg. |
|---|---|---|---|---|---|
| | | | Seed Yield (kg/ha) | | |
| 1 | 60 | 60 | 2241 | 2590 | 2416 |
| 2 | 75 | 60 | 2347 | 2688 | 2518 |
| 3 | 90 | 60 | 2192 | 2792 | 2492 |
| 4 | 60 | 75 | 2665 | 3292 | 2979 |
| 5 | 75 | 75 | 2869 | 3683 | 3276 |
| 6 | 90 | 75 | 2506 | 3367 | 2937 |
| 7 | 60 | 90 | 2683 | 2833 | 2758 |
| 8 | 75 | 90 | 2703 | 3146 | 2925 |
| 9 | 90 | 90 | 2682 | 3250 | 2966 |
| | | LSD 5% | 277 | 393 | |

**Disease and Insect/Pest Reaction:**

**Disease Incidence:** The data on infestation of diseases (Alternaria blight, Powdery mildew, Downy mildew and White rust) was recorded at Plant Protection Research Institute (PPRI), Faisalabad (Pakistan) during 2009-10 and 2010-11. The candidate variety ZBJ-06012 was compared with check variety Raya Anmol using KJ-159 as Spreader line. The data showed that AARI Canola (ZBJ-06012) was highly resistant against Alternaria blight, Powdery mildew, Downy mildew and White rust (Table 8). Mahmood *et al.,* [16] & Mahmood *et al.,* [15] adapted same procedure for to estimate the disease infestation in their experiment.

**Table 8: Disease response of ZBJ-06012**

| Variety/Line | Disease intensity | Average disease %age | | |
|---|---|---|---|---|
| | Alternaria Blight (0-9)* | Powdery Mildew% | Downey Mildew% | White Rust% |
| ZBJ-06012 | 2(HR) | 0 | 0 | 0 |
| Raya Anmol (Check) | 3(HR) | 0 | 0 | 0 |
| KJ-159 (Spreader) | 9(HS) | 80 | 60 | 100 |

*** 0 = Resistant, 9 = Susceptible**

**Aphid Attack on ZBJ-06012:** Due to short season crop, AARI Canola (ZBJ-06012) had matured in January and escaped from aphid attack. Sarwar *et al.,* [18] have also proved that crop sown in first week of October can escape aphid attack.

**Quality Characteristics:** First ever locally developed short duration canola quality line of *Brassica juncea* having good characteristics and suitable for the edible purpose. The promising strain ZBJ-06012 has the Erucic acid 1.00 -1.44% and Glucosinolates 23-25 µ mole/g oil free meal and it has 40-42 % oil content. Swern [19] illustrated that Erucic acid is less than 2% of the total composition of the fatty acids in canola oil varieties. In addition, the level of glucosinolates in the seed has been lowered to less than 30 mmol/g, resulting in better meal quality.

**Fig. 1: AARI Canola on left and JS-30 on right with same sowing date**

**ZBJ-06012 Approved as Variety (AARI canola) by Punjab Seed Council, Pakistan**

The candidate variety was evaluated by spot examination committee on 20-01-2015. The committee has recommended for submission of variety approval case to the Experts Sub-committee for its approval. The candidate variety ZBJ-06012 (AARI Canola) was recommended by Expert Sub- Committee in its 71st meeting held on 09-03-2015 for its approval in Punjab Seed Council. Finally, Punjab Seed Council, Pakistan had approved AARI canola as variety on 7 January, 2016 for general cultivation in Punjab province (Pakistan). Mahmood *et al.,* [15] & Mahmood *et al.,* [16] adapted same procedure for the development, evaluation and approval of "Punjab Sarson" and "Faisal Canola" respectively. It had also been taken seed yield for evaluation and approval of broccoli variety "Imperial" [20].

**CONCLUSION**

AARI canola is the first ever Canola quality variety of *Brassica juncea* in summer mustard group. High seed yield, bold seed size, Non - Shattering and heat tolerance traits of this canola variety fulfil the demand of Canola growers of this region. AARI canola is also tolerant against diseases (Alternaria blight, Downy mildew, Powdery mildew and White rust) and escape the aphid attack due to earliness. Due to short maturity duration, it is quite suitable for existing cropping pattern. It is well adopted in southern, central and northern Punjab areas of Pakistan.

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