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# Comparative Performance of Canola Hybrids in Response to Different Phosphatic Fertilizers

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## ABSTRACT

Phosphorus accounts for one of the largest energy inputs in canola production. Understanding the effects of phosphorus on yield and oil quality of canola will help in increasing its chances to better fit in the present cropping systems of Pakistan. This study determined the response of canola hybrids to different sources of phosphatic fertilizers. Two canola hybrids, namely Hyola-43 and Hyola-401 were grown using four different sources of phosphorus (MAP, DAP, NP, SSP) during 2004-05 and 2005-06. Canola hybrids differed significantly for all the yield and oil quality traits during both years of study. Hyola-43 resulted in 6.7 and 13.4% increase in seed yield over Hyola-401 during 2004-05 and 2005-06, respectively. Hyola-43 also produced significantly higher values of oil and protein content over Hyola-401. Increase in oil and protein content varied from 3.3-5.5% and 5.0-5.1% in 2004-05 and 2005-06, respectively. Differences in seed yield, yield parameters and oil quality were non-significant in response to phosphatic fertilizers.

**Key Words:** Canola hybrids; P fertilizers; Seed yield; Oil content; Protein content

## INTRODUCTION

High demands for food due to rapidly increasing population and changes in dietary habits are increasing pressure on agriculture. To meet the food requirements of this increased population, Pakistan is spending billions of dollars for importing food commodities, out of which edible oil is the single largest food item. Domestic production of edible oils meets only 30% of the total requirements (Government of Pakistan, 2006), while rest is imported. Huge gap between the consumption and domestic production of edible oils can be filled up by increasing the area under oilseed crops like rapeseed and mustard, sunflower and soybean or increasing production per unit area. Productivity and quality of oilseed crops can possibly be improved by adopting better agronomic practices and replacing conventional rapeseed and mustard varieties with canola, which has the potential to fit in the current cropping systems due to its premium quality oil (Starner, 1999; Manaf & Hassan, 2006).

Judicious use of fertilizers is considered one of the most important agronomic factors that affect the yields of oilseed crops (Patel & Shelke, 1998). Phosphorus (P) is one of the major plant nutrients that directly or indirectly affect all biological processes and is needed in fairly large quantities by the plants. In spite of its importance; plants strive hard to obtain P form the rhizosphere, primarily due to low availability, because it is one of the least available mineral nutrients in most of the cropping systems all over the world (Shenoy & Kalagudi, 2005). Its deficiency can reduce the crop yields up to 10-15% (Saleem, 1990; Gill *et al*., 2004; Shenoy & Kalagudi, 2005). Low level of soil P, less availability of P compounds and fixation of applied soluble sources of P are major hindrances in sustainable production of arable crops (Brady & Weil, 2002).

Availability and effectiveness of phosphorus to plants depends on many factors like pH, soil physico-chemical properties (Gupta *et al*., 1985), prevailing climate and soil organic matter (Fixen, 1990) and source of P fertilizer (Saleem, 1990; Blake *et al*., 2000). Degree of reduction in availability and absorption of P from different sources present in the soil depends on solubility of P in these sources, climate and presence of additional nutrients (Fried & Dean, 1952; Baker *et al*., 1970; Papadopoulos, 1985; Upadhyay *et al*., 1988). Thomas and Rengel (2002) observed that 28 days after sowing, growth of canola fertilized with Mono-ammonium phosphate (MAP) and Di-ammonium phosphate (DAP), was greater than those fertilized with Triple super phosphate (TSP) but movement of P was greater from DAP band possibly due to less fixation of P as a result of an increase in pH surrounding the DAP band that reduced the fixation of P with soil thus making it best suitable in P fixing soils. Other reason for better canola growth when fertilized with DAP than MAP may be the greater movement and availability of P and N from the DAP compared with MAP band. Some researchers

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(Ranjha & Mehdi, 1990; Suhog & Makhdoom, 1990; Gokmen & Sencar, 1999) have reported no differences among sources of P fertilizers (DAP, SSP & NP) on growth and yield of maize, wheat, rice and cotton.

Exploitation of differences in P acquisition and utilization among cultivars is a promising strategy to increase use efficiency of applied as well as native soil P (Aziz *et al*., 2005). Little is known about genotypic differences among *Brassica* spp. for their capacity to grow in soils with low P availability (Marschner *et al.,* 2007). Recently introduced high yielding canola hybrids have good genetic makeup but the test of their performance and adaptation to the new environment and response to P fertilizer needs immediate attention for realizing their full potential.

Little work has been done to understand the management of P and its impact on productivity of canola and quality of environment. Concerns related to the P fertilizer sources for canola warrant further studies for better understanding of role of P sources to develop improved approaches for P management. Hence, this study was undertaken to evaluate the canola performance as influenced by different sources of phosphorus.

## MATERIALS AND METHODS

**Site description.** The experiments were conducted during winter (October to April) seasons of 2004-05 and 2005-06 at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan (31°25′ lat. N; 73°09′ long. E, 185 m asl). The climate of the region is semi-arid subtropical, with minimum temperatures around 0°C in the winter and maximum temperature around 50°C in summer. Monthly average maximum and minimum temperature (°C) and rainfall (mm) data for the growing period during both the years are presented in Table I. Experimental soil belonged to Lyallpur soil series (aridisol-fine-silty, mixed, hyperthermic Ustalfic, Haplarged in USDA classification and Haplic Yerrmosols in FAO Classification. with the following average characteristics in 0-30 cm depth: 66% sand, 16% silt and 18% clay.

**Experimental details.** Before sowing the canola crop, soil samples were taken for physical and chemical analysis. Soil samples were collected from the experimental soil with the help of a soil auger to a depth of 0-30 cm prior to fertilizer application. Composite samples were air dried, ground and passed through a 2 mm sieve and got analyzed for the physico-chemical properties. Organic matter of the soil was 0.71%, pH 7.9, N 0.052%, available P 5.42 ppm and K 175 ppm.

Experiments were laid out in randomized complete block design with split plot arrangement and were replicated three times with net sub-plot size of 2.4 m x 5 m. Treatments comprised of two hybrids (Hyola-401 & Hyola-43) in main plots and different sources of P (MAP, SSP, DAP & NP) in sub plots. Before seedbed preparation, pre-soaking irrigation of 10 cm was applied. When soil reached to proper moisture level seedbed was prepared by cultivating the soil 2-3 times with tractor mounted cultivator each followed by planking. Crop was sown on October 11 and 08 and was harvested on April 7 and 10 in 2004-05 and 2005-06, respectively.

Sowing was done with the help of single row hand drill in 45 cm spaced rows using seed rate of 5 kg $ha^{-1}$ and an interplant distance of 15 cm was maintained by thinning at 4-6 leaf stage. Nitrogen fertilizer was applied @ 90 kg $ha^{-1}$. Half dose of N and full dose of P was applied at sowing, while remaining N was applied with first irrigation. All other agronomic practices were kept normal and uniform for all the treatments. Plant protection measures were adopted to keep the crop free from weeds, insect pests and diseases. Insecticide methamidophos was sprayed once 1 L $ha^{-1}$ for the control of aphids.

Crop was harvested when more than 50% siliquae were turned brown and was left in respective sub-plots for almost one week for sun-drying. Sun-dried crop was threshed manually 4-6 days after harvesting depending upon the intensity of sunlight. Seed and biomass yield from the whole plots were measured and converted into kg $ha^{-1}$. Five plants were randomly selected from each plot for recording average plant height per plant, number of branches per plant and number of siliquae per plant. Twenty five siliqua were randomly selected from these five plants to calculate average number of seeds per siliqua. Oil contents were determined by Soxhlet Fat Extraction method (AOAC, 1990). Protein contents of seeds were calculated by determining nitrogen contents using Kjeldahl method (Bremner, 1964).

**Statistical analysis.** All the data collected were statistically analyzed using computer package SAS 9.1 (SAS Institute, 2008) using the Fisher's analysis of variance technique and LSD test at 5% probability was used to compare the differences among treatments' means (Steel & Torrie, 1984). To determine the significance of treatments, least significant differences (LSD) were estimated at 5% probability level using Tukey's test.

## RESULTS

Significantly taller plants (174.16 cm) were recorded in 2004-05 as compared to 2005-06 (166.25 cm). Data regarding plant height (Table II) show that during both the years canola hybrids differed significantly for plant height where Hyola-43 produced taller plants (182.16 & 169.00 cm) than Hyola-401 (166.6 & 163.50 cm) in 2004-05 and 2005-06, respectively. Non-significant differences were found between two years for number of branches, while Hyola-43 had significantly more number of branches as against Hyola-401 (9.02 & 9.11) in 2004-05 and 2005-06, respectively.

Differences between years for number of siliquae per plant and hybrids were also found to be significant. Higher

**Table I. Weather data during the course of study**

| | Mean monthly temperature (°C) | | Mean monthly relative humidity (%) | | Total monthly rainfall (mm) | |
|---|---|---|---|---|---|---|
| **Months** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** |
| October | 25.48 | 27.06 | 54.00 | 44.20 | 0.80 | 10.00 |
| November | 21.65 | 20.83 | 60.10 | 50.50 | 9.00 | 0.00 |
| December | 16.66 | 14.58 | 61.00 | 52.00 | 2.00 | 0.00 |
| January | 13.12 | 13.54 | 67.50 | 58.10 | 32.80 | 8.20 |
| February | 14.92 | 20.28 | 67.70 | 67.07 | 35.10 | 14.60 |
| March | 21.55 | 21.00 | 56.40 | 46.97 | 48.60 | 37.0 |
| April | 26.61 | 25.00 | 35.00 | 35.13 | 10.80 | 0.00 |

Source: Agricultural Meteorology Cell, Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan

**Table II. Effect of canola hybrids on yield and yield components**

| Treatments | Plant height (cm) | | No. of branches per plant | | No. of siliquae per plant | | No. of seeds per siliqua | | 1000 seed weight (g) | | Seed yield (kg ha$^{-1}$) | | biological yield (kg ha$^{-1}$) | | harvest index (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** |
| Hyola-401 | 166.16b | 163.50b | 9.02b | 9.11b | 387.06b | 352.72b | 24.55b | 23.46b | 3.69b | 3.64b | 2405b | 2004b | 9452b | 9193b | 25.67 | 21.81b |
| Hyola-43 | 182.16a | 169.00a | 9.93a | 9.82a | 418.01a | 393.29a | 25.78a | 25.00a | 3.92a | 3.86a | 2585a | 2315a | 9840a | 9880a | 26.19 | 23.45a |
| LSD at 0.05 | 11.68 | 11.68 | 0.20 | 0.25 | 9.80 | 17.94 | 0.60 | 0.40 | 0.04 | 0.12 | 82.07 | 48.73 | 217.16 | 393.44 | NS | 0.88 |

**Table III. Effect of P fertilizers on yield and yield components**

| Treatments | Plant height (cm) | | No. of branches per plant | | No. of siliqua per plant | | No. of seeds per siliqua | | 1000 seed weight (g) | | Seed yield (kg ha$^{-1}$) | | biological yield (kg ha$^{-1}$) | | Harvest index (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** | **2004-05** | **2005-06** |
| MAP | 175.66 | 167.00 | 9.55 | 9.51 | 403.03 | 371.77 | 25.07 | 24.20 | 3.82 | 3.80 | 9665 | 9611 | 2488 | 2143 | 25.88 | 22.29 |
| SSP | 174.50 | 166.02 | 9.48 | 9.49 | 407.99 | 375.24 | 25.36 | 24.40 | 3.81 | 3.71 | 9591 | 9530 | 2506 | 2171 | 26.27 | 22.76 |
| DAP | 172.83 | 167.66 | 9.45 | 9.44 | 401.28 | 372.59 | 25.33 | 24.29 | 3.83 | 3.75 | 9745 | 9555 | 2505 | 2186 | 25.86 | 22.87 |
| NP | 173.66 | 164.31 | 9.41 | 9.42 | 397.84 | 372.43 | 24.91 | 24.03 | 3.78 | 3.74 | 9583 | 9450 | 2480 | 2136 | 25.72 | 22.62 |
| LSD at 0.05 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

number of siliquae per plant (402.53) were observed in 2004-05 as compared to 2005-06 (373.0), while Hyola-43 produced more number of siliquae per plant (418.01 & 393.29) than Hyola-401 (387.06 & 352.72) during 2004-05 and 2005-06.

Year means and hybrids showed significant differences between them for number of seeds per siliqua. More number of seeds was observed in 2004-05 (25.17) over 2005-06 (24.23), while higher number of seeds per siliqua was recorded in case of Hyola-43 (25.78 & 25.0) than Hyola-401 (24.55 & 25.0) in 2004-05 and 2005-06. Significantly higher 1000-seed weight was recorded in Hyola-43 (3.92 & 3.86 g) as compared to Hyola-401 (3.69 & 3.64 g) in 2004-05 and 2005-06, respectively while it was statistically same in both years. Similar trend was observed in case of biological yield where higher biological yield was recorded in case of Hyola-43 (9840 & 9880 kg ha$^{-1}$) as compared to Hyola-401 (9452 & 9193 kg ha$^{-1}$) in 2004-05 and 2005-06.

As far as seed yield is concerned significant differences were found between the years of study. Higher seed yield (2490 kg ha$^{-1}$) was observed in 2004-05 over 2005-06 (2159 kg ha$^{-1}$). Both the hybrids also showed significant differences for seed yield. Hyola -43 produced higher seed yield (2585 & 2315 kg ha$^{-1}$) over Hyola-401 (2405 & 2004 kg ha$^{-1}$) in 2004-05 and 2005-06, respectively. Higher value of harvest index (25.93%) was observed in 2004-05 over 2005-06 (22.63%) and differences were significant. Differences between hybrids were significant for harvest index only in 2005-06 where higher value of harvest index (23.45%) was recorded in case of Hyola-43 over Hyola-401 (21.81%).

Similar to seed yield and yield parameters, quality traits (Table IV) were also affected significantly. Hyola-43 produced more seed oil content (41.16 & 42.22%) as compared to Hyola-401 (39.79 & 39.90%) during 2004-05 and 2005-06. Differences between canola hybrids for protein content were found to be significant only in 2005-06. Higher value of protein content (23.45%) was recorded in Hyola-43 as compared to Hyola-401 (21.81%).

Sources of P fertilizers and interaction between sources of P and hybrids had non-significant impact on seed yield, yield parameters and quality traits of canola hybrids (Table III & Table V).

## DISCUSSION

The results indicate that only the hybrids are responsible for the variations in yield, yield components and oil quality of canola, while different sources of P behave similarly. Differences between canola hybrids confirm the general understanding that genotypes can express differential comparative productivity and are major modifiers of yield and oil quality (Leon *et al*., 2003; Zheljzkov *et al*., 2008). Seed oil content in present study was similar to previous reports (Cheema *et al*., 2001). Differences in oil content between canola hybrids can be attributed to the genotypic differences for translocation of dry matter to the seeds and on oil-filling pattern (Santonoceto *et al*., 2002). Similar to the present findings Aziz *et al*. (2006) also found significant differences in

**Table IV. Effect of canola hybrids on oil and protein content**

| | Oil content (%) | | Protein content (%) | |
|---|---|---|---|---|
| **Treatments** | **2004-05** | **2005-06** | **2004-05** | **2005-06** |
| Hyola-401 | 39.79b | 39.90b | 25.67 | 21.81b |
| Hyola-43 | 41.16a | 42.22a | 26.19 | 23.45a |
| LSD at 0.05 | 0.53 | 1.25 | NS | 0.88 |

**Table V. Effect of P fertilizers on oil and protein content**

| | Oil content (%) | | Protein content (%) | |
|---|---|---|---|---|
| **Treatments** | **2004-05** | **2005-06** | **2004-05** | **2005-06** |
| MAP | 40.45 | 41.32 | 25.20 | 24.36 |
| SSP | 40.65 | 40.91 | 25.20 | 24.81 |
| DAP | 40.43 | 41.24 | 25.20 | 24.48 |
| NP | 40.38 | 40.77 | 25.19 | 24.7 |
| LSD at 0.05 | NS | NS | NS | NS |

*brassica* cultivars and suggested differential adaptive mechanisms for P acquisition, utilization and translocation from roots towards shoots. Previous work on sources of P fertilizer shows inconsistent results. Most of the studies (Suhog & Makhdoom, 1990; Gokmen & Sencar, 1999; Aziz *et al*., 2006) have reported results similar to the present study, where different P fertilizers in various field crops showed non-significant results. However, Gupta *et al*. (1985) found that different sources of P fertilizer differ significantly and DAP gave better result than other sources possibly due to increased pH surrounding the DAP band that reduced the fixation of P with and greater movement and availability of P and N from the DAP compared with MAP band (Thomas & Rengel, 2002). Similarly, Upadhyay *et al*. (1988), while working on soybean reported better economic yield in case of SSP over DAP, possibly due to additional amount of sulphur in SSP which increased the availability of phosphorus. In another study, Papadopoulos (1985) reported yield differences in barley in response to different source of P fertilizer (DAP, MAP, TSP). DAP was more effective than TSP at lower P levels and least effective at higher P levels than MAP and TSP, possibly due to differences in Ca-phosphate precipitation. On the other hand some studies have also shown negative effect of DAP (Baker *et al*., 1970; Nyborg & Lopetinsky, 1972) on the yield of rapeseed due to poor germination and less plant population, which could be attributed to the release of ammonia around seed.

In conclusion, seed yield, oil and protein contents in canola differ due to genetic differences amongst hybrids. Different sources of P had no effect on the productivity and quality of canola. Hyola-43 produced higher seed yield, oil content and protein content than Hyola-401.

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