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Improving the Growth and Yield of Canola (*Brassica napus* L.) With Seed Treatment and Foliar Sprays of Brassica (*Brassica naups* L.) And Moringa (*Moringa olifera* L.) Leaf Extracts

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Abstract: A field trial to assess the role of brassica and moringa water extracts in increasing the growth and yield of canola was conducted at Agronomic Research Area, University of Agriculture Faisalabad Pakistan, during winter 2010-11. The experiment was laid out in Randomized Complete Block Design (RCBD). There were seven treatments that were replicated thrice. The net plot size was maintained at 2.7 × 5.0 m. All seeds except that of control treatment were soaked in 2% brassica, moringa and their combined solution for an hour as a seed treatment. The experimental treatments were comprised of two and three foliar sprays of 2% brassica, moringa and brassica + moringa at 15, 30 and 45 DAS respectively. The maximum seed yield (2942 kg ha^{-1}), biological yield (13721 kg ha^{-1}) and harvest index (21.44%) were given by T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS). The maximum number of siliques $plant^{-1}$ (394.18), number of seeds $silique^{-1}$ (28.93) and 1000-seed weight (4.63 g), were given by T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS). Similarly significantly higher leaf area indices, crop growth rates and net assimilation rate were also recorded by T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS).

Key words: Allelopathy · Foliar application · Nutrient supplements · Phytohormones · Seed yield

INTRODUCTION

The oil seed crops of Pakistan include rapeseed, mustard, linseed, sesame as well as castor which are grown in this region since immemorial times and are called traditional oil seed crops while sunflower, safflower, soybean were introduced in subcontinent by importing from other regions and are called non-traditional oil seed crops. In addition to these oil seed crops, three oil bearing trees olive, coconut and palm oil also sustain their presence in some agro-ecological zones of Pakistan. It is quite surprising to mention that Pakistan is unable to produce edible oil to meet its domestic edible oil demand of 2.78 million tons as out of total domestic oil requirement, local production is only 0.83 million tons [1]. Although among different oilseed crops of Pakistan, the share of rapeseed and mustards is 17% but the problem is that their oil quality is low because of the presence of erucic acid and glucosinolates [2]. Taste and flavor is reduced by erucic acid while nutritional disorder develops due to glucosinolates and goiters also develop due to this chemical [3]. These chemicals are present in canola in a very minute amount making it highly desirable edible oil. In Pakistan, canola was introduced in the start of 1985, but its yield of canola in Pakistan is only 15-46% of the potential [4]. Less edible oils production is due to number of factors including oil seed crops competition with cash and staple crops such as wheat as well as comparatively less returns. Lack of high yield producing production technology, post- harvest losses and less efficient extraction machinery are the major factors which contribute to low productivity of canola oil. In Pakistan, marketing system is full of flaws which promote the exploitation of local producers at the hands of importers who decline the market prices of canola as soon as the maturity period of oil seed crops sets in [5]. But most importantly, in Pakistan, along with other factors, imbalanced application and mismanagement of fertilizers reduce the yield of the crops. Fertilizers are applied in less than optimum amounts and if applied, these too in an

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imbalanced manner which reduce the yield of oil crops especially of canola. Thus in order to achieve yields according to potential and in order to achieve self- sufficiency in agriculture, nutrient management holds key importance [6]. By utilizing allelochemicals, crops yield can be increased to many folds and similar is the case of oil seed crops including canola. The results of allelochemical action can be traced at various levels of plant vital processes. Enzyme activation, enhanced cell division, more membrane permeability, increased ion uptake and increased plant growth and development are direct actions of allelochemicals [7]. Phytohormones are major component of oil and protein structure found to enhance both the yield and quality of oilseed crops [8]. Among different natural sources of phytohormones, moringa leaves have attained a prominent position among the scientific community because its leaves contain a substance known as zeatin. This substance can be used as a source of cytokinin [9]. Moringa is the sole genus of *Moringaceae* family. *Moringa oleifera* L. is widely distributed in the Pacific region, sub- tropical regions [10] and in West Africa [11]. The charisma of moringa leaf juice is a substance called zeatin which is natural plant hormone [12]. Brassica water extracts contain a substance known as brassinolide which is natural plant steroid [13]. The brassinosteroids are included in a unique class of natural plant growth regulators having the potential to enhance yield of a number of agronomic crops. They were originally discovered simultaneously in Japan and America, in "Isunoki," which is an evergreen tree and in pollen of canola (*Brassica napus* L.) [14]. Brassinolides are natural plant hormones that promote vegetative growth, enhance yields of grain crops as well as fruit crops while increase the plant potential to withstand drought and cold weather more effectively and efficiently [15, 16, 17]. Plants that cannot generate these substances become dwarf, thus are essential for normal growth and development of the plants if applied in small concentration and in higher concentration inhibit the growth of plants as that of weeds [18-21].

The present field study was designed with the dual objective of assessing the comparative efficacy of brassica and moringa water extracts along with their role in increasing canola performance in terms of growth and seed yield.

MATERIAL AND METHODS

Experimental Site and Design: To evaluate the comparative efficacy of brassica and moringa water extracts and their role in increasing canola growth and yield was conducted at Agronomic Research Area, University of Agriculture, Faisalabad (Latitude 31.26 °N, Longitude 73.06 °E) Pakistan, during winter 2010-11. Pre-sowing physico-chemical analysis of experimental site was conducted as shown in Table 1. Metrological data for temperature, relative humidity and rainfall were recorded during growing season of rice as shown in Fig. 1. The experiment was laid out in Randomized Complete Block Design (RCBD). There were seven treatments that were replicated thrice. The net plot size was maintained at 2.7 × 5.0 m (6 lines per plot). The 7 experimental treatments include a control (without using any spray) for comparison, two sprays of 2% brassica at 15 and 30 DAS, Three sprays of 2% brassica at 15, 30 and 45 DAS, Two sprays of 2% moringa at 15 and 30 DAS, Three sprays of 2% brassica at 15, 30 and 45 DAS, Two sprays of 2% brassica+ 2% moringa at 15 and 30 DAS, Three sprays of 2% brassica + % moringa at 15,30 and 45 DAS. The treatments were then designated as T_1, T_2, T_3, T_4, T_5, T_6 and T_7, respectively.

Table 1: Pre-sowing physico-chemical analysis of experimental soil from samples taken at 30 cm and 60 cm depth

Characteristics	Values	
Mechanical analysis	30 cm depth	60 cm depth
Sand %	62	61
Silt %	20	22
Clay %	18	18
Textural class	Sandy clay loam	Sandy clay loam
Chemical analysis		
pH	7.8	7.9
EC (dSm^{-1})	1.43	1.45
Organic matter (%)	0.64	0.67
Total Nitrogen (%)	0.057	0.058
Available Nitrogen (ppm)	6.54	6.43
Available potassium (ppm)	117	119

ppm= Parts per million

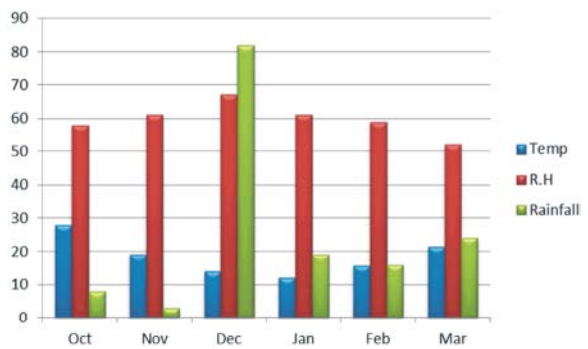

Fig 1: Mean monthly temperature (°C), relative humidity (%) and rainfall (mm) during the crop growing season.

Crop Husbandry: All seeds except that of control treatment were soaked in 2% brassica, moringa and their combine solution for one hour and allowed to shade drying before sowing. The crop was sown on a well prepared seed bed on 18th of October 2010. Canola (cv. Punjab Sarsoon) was sown in 45 cm apart rows. DAP and urea were used as a source of phosphorous and nitrogen. DAP was applied @ 60 kg ha-1 at the time of sowing as a whole.

While urea fertilizer was applied @ 90 kg ha-1 in two equal splits. First split was applied at the time of sowing and the remaining was sprayed when first irrigation was applied. Insecticide Methamidophos @ 1 liter ha^{-1} was sprayed once for the aphid control. All other practices were kept same and uniform for all treatments.

Brassica Water Extract Preparation Protocol: Allelopathic water extract of brassica was prepared by following the method of Cheema and Khaliq [22]. Herbage (stem and leaves) of brassica crop were harvested at maturity; dried for a couple of days under shade and then chopped into 2 cm pieces with the help of electric fodder cutter. This chopped material was soaked in water in a ratio of 1:10 (w/v) for 24 hours. This soaked material was filtered by passing through sieves. The filtrates were boiled at 100°C for reducing the volume by 20 times. The concentrated water extract was stored at room temperature for future use.

Bioassay for Moringa Leaf Juice Preparation: Moringa leaf extract (MLE) was prepared by collecting young and disease free leaves from moringa tree. Theses leaves were washed and then frozen for two days in refrigerator at 4°C. Leaves were grinded in a manual juicer to extract the leaf juice. The juice was collected and filtered by passing through a muslin cloth to remove all the green matter. After that the extract was stored at room temperature. All foliar sprays were applied with the help of knap sack sprayer after calibration.

Data Collection: All parameters were taken by following standard procedures and techniques. Plant leaf area was measured with the help of digital leaf area meter (Model CI203, CID Bioscience, USA) and leaf area indices of canola at 30, 45, 60 and 75 days after sowing were calculated as suggested by Hunt [23].

LAI= Crop Leaf area (m^2) / Land area (m^2)

Crop growth rate (CGR) was recorded four times as suggested by Hunt [23].

$$CGR = W_2 - W_1 / T_2 - T_1 \ (g\ m^{-2}\ d^{-1})$$

Where W_2 and W_1 are the dry weights of first and second harvest at times T_2 and T_1 respectively.

Net assimilation rate (NAR) was calculated during 30-45, 45-60, 60-75 and 75-90 days after sowing by formula given by Hunt [23].

$$NAR = TDM / LAD \ (g\ m^{-2}\ d^{-1})$$

Where TDM= Total dry matter accumulated at harvest and LAD= Leaf area duration

Harvest index (HI) was calculated as suggested by Hunt [23].

HI= Grain yield / Biological yield × 100

Statistical Analysis: Data collected were analyzed statistically using MSTAT-C, a computer package for statistical analysis [24] and difference among treatments means were compared by employing least significant difference (LSD) test at 5% probability level [25].

RESULTS AND DISCUSSION

Leaf Area Indices (LAI): Leaf area index is a key attribute of plant canopies and reflects the size and capacity of assimilatory system of crops as leaves are the most dominant photo-synthetically active tissues in plant canopies. The maximum leaf area indices of 1.93, 2.76, 3.86 and 3.97 at 30, 45 and 60 days after sowing respectively, were recorded in plots that were treated with three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS (T_7) and it was followed by T_6 (Two sprays of 2% brassica + 2% moringa at 15 and 30 DAS) as shown in Fig. 2. All foliar sprays increased canola yield as compared to

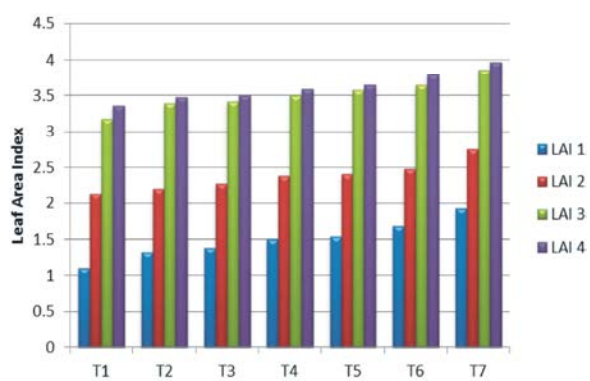

Fig 2: Leaf area indices of canola taken at 30, 45, 60 and 75 DAS as affected by foliar sprays of brassica and moringa.

control treatment but they were much less significant than T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 days after sowing). This increase in leaf area indices was probably due to more vegetative growth as a result of robust photosynthesis. Other factors that might had contributed to more leaf area indices were the presence of zeatin, brassinolide and other phytohormones along with several micronutrients in brassica and moringa leaf juice. These findings are in complete confirmation with Munoz *et al.* [26], Yasmeen *et al.* [27], Ambler *et al.* [28] and Anuradha [29] who reported more robust growth and development of plants with application of zeatin and brassinolide.

Crop Growth Rate (CGR): Crop growth rate depicts the rate of accumulation of dry matter and is closely associated with crop leafa area because leaves are the solar radiation capturing units. As Figure 3 showed that all foliar sprays incresed the crop growth rates but the maximum crop growth rates of 4.98, 5.25, 7.01 and 3.94 ($gm^{-2}d^{-1}$) during 30-45, 45-60, 60-75 and 75-90 DAS respectively were given by T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS) and it was followed by T_6 (Two sprays of 2% brassica + 2% moringa at 15 and 30 DAS). More crop growth rates were recorded upto75 days after sowing but after 75 days there was much less crop growth rate. More crop growth rate was might be due extensive growth of leaves both in terms of number as well as size. Zeatin, cytokinin and other micronutrients present in moringa leaf juice and brassinosteroids present in brassica water extracts might have played their promoting effect on the growth and development of canola. These results are in accordance with Anuradha *et al.* [30], Cheikh and Jones [31], Einhellig [32], Phiri [33] and Fariduddin *et al.* [34], who reported more crop growth rates of different crops with application of zeatin and brassinolide.

Net Assimilation Rate (NAR): The net assimilation rate of a crop represents the net photosynthetic production per unit leaf area duration. The maximum net assimilation rate of 2.87 ($gm^{-2}d^{-1}$) was recorded by T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS) and it was followed by T_6 (Two sprays of 2% brassica + 2% moringa at 15 and 30 DAS) which gave 2.76 87 ($gm^{-2}d^{-1}$). This significantly higher net assimilation rate was probably due to more number and vigorous growth of leaves which accelerated the photosynthetic process and in turn there was more crop growth rate and resultantly significantly higher net assimilation rate was

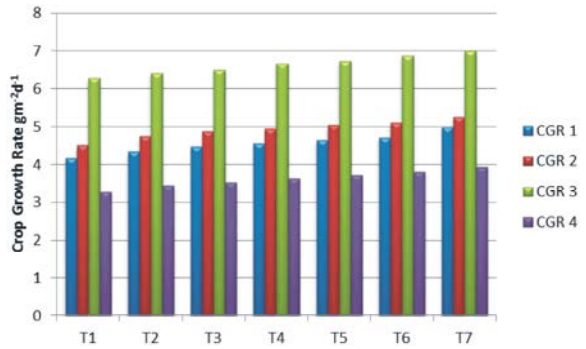

Fig 3: Crop growth rate ($gm^{-2}d^{-1}$) of canola during 30-45, 45-60, 60-75 and 75-90 DAS as affected by foliar sprays of brassica and moringa.

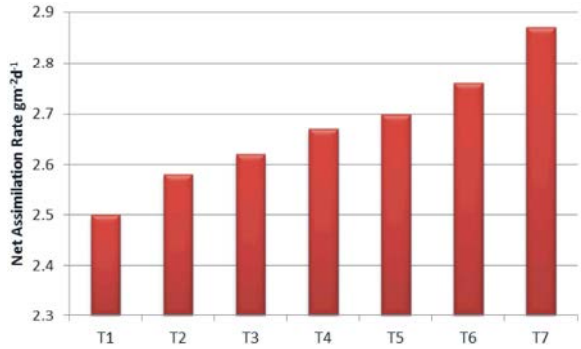

Fig 4: Net assimilation rate ($gm^{-2}d^{-1}$) of canola as affected by foliar sprays of brassica and moringa.

observed. These findings are in line with Iqbal *et al.* [35], Kato *et al.* [36], who recorded more photosynthetic production as a result of exogenous application of phytohormones.

Number of Siliques per Plant, Number of Seeds per Silique and 1000 Seed Weight: The number of siliques per plant, number of seeds per silique and 1000-seed weight are key indicators of final seed yield of canola. The maximum number of siliques per plant (394.18), number of seeds per silique (28.93) and 1000-seed weight (4.63 g) were given by T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS) and it was followed by T_6 (Two sprays of 2% brassica + 2% moringa at 15 and 30 DAS) (Table 2). Other foliar sprays also increased the number of siliques per plant, number of seeds per silique and 1000-seed weight of canola as compared to control treatment but those were much less significant than T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS). As there were more crop growth rates and net assimilation rate which resulted in better reproductive growth of canola and significantly higher number of

Table 2: Number of siliques per plant, number of seeds per silique and 1000 seed grain weight (g) of canola as affected by foliar sprays of brassica and moringa.

Treatments	No. of Silques Plant^{-1}	No. of Seeds Silique^{-1}	1000-Seed Weight (g)
T_1= Control	316.24 F	17.68 F	3.91 G
T_2= Two sprays of 2% brassica at 15 and 30 days after sowing	334.52 E	19.24 DE	4.06 F
T_3= Three sprays of 2% brassica at 15, 30 and 45 days after sowing	349 CD	20.79 D	4.19 E
T_4= Two sprays of 2% moringa at 15 and 30 days after sowing	360.79 C	21.03 D	4.33 D
T_5= Three sprays of 2% moringa at 15, 30 and 45 days after sowing	372.38 BC	23.76 C	4.46 C
T_6= Two sprays of 2% brassica + 2% moringa at 15 and 30 days after sowing	381.46 B	25.61 B	4.51 B
T_7= Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 days after sowing	394.18 A	28.93 A	4.63 A

Table 3: Seed yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) of canola as affected by foliar sprays of brassica and moringa.

Treatments	Seed Yield (Kg ha^{-1})	Biological Yield (Kg ha^{-1})	Harvest Index (%)
T_1= Control	2697 F	13176 G	20.46 E
T_2= Two sprays of 2% brassica at 15 and 30 days after sowing	2739 E	13287 F	20.61 D
T_3= Three sprays of 2% brassica at 15, 30 and 45 days after sowing	2751 D	13327 E	20.64 D
T_4= Two sprays of 2% moringa at 15 and 30 days after sowing	2787 C	13412 D	20.77 CD
T_5= Three sprays of 2% moringa at 15, 30 and 45 days after sowing	2812 BC	13489 C	20.80 C
T_6= Two sprays of 2% brassica + 2% moringa at 15 and 30 days after sowing	2866 B	13514 B	21.20 B
T_7= Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 days after sowing	2942 A	13721 A	21.44 A

siliques per plant, number of seeds per silique and 1000-seed weight were observed with application of phtyhormones present in brassica and moringa water extracts. These findings are in line with Ella and Zapata [37], who reported more seed production due to vigorous vegetative growth of crops as a result of exogenous application of phytohormones.

Seed Yield, Biological Yield and Harvest Index: The maximum seed yield (2942 kg ha^{-1}), biological yield (13721 kg ha^{-1}) and harvest index (21.44%) were given by plots that were treated with three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS (T_7) and following the pattern it was followed by T_6 (Two sprays of 2% brassica + 2% moringa at 15 and 30 DAS), while all other treatments were much significantly less than T_7 (Three sprays of 2% brassica + 2% moringa at 15, 30 and 45 DAS) as depicted in Table 3. Zeatin, brassinolide and micronutrients resulted in more vigorous vegetative growth, significantly higher leaf area indices, crop growth rate and net assimilation rate and ultimately much higher seed yield and biological yield was obtained. These finding are in agreement with Phiri and Mbewe [38] and Qayyum *et al.* [39], who reported more yield and harvest index of a variety of oil seed and other cereal crops with exogenous application of phytohormones especially zeatin and brassinosteroids.

CONCLUSION

On the basis of this field trial, it can be concluded that foliar application of 2% moringa and brassica water extracts at 15 days interval has the capacity to give 10% more canola yield and that too in a cheap and economical way, particularly in the wake of skyrocketing prices of inorganic fertilizers. These allelochemicals are quite economical and environmental friendly with no hazardous effects as that of inorganic fertilizers and will be an excellent mean to fill the plant nutrition gape in times to come with prevalence of organic food.

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