▼ Journal of Research (Science), Bahauddin Zakariya University, Multan, Pakistan.
Vol.14, No.2, December 2003, pp. 177-186 ISSN 1021-1012

INTRA-SPECIFIC VARIABILITY IN SESAME (*SESAMUN INDICUM* L.) FOR VARIOUS QUANTITATIVE AND QUALITATIVE ATTRIBUTES UNDER DIFFERENTIAL SALT REGIMES

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Abstract: Salt tolerance of four sesame cultivars; Faisalabad Black, Pb-90-93, Pb-T-90 and T-S-3 was assessed at germination and later growth stages. Seed germination and vegetative growth were evaluated in response to five salinity levels of NaCl and Na_2SO_4 while yield experiment was conducted using three concentrations of these salts. The cultivars differed in their sensitivities to these salts for germination and seedling development. T-S-3 emerged as a sensitive cultivar at the germination stage. Likewise, Pb-90-93 produced lower fresh and dry seedling biomass in response to salinity regimes. However, Faisalabad Black exhibited higher germination and produced greater dry biomass of seedlings. Plant height, leaf growth and flowering appeared to be sensitive parameters to salt stress. A considerable degree of variability was found between cultivars for quantitative and qualitative traits. In general, the responses of Pb-T- 90 and Pb-90-93 were intermediate while T-S-3 appeared to be more prone to salinity for yield attributes. Faisalabad Black sustained growth, yield and qualitative traits under varying salt regimes and revealed a consistent degree of salt tolerance with time course changes in growth. The study affirmed that individuals who can withstand prevailing stress at early growth stages could certainly produce tolerant adult plants.

Keywords: chloride, growth, salinity, *Sesamun indicum,* sulphate, yield.

INTRODUCTION

Salinity has a critical influence on plant establishment and crop productivity in arid and semi-arid regions [Munns 2002]. Large areas in Pakistan are also beset with this problem where salinity is causing substantial crop losses [Khan and Ungar 1998]. High concentrations of salts have multiple adverse effects on morphology, qualitative and quantitative traits of crop plants [Ashraf 1994]. Therefore, it is imperative that salt tolerant high yielding crop plants should be identified for the utilization of salt affected areas.

Sesame (*Sesamun indicum* L.) is an important oil seed crop whose average seed oil contents are about 50% as compared to soybean and mustard oil, which contain 20% and 40% oil respectively. The sesame oil is of better quality and is mostly utilized for ghee making [Yermonas *et al.* 1972]. This crop can tolerate moderately saline soils [Yousif *et al.* 1972]. Therefore, identification and selection of the most salt tolerant cultivar of the species would be of immense value for agriculture.

Salinity tolerance of the species was assessed using NaCl and Na_2SO_4 because saline soils are mostly dominated by sodium, chloride and sulphate ions. This study reports intra-specific differences for various quantitative and qualitative parameters as these attributes are major

focuses of plant scientists for evaluating salt tolerance in crop plants [Afiah *et al.* 1999].

MATERIALS AND METHODS

GERMINATION

Seeds of four sesame cultivars; Faisalabad Black, Pb-90-93, Pb-T-90 and T-S-3 were obtained from Ayub Agriculture Research Institute, Faisal-abad. Thirty surface sterilized seeds were placed in each of 120 plastic Petri dishes containing filter paper (Whatmann No. 1). Five salt concentrations 0 (control), 30, 60, 90, 120 m mol L^{-1} were prepared for both NaCl and Na_2SO_4. Three replicates were made for each treatment and experiment was completely randomized. 5ml of appropriate treatment solution was applied daily to labeled Petri dishes after rinsing out the previous solution. The experiment was conducted in a germination chamber at 25±3 ^oC and observations were recorded for 10 days.

SEEDLING

These experiments were conducted in a wire netting greenhouse at the Botanical Gardens, Bahauddin Zakariya University, Multan, Pakistan. 120 plastic buckets (20cm internal diameter) were filled with 2.5 kg of sandy loam soil. The experiment was laid out in randomized block design, with three blocks, each containing four cultivars and five treatments for each salt. Six seedlings (pre-germinated) were randomly chosen for each cultivar and transplanted equidistant into these pots. The salt concentrations were 0 (control), 30, 60, 90, 120 m mol L^{-1} for NaCl and Na_2SO_4. 1.5 L of treatment solution was applied to each pot. All pots were weighed and salinity levels were maintained by weighing each pot on alternate day and water loss was made up. The experiment was terminated after 6 weeks when whole plants were taken out from pots. Shoots and roots were separated carefully and placed in labeled paper bags. Fresh biomass of all the samples was taken and plant material was then dried at 70 ^oC for three days for dry weight measurements. Percentage moisture content per plant was determined on fresh weight basis.

GROWTH AND YIELD

Growth and yield were assessed at three levels (0, 60 and 120 m mol L^{-1}) of both salts. The plants were allowed to grow for 16 weeks until fruiting then data for plant height and leaves were taken for each plant. During the course of experiment, flowers produced by each plant were also recorded and expressed as mean values. Plants were harvested at fruiting stage when most of the capsules were green.

Yield attributes i.e., seed weight (g $plant^{-1}$) and 1000-seed weight, were evaluated in addition to total seed protein and percentage oil content. Nitrogen analysis of seed samples was carried out following Black [1965]

and total protein content was calculated by multiplying N content with a factor 6.25 while, percentage oil content was estimated by organic solvent extraction [Jayaraman 1981].

DATA ANALYSIS

Data for all parameters were expressed as mean values. Data expressed as percentages were arcsin transformed for statistical analysis. A two-way analysis of variance (ANOVA) was carried out using EXCEL 2000 in order to reveal significant effect of salt treatments on cultivars as well as to elucidate intra-specific differences.

RESULTS

GERMINATION AND EARLY VEGETATIVE GROWTH

Increasing concentrations of both salts had adversely ($P < 0.001$) affected seed germination (Table 1). Faisalabad Black showed higher germination percentage than the other three cultivars at elevated salinity levels. On the other hand, T-S-3 exhibited the lowest germination at the higher salt concentrations of both salts (Fig. 1).

Table 1: Analysis of variance (mean squares) for various attributes in four cultivars of s*esamun indicum* when grown at varying levels of NaCl and $Na_2 SO_4$

	NaCl			$Na_2 SO_4$		
Attributes	MS_T	MS_C	MS_I	MS_T	MS_C	MS_I
Germination	1198.80 ***	302.40*	195 ns	7992.40 ***	203.50 ns	167.30 ns
Fresh weight	143456***	98875***	72211***	114281 ***	89762 ***	22110 **
Dry weight	26482 ***	19569***	14466***	18468***	12996 ***	6098***
Water content	74.90**	46.20 ns	52.90 **	90.70 **	87.10 *	71.20 **
Plant height	1780.054 ***	32.66 ***	174.2 ***	3282.36 *	56.03 ***	76.75 *
Number of leaves	633.15***	46.62 ***	76.69 ***	1276.63 **	43.84 ***	94.23 **
Number of flowers	171.18 ***	36.43 ***	73.81***	326.36 ***	49.29 ***	22.42 *
Seed weight	95.95 *	10.48*	1.75 ns	92.81*	7.24*	1.09 ns
1000 seed weight	2.94 ns	1.41 ns	0.59 ns	3.88*	1.99 ns	0.18 ns
Total protein	123.86 ***	7.94 ***	20.10***	28.16 ***	56.21 ***	9.06 ***
Oil contents	621.42***	117.32***	83.77***	1389.88 ***	85.85 ***	31.44 ***

*, **, *** = significant at 0.05, 0.01 and 0.001 levels of probabilities, respectively. ns= non significant. MS_T, MS_C, and MS_I = treatment, cultivar and interaction mean squares, respectively.

Fresh biomass decreased markedly in cultivars in response to differential salt stress levels. However, T-S-3 showed significantly ($p < 0.05$) greater fresh biomass and Faisalabad Black produced greater dry biomass at the highest salinity regime (Fig. 1). A considerable ($p < 0.001$) decline in seedling biomass and highly significant ($p < 0.01$) intra-specific differences were observed for both salts (Table 1). Similarly, a highly significant cultivar x treatment interaction was observed for biomass production ($P < 0.001$ for NaCl and $P < 0.01$ for Na_2SO_4). A marked reduction in plant water contents ($P < 0.01$) was observed but cultivars varied for Na_2SO_4 applications. Overall plant water contents were higher in Faisalabad Black than the other cultivars at all salinity levels of both salts (Fig. 1).

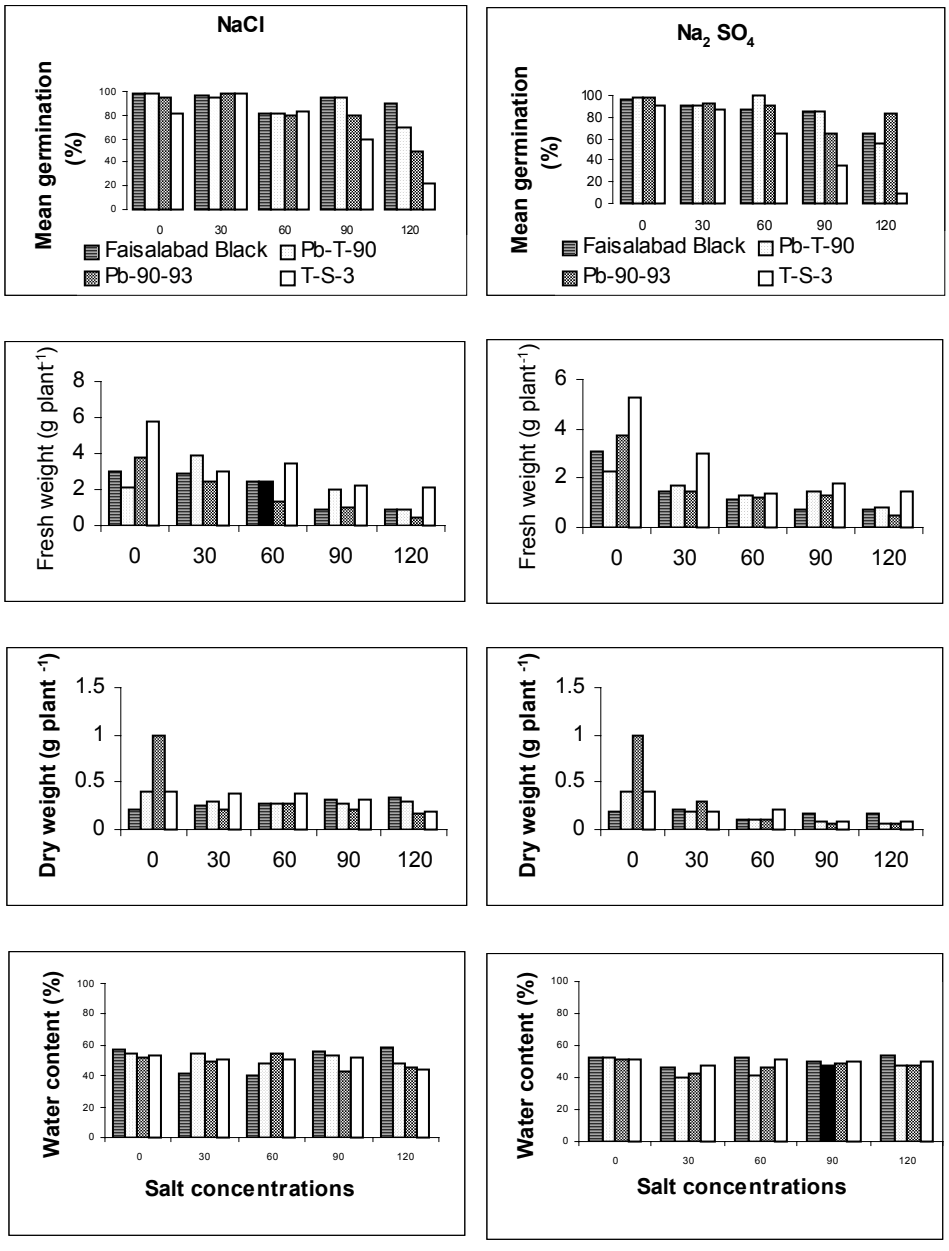

Fig. 1: Mean values for various attributes in four cultivrs of *sesamun indicum* when grown at varying levels of NaCl and Na_2SO_4.

PLANT HEIGHT

Overall mean plant height was not adversely affected by the application of salt treatment up to 60 m mol L^{-1} whereas the highest salinity regimes of NaCl and Na_2SO_4 had caused a profound effect on plant height (Fig. 2) The highest mean was observed for Faisalabad Black at 120 m mol L^{-1} of

salt stress. Table 1 revealed significant differences between treatments and cultivars.

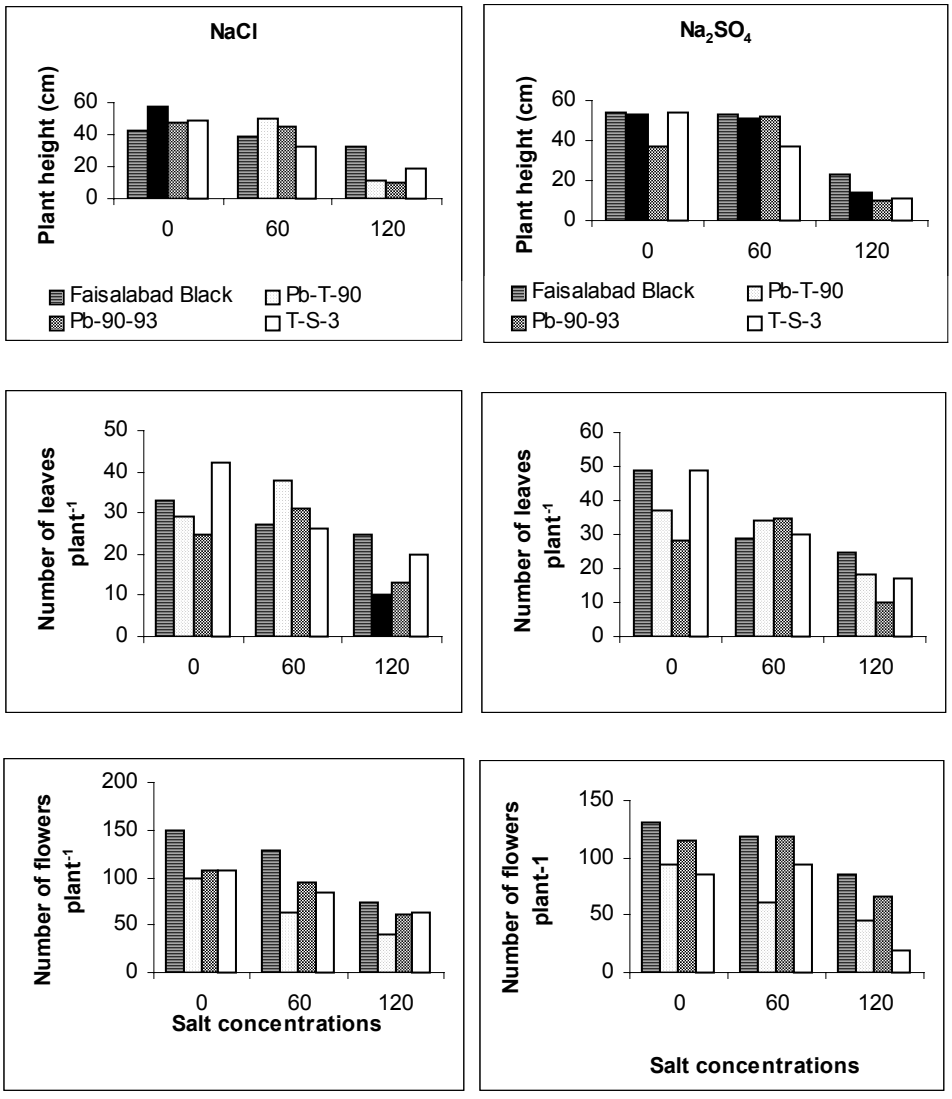

Fig. 2: Mean values for growth attributes in four cultivrs of *sesamun indicum* when grown at varying levels of NaCl and Na_2SO_4.

NUMBER OF LEAVES PER PLANT

Varying levels of NaCl and Na_2SO_4 had significantly reduced the number of leaves per plant in all four cultivars. Significant ($p< 0.001$) differences between cultivars and treatments are evident from Table 1. Faisalabad Black excelled in the leaf production from all other cultivars when grown at the highest salinity regime of both salts. Pb-T-90 exhibited its sensitivity

to NaCl while Pb-90-93 produced the lowest leaf number in response to Na_2SO_4 at the highest salt treatment (Fig. 2).

NUMBER OF FLOWERS PER PLANT

Although, flower formation was significantly lower in cultivars but Faisalabad Black and Pb-90-93 consistently produced greater number of flowers under varying salt stress. Analysis of variance (Table 1) revealed significant adverse effects of increasing salt concentrations ($p<0.001$) as well as marked intra-specific variability for this attribute.

SEEDS WEIGHT

Faisalabad Black produced significantly ($p< 0.05$) greater seed weight than the other cultivars (Fig. 3) after receiving salt treatments. On the other hand, poor yield was observed in Pb-90-93 in response to both NaCl and Na_2SO_4. Significant inhibitory effects of salinity on seed weight and at the same time differential responses of cultivars are evident from Table 1.

1000-SEED WEIGHT

A decrease in yield component is obvious from Fig 3. The reduction in yield was more profound at 120 m mol L^{-1} of both salts. However, Faisalabad Black consistently showed better yield component under both salts. Pb-90-93 and T-S-3 in exhibited poor yield at the highest salt regime but variable responses of cultivars in relation to differential salt stress were found to be non significant (Table 1).

TOTAL SEED PROTEIN

Seed proteins increased in Faisalabad Black, Pb-T-90 and Pb-90-93 when grown at the highest salt concentrations of both salts (Fig. 3). However, T-S-3 did not show any increase under differential salt stress. By contrast, Pb-90-93 showed higher protein contents when given a lower level of Na_2SO_4. Table 1 revealed a significant ($p< 0.001$) influence of salts on the amount of seed protein as well as distinct responses of cultivars.

OIL CONTENT

The reduction in oil content was particularly marked at the highest salt stress in all cultivars (Fig. 3). The cultivars were found to be significantly variable ($p< 0.001$). Pb-90-93 under NaCl and Faisalabad Black under Na_2SO_4 yielded about 45% and 30% oil, respectively at 120 m mol L^{-1} as shown in Fig. 3.

DISCUSSION

Successful selection of salt tolerant plants essentially requires the assessment of variability in relation to differential salt stress because

plants differ in their abilities to resist to different ions. Furthermore, salt tolerance is a feature that varies with stages of plant growth. Thus, differential salt tolerance and consistency at various growth stages become a critical aspect for intra-specific selection where germination, growth and yield attributes are important expressions that signify salt tolerance.

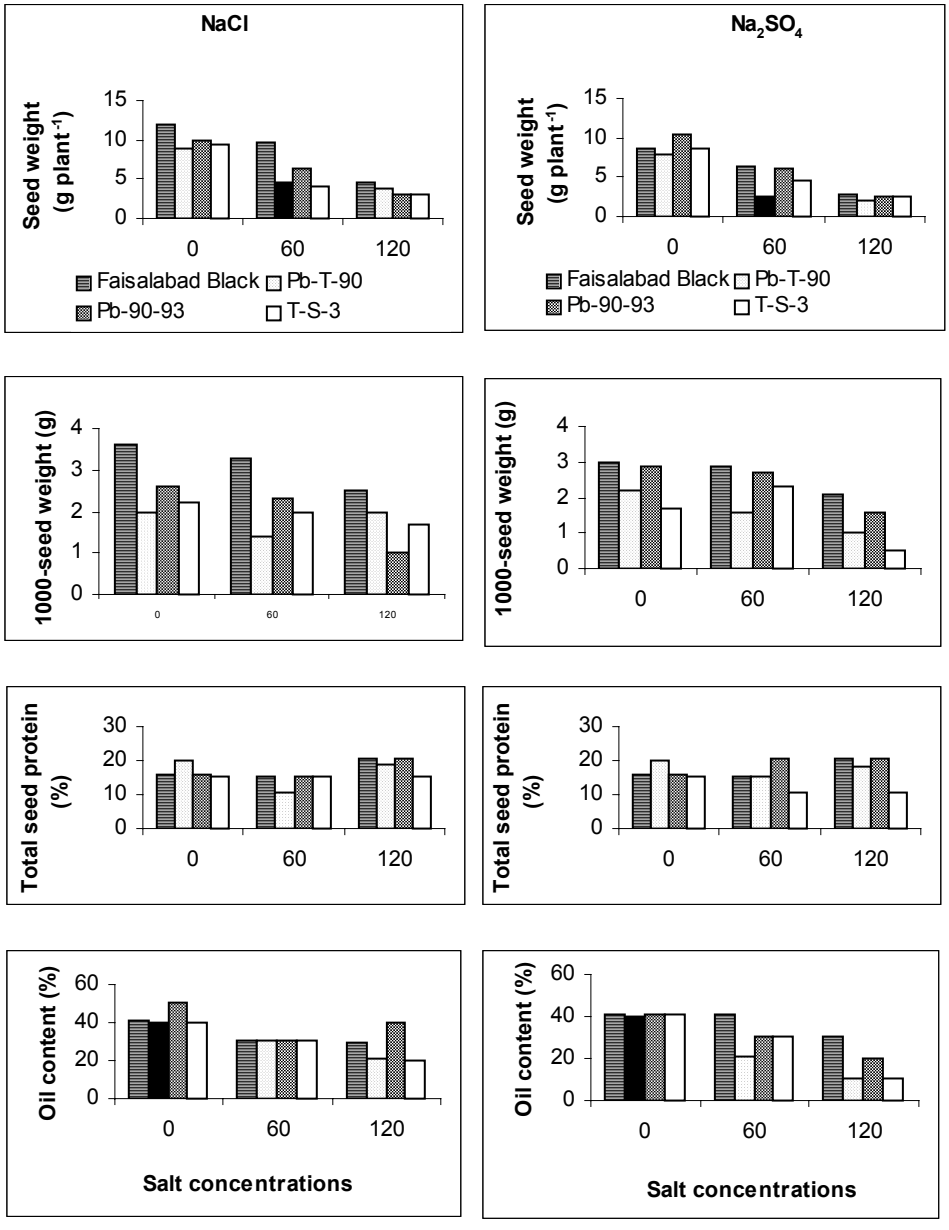

Fig. 3: Mean values for yield and qualitative attributes in four cultivrs of *sesamun indicum* when grown at varying levels of NaCl and Na_2SO_4.

The successful germination determines the subsequent establishment of plants and is of prime importance in the appraisal of salt tolerance of a crop [Katembe *et al.* 1998]. The observations reported here depicted intra-specific differences in response to two salts at germination stage. The combination of results for both salts suggested that Faisalabad Black had considerable salinity tolerance at germination stage. The cultivar T-S-3 appeared to be sensitive while, Pb-90-93 showed varying degree of germination tolerance in response to differential salt stress. In general, in sesame potential for salt tolerance seem to exist at germination stage like other oil seed crops [Shekari *et al.* 2000].

The greater fresh biomass production by T-S-3 under both salts suggested its ability to maintain water uptake under saline conditions. However, consistent tolerance cannot be established between germination and seedling growth for this cultivar. Thus, an inconsistent variation pattern at early growth stages is not surprising and is well reported for other species [Matsurma *et al.* 1998].

Dry biomass production can be used as a predictor for net carbon assimilation. Faisalabad Black sustained its growth at varying concentrations of Na_2SO_4 while dry biomass was significantly influenced by NaCl. Thus, differential salt stress seems to alter the same response. These observations are in close conformity to Botia *et al*. [1998] who reported considerable variability for same attributes in *Cucumis* cultivars in relation to differential salt stress.

Lower levels of both salts had caused growth enhancement in plants. Ng [1987] and Salim [1988] also indicated growth improvement at lower salinity levels. However, plant height and leaf formation dropped significantly in cultivars of *S. indicum* at the highest salinity regimes. Faisalabad black exhibited consistently greater mean values for various attributes and the degree of salt tolerance seems not to vary with stages of plant development. Our result supported the findings of Ashraf [1994] who emphasized that consistent tolerance at various developmental stages is crucial and provides a successful selection criterion.

Sodium, sulphate, and chloride ions have posed a critically influence on flowering thus floral inhibition in relation to salinity was observed in cultivars. These observations are in lines with those of Jeschke *et al*. [1992] and Channan [1999] who demonstrated complex effects of ions on floral induction.

Quantitative traits undoubtedly are of great importance while considering the crop yield. Hence, inter/intra specific selection for better crop yield in addition to salt tolerance can certainly be of great value. Yield and its component (1000-seed weight) were significantly lower in cultivars in response to the highest salt stress. However, Faisalabad Black maintained its tolerance for yield attributes. Thus, consistent salt tolerance of Faisalabad Black at different growth stages is evident from this study. These findings suggested that young tolerant plants facilitate

the selection of highly tolerant adult plants for yield purposes and supported other studies [Nobel *et al*. 1984, Blum 1985] although reduction in yield under prevailing stress is well reported [Sharma and Gill 1992].
Similarly, the oil and proteins are important quality attributes in sesame because it is primarily grown for its edible oil, the meal that remains after oil extraction has value as a source of protein for the livestock. Our results indicated a significant reduction in these attributes. A progressive decrease in amino acids, proteins and oil is well documented for salinity stress [Belkhodja and Saadi 1993, Natra *et al*. 1995] but greater protein and oil accumulation in Faisalabad Black can be related to the steady maintenance protein and fatty acid biosynthesis in saline environment. Yanyou *et al*. [1998] and Torre-Schumann *et al*. [1992] also reported sustainable synthesis of proteins and oils in salt tolerant crops.

CONCLUSIONS

Based on the attributes studied during this investigation, it can be concluded that a fair degree of intra-specific variability exists in *S. indicum* for salt tolerance. It was affirmed from this study that salt tolerance should not vary with the stages of plant development. Furthermore, tolerant plants at early growth stages would undoubtedly provide tolerant adults. The study revealed that Faisalabad Black sustained its growth and maintained qualitative traits under saline environment and showed a considerable potential for salt tolerance.

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