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Variation in morpho-physiological characters of four lentil genotypes of Bangladesh

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ABSTRACT

Morpho-physiological growth analysis is very important for the study of growth, development and yield of a crop. In order to study the growth indices and yield performance of lentil field experiments were carried out at two locations (Sub-stations viz. Magura and Ishurdi) of Bangladesh Institute of Nuclear Agriculture (BINA) with two varieties (Binamasur-3 and Binamasur-4) and two mutants (N_4I-404 and E_4I-925) of lentil during rabi season (November–March) 2014. Experiments were laid out in a randomized complete block design (RCBD) with three replications. Growth parameters, physiological data and yield components were evaluated following standard formula and software. At both locations, absolute growth rate (AGR) was higher in mutantline E_4I-925 at 75 DAS (days after sowing). The relative growth rate (RGR) was also found higher in mutant E_4I-925 at 60 DAS followed by mutant line N_4I-404. Total dry matter (TDM) was higher in mutants than varieties at both the locations at final harvest. For both the locations the highest TDM accumulation was also observed in mutant line E_4I-925. Seed size was higher in mutants and the mutant line E_4I-925 showed the highest seed weight plant^{-1} at both the locations (2.1 kg ha^{-1} at Magura; 2.3 kg ha^{-1} at Ishurdi). Regression analysis confirmed that all the morphological and physiological parameters were positively correlated with yield. On the basis of morpho-physiological characteristics the mutant line E_4I-925 was found superior among four genotypes of lentil.

Keywords: Growth parameters, drymatter, yield components, yield, lentil

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1 Introduction

Lentil (*Lens culinaris* Medik) had been in the second position among pulses according to area and production (BBS, 2010) in Bangladesh for long time. But this scenario has recently changed and lentil acquired the first place (BBS, 2016) for consumer's preference due to its balanced and high food quality especially protein content, palatability and easy digestibility (Tanner, 2016). Although Bangladesh ranks 3rd among lentil growing countries of the Asia Pacific region, domestic pulse production can't satisfy the country's demands and therefore she needs to import some 489375 metric tons of lentil at a cost of about 4.45 crore Taka (BBS, 2016) mostly from Australia, Nepal, Turkey and Canada. Globally, it is cultivated as a rainfed crop on 3.85 million hectares area with 3.59 million tons production (Kumar et al., 2013). In Bangladesh, it is grown in 154655 ha of land producing 158228 metric tons of grain with an average yield of 1023 kg ha^{-1} and contributing about 42% to the total pulses production. To improve lentil production international endeavors have been promising in some cases (Erskine, 1998) but it is not the case everywhere. In South Asia, the yield of lentil remains low and average seed yield on a country basis is below 1.0 t ha^{-1} (SAIC, 2009). Further, the area under lentil cultivation in South Asia has been decreasing at a faster rate because of increasing demand for staple grains like rice and wheat (Rahman and Ali, 2011). The average yield of existing local lentil varieties is very poor in Bangladesh. Through introduction of high yielding genotypes, development of new varieties/hybrids through hybridization or mutation breeding techniques and adoption of improved management practices the different research institutes of Bangladesh are trying to increase lentil production to save forex and at the same time to meet the food and nutritional demand of the nation.

Like other leguminous crops, lentil increases soil fertility by fixing atmospheric nitrogen (150.19 kg ha^{-1} $year^{-1}$) to the soil (Rennie and Dubetz, 1986) and hence plays an important role in cropping systems. The main production constraints to the lentil crop in Bangladesh are low yield potential, susceptibility to diseases, delayed sowing, and drought and weed infestation (Rashid et al., 2007; Ahad et al., 2012). The lack of genetic variability in local germplasms is the main hindrance of lentil improvement (Sarker et al., 1991) in Bangladesh. Through mutation breeding technique variability can be created in genomic level which can sustain generation after generation and may enhance the crop yield and quality as well.

In third world countries, it is seen that introduction of crop production technologies including improved high yielding germplasms/varieties is an essential component of agriculture-led development strategies. Technological advances have been utilized in anti-poverty programs in order to stimulate productivity, promote economic growth and raise income levels (Preece, 1989). Although some introduced varieties have been found to be suitable for farmers, a majority of the farmers in the country are still reluctant to adopt these new innovation/varieties. Since many farmers have not adopted these varieties the level of pulse production remains far below its annual demand. In order to improve this important crop refine research is very important in each growth stage. To evaluate the contribution of different morpho-physiological characters during vegetative and reproductive stages of plant growth to yield is still the basic and important method for evaluating the potentiality of a new germplasm (Sharifi and Zadeh, 2012). Some properties have been determined in several studies such as, dry matter, biomass, absolute growth rate (AGR), relative growth rate (RGR) etc. to determine their effect on yield (Edwards et al., 2005; Hunt et al., 2002; Sharifi and Pirzad, 2011). Some researchers reported about the contribution of various yield components towards yield (Dutta and Mondal, 1998; Samad et al., 2007; Mondal et al., 2012) but little is known about the morpho-physiological and biochemical characteristics that explain the causes of low yield of lentil in South Asian region. It is therefore essential to quantify the components of growth, and its variation to understand the physiological basis of yield difference among the lentil genotypes. Bangladesh Institute of Nuclear Agriculture (BINA) develops and releases crop varieties through mutation technique. By this technique some lentil varieties have released and research is continuing with some mutants.

In present study some lentil varieties were subjected to chemical mutagen for changing the genic level to produce the mutant.The aim of this investigation was to study the variability among the genotypes (two mutants and two varieties) of lentil for certain physiological and morphological characters based on growth parameters and their relation with seed yield as a source of genetic variability on the basis of regression.

2 Materials and Methods

The experiments were conducted at lentil growing area under two substation of BINA *viz*. Magura and Ishurdi during Rabi season, 2014. The soil type was silt to clay silt. During growing period the climatic condition was suitable and weather was optimally dry and humid, suitable for lentil production. From November to March average temperature, rainfall and humidity data were 23.3 °C, 25.16 mm, 75% and 22.6 °C 17.72 mm, 72.6% at Magura and Ishurdi respectively (Bangladesh Meteorological Department).

As plant materials, two mutant lines (N_4I-404 and E_4I-925) and two lentil varieties (Binamasur-3 and Binamasur-4) were used. Mutant lines were developed from local lentil variety L-5 by the treatment with chemical mutagen, ethyl methane sulphonate to get mutants through the change of inheritance pattern. The mutants E_5M-1018 and E_4M-934, produced by mutation breeding, were registered as Binamasur-3 and Binamasur-4 in 2005 and 2009, respectively by National Seed Board of Bangladesh. The growth duration of Binamasur-3 and Binamasur-4 are 110 d and 120 d, respectively and their average yield are 1.45 t ha^{-1} and 1.55 t ha^{-1}, respectively. Binamasur-3 and Binamasur-4 were used as check to determine growth analysis and find out the morphological, physiological and yield performance.

The experiments were carried out in a randomized complete block design (RCBD) with three replications. For both the experiments sowing was done on 17 November 2014. The Unit plot size was 4 m

$\times$ 3 m. Distances between row to row and plant to plant were 30 cm and 5-6 cm respectively. Seed rate used for all the varieties/mutant lines was 35 kg ha^{-1}. Urea, triple superphosphate and muriate of potash were applied at the rate of 40, 120 and 80 kg ha^{-1}, respectively and 1.5 kg ha^{-1} biofertilizer was also used at the time of final land preparation. Proper cultural practices were followed as and when necessary. Seeds were treated with Vitavex–200 @ 3 g kg^{-1} seed, and Tilt–250 EC was sprayed 2-3 times to control fungus. No irrigation was needed and the experimental plot was under well drainage system.

Data were collected at 30, 45, 60 and 75 days after sowing (DAS) from randomly selected 10 plants from each plot on plant height and branches plant^{-1}. Number of pods plant^{-1}, seeds plant^{-1}, 1000-seed weight, and seed weight plant^{-1} were recorded after harvest. To determine dry matter (DM) accumulation, five plants from the central rows of each plot were harvested at 30, 45, 60 and 75 DAS and were calculated after oven drying at 80 $\pm$ 20 °C for 72 h. Absolute growth rate (AGR) and relative growth rate (RGR) were calculated by using the following formula according to Evans (1972) and Hunt et al. (2002) as follows–

$$AGR = \frac{W_2 - W_1}{T} \tag{1}$$

$$RGR = \frac{lnW_2 - lnW_1}{W_2 - W_1} \tag{2}$$

where, W_1, W_2 are total dry mass of plant at first and second count, respectively, and T is the time interval (d).

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) using the statistical computer package, MSTAT-C (Russell, 1968).

3 Results and Discussion

3.1 Growth parameter

The effect of lentil genotypes on ontogenetic growth characters like total dry mass (TDM), relative growth rate (RGR) and absolute growth rate (AGR) was significant (Figs. 1 to 3). The AGR and RGR are influenced by total dry matter (Egly and Guffy, 1987). The TDM and AGR were increased slowly up to 60 d and steeply later up to harvest (Figs. 1 and 2). Similar finding was reported in soybean by Kumari and Balasubramanian (1990). In both locations, TDM and AGR were recorded the highest in mutant E_4I-925 and the lowest in Binamasur-4 which indicates the increase in its dry mass per unit of time is higher in E_4I-925. This result indicates that at vegetative and-flowering stages, higher growth rate is desirable for getting higher grain yield in lentil.

Plant growth and yield are represented by the ability of crop to intercept solar radiation at early stage and its subsequent utilization for biomass production (Hanlan et al., 2006). In lentil, increased interception of solar radiation at early growth stage enables plant to make rapid early growth, resulting in high yield (Purcell et al., 2002). It was also reported that during plant growth stages RGR values are interrelated with TDM accumulation and AGR (Wiresma, 2002; Sharifi et al., 2014). In case of RGR, it was increased slowly at 45 DAS, peaked at 60 DAS then declined at 75 DAS at Magura but at Ishurdi, RGR was highest at initial stage of 45 DAS then decreased at 60 DAS and further declined at 75 DAS. Because of relatively suitable weather and optimum climatic conditions at Ishurdi than Magura RGR was found higher initially at Ishurdi hence, seed yield of Ishurdi was relatively higher than Magura location. Highest RGR was recorded in mutant E_4I-925 at both the locations which might have a significant influence on the increase in dry mass and finally on yield. Similar result was also reported by Samad et al. (2007) who observed that the genotypes, which had capacity to early higher growth rate, also showed higher seed yield in lentil. Bagheri et al. (2014), on the contrary reported same RGR for two cultivars they studied. Ozturk et al. (2014) opined that the effects of different environmental conditions provided the changes in RGR values.

3.2 Morphological characters

Plant height and number of branches plant^{-1} varied significantly among the mutants/varieties (Table 1). Plant height ranges from 37.07-48.13 cm at Magura and 37.80-41.83 cm at Ishurdi. The tallest plant was found in mutant N_4I-404 (48.13 cm) at Magura and in mutant E_4I-925 (41.83 cm) at Ishurdi while there was no significant difference for plant height among the varieties. Number of branches plant^{-1} ranges from 15.75-17.8 at Magura and 14.83-15.63 at Ishurdi. Mutant E_4I-925 produced higher number of branches plant^{-1} at both locations (17.8 at Magura and 15.63 at Ishurdi) and also showed higher seed yield. In contrast, the lowest and similar branch production was recorded in rest of the genotypes (14-16 plant^{-1}) and these two genotypes also showed lower yield performance, indicating branch production is more important than plant height in achieving higher seed yield in lentil. Similar result was also reported by many workers in lentil (Yadav et al., 2003; Anjam et al., 2005; Kakde et al., 2005; Karadavut, 2009) who reported that seed yield was positively and significantly correlated with branch number. On the other hand, Hanlan et al. (2006) suggested that short plant

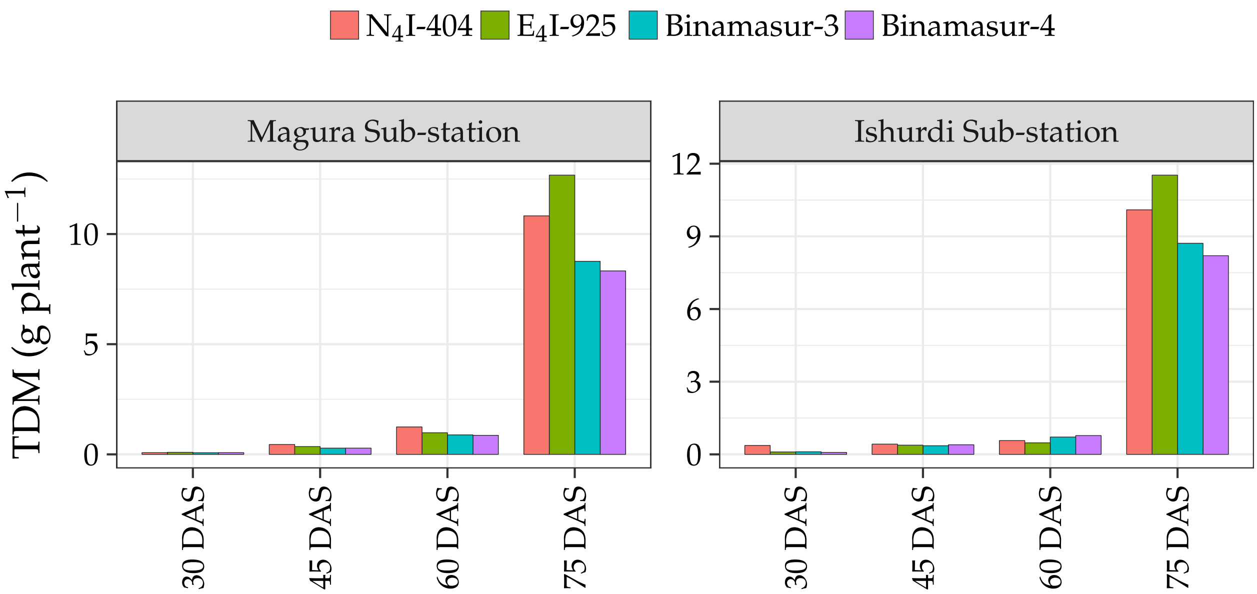

Figure 1. Total dry mass (TDM) of the leintil genotypes at Magura and Ishurdi sub-stations

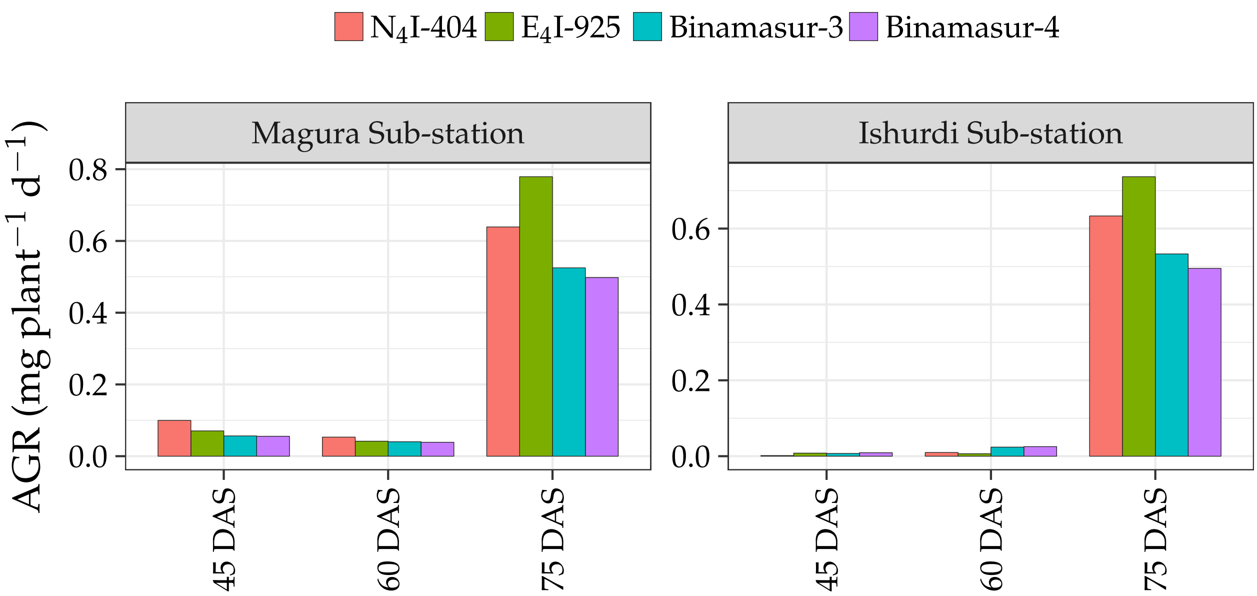

Figure 2. Avergae growth rate (AGR) of the leintil genotypes at Magura and Ishurdi sub-stations

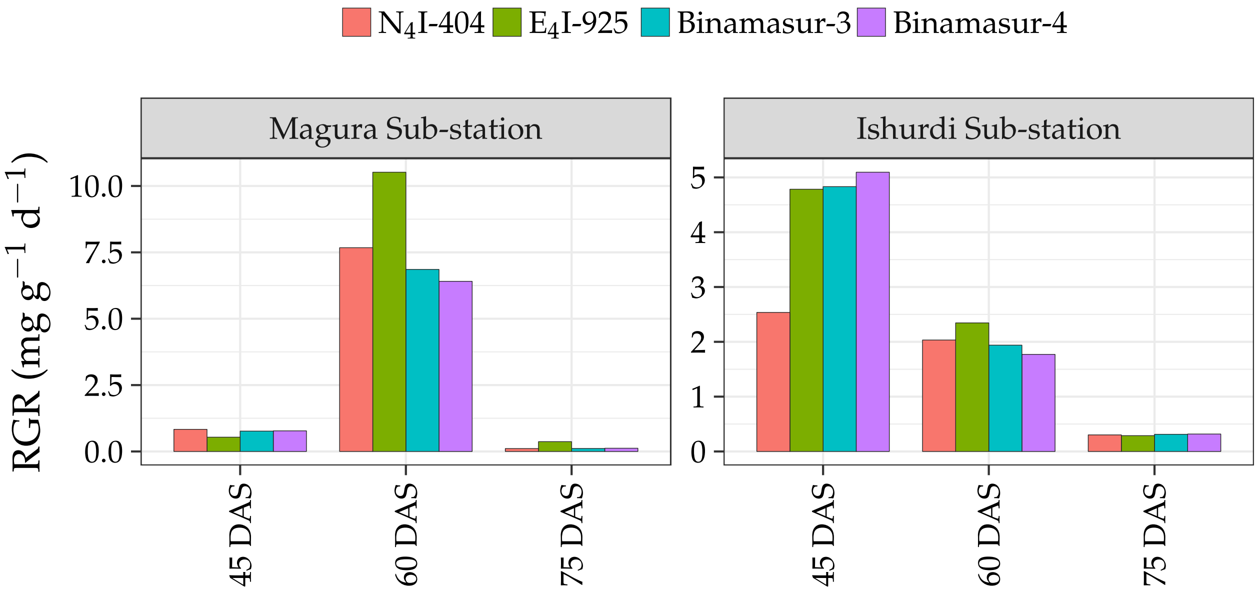

Figure 3. Relative growth rate (RGR) of the leintil genotypes at Magura and Ishurdi sub-stations

stature with less number of branches are desirable to achieve higher seed yield in lentil, which disagrees to the present findings.

3.3 Seed yield and yield attributes

At Magura, Significant difference was not found for number of pods plant^{-1}, and number of seeds pod^{-1} among genotypes. Average pod number was 92 and number of seeds per pod was 1.4 plant^{-1}. Because of bold sized seed, 1000-seed weight (18.87 g) was observed significantly higher in mutant line E_4I-925. Second bold sized seed was observed in mutant line N_4I-404. At Ishurdi, number of pod plant^{-1}, number of seed pod^{-1} and 1000-seed weight were found significantly higher in mutant line N_4I-404 than other genotypes studied in this experiment which resulted in second highest seed yield. At both locations, seed weight plant^{-1} was statistically higher in mutant line E_4I-925 than other genotypes which produced statistically similar seed weight plant^{-1}. Seed yield ha^{-1} was recorded the highest in mutant line E_4I-925 followed by another mutant line N_4I-404. In contrast, the lowest seed yield was recorded in Binamasur-3 and Binamasur-4. The seed yield was higher in mutants than varieties due to higher number of pods plant^{-1} and/or higher 1000-seed weight (Table 1). Results revealed that the mutant E_4I-925 produced the highest seed yield at both locations (2.1 and 2.3 t ha^{-1} for Magura and Ishurdi, respectively) while N_4I-404 produced moderate yield (1.9 t ha^{-1}) at both locations (Table 1). The yield was higher in those two mutants (E_4I-925 and N_4I-404) due to production of higher pods plant^{-1} and bolder seeds. In contrast, Binamasur-3 and Binamasur-4 produced lower seed yield (1.4 to 1.6 t ha^{-1}) due to lower yield attributes. Based on the superior morpho-physiological characters and yield, two mutants such as E_4I-925 and N_4I-404 may be selected for further field trial at different agro-ecological zones of Bangladesh to confirm the results.

3.4 Correlation study

In lentil pod number is the prime yield attribute which had positive association with plant height.The TDM and RGR and showed significant positive correlations with branch number (r = 0.40*), 1000-seed weight (r = 0.50*), RGR (r = 0.54**). The parameter 1000-seed weight was also highly correlated with seed yield (r = 0.74**), TDM (r = 0.82**) and RGR (0.79**); therefore, seed yield is strongly correlated with all the yield contributing parameters (Table 2). This suggests that increasing sink (pod number) production would increase seed yield and pod production depending on morpho-physiological characters. These findings are in good agreement with those of many authors who also revealed that seed yield increased with the increase in number of pods plant^{-1} in lentil (Yadav et al., 2003; Anjam et al., 2005; Bicer and Sakar, 2008; Younis et al., 2008; Karadavut, 2009).

4 Conclusions

A high yielding lentil genotype should possess a relatively higher growth rate at early growth stages and having capacity to better dry matter partitioning to

Table 1. Performance of some lentil genotypes on morphological characters and yield during rabi season at Magura and Ishurdi sub-stations

Genotypes	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000- seed weight (g)	Seed wt. plant^{-1} (g)	Seed yield (t ha^{-1})
Magura Sub-station							
N_4I-404	48.13 a	16.20 b	85.5	1.47	18.23 b	2.95b	1.9 b
E_4I-925	38.40 b	17.80 a	100.1	1.43	18.87 a	3.34a	2.1 a
Binamasur-3	37.07 b	17.60 a	84.03	1.43	16.73 c	2.10b	1.4 c
Binamasur-4	38.13 b	15.73 b	98.47	1.47	16.40 c	2.27b	1.5 c
F-test	**	**	NS	NS	**	*	**
CV%	4.28	4.39	11.48	4.14	1.5	8.22	12.01
Ishurdi Sub-station							
N_4I-404	37.40 b	14.83 b	88.07 a	1.33 b	18.77 a	2.63 b	1.9 b
E_4I-925	41.83 a	15.63 a	79.30 b	1.47 a	18.20 b	3.46 a	2.3 a
Binamasur-3	37.80 b	15.20 b	64.67 c	1.37 ab	16.83 c	2.28 b	1.5 c
Binamasur-4	41.13 a	15.00 b	83.77 ab	1.43 ab	16.47 c	2.45 b	1.6 c
F-test	**	*	**	**	**	**	**
CV%	2.19	3.8	5.27	4.76	1.5	10.26	12.01

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT;
* and **indicate significant at 5% and 1% level of probability, respectively.

Table 2. Simple correlation coefficient† among different quantitative characters in lentil

Attributes	Plant height	Branch plant^{-1}	Pod plant^{-1}	TSW	Seed yield	TDM	AGR	RGR
Seed yield	0.46*	0.59*	0.40*	0.74**	–	0.97**	0.96**	0.20 NS
Pod plant^{-1}	0.20 NS	0.40*	–	0.50*	0.40*	0.24 NS	0.24 NS	0.54*
TSW	0.21 NS	0.03 NS	0.50*	–	0.74**	0.82*	0.82**	0.79**

† N = 12; *, **, and NS indicate significant at 5% and 1% level of probability, and not significant, respectively; TSW, TDM, AGR and RGR indicate 1000-grain weight, total dry mass, avergae growth rate and relative growth rate, respectively.

economic yield in addition to superior characters for yield components. From above discussion it is clear that mutant E_4I-925 has wide variability and is the best performer in relation to all aspects followed by mutant N_4I-404, because all growth related parameters, morpho-physiological traits and yield components were higher than other mutant and two varieties studied in this experiment. Therefore, mutant line E_4I-925 may be recommended for further site specific trials for formulating the agronomic package for its production before releasing as a new potential lentil variety.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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