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Impact of Morpho-Physiological Traits on Seed Yield of Lentil (*Lens culinaris* Medik.)

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Abstract – **The present experiment was conducted to evaluate some morpho-physiological features and its impact on seed yield of four lentil varieties *viz*., Binamasur-3, Binamasur-4, Binamasur-5 and BARI Masur-5 during the period from November 2014 to March 2015 at Ishurdi, Bangladesh under sub-tropical condition (24°8´ N 90°0´ E). The growth rate found very slow during the vegetative phase in all the genotypes due to a relatively smaller portion of dry matter production before flower initiation and bulk of it after anthesis. The maximum growth rate was observed at flowering stage (62-72 days after sowing) in all genotypes. Binamasur-5 showed maximum growth and dry mass accumulation at vegetative stage but minimum at reproductive stage in comparison to other genotypes. Plant height of Binamasur 5 found minimum but seed yield and harvest index and other yield attributes were produced height among the four genotypes. Besides maturity duration of Binamasur-5 is lower (96 days) than Binamasur-4 (97 days), BARI Masur-5 (98 days) and Binamasur- 3 (100 days). Results indicate that genotype improvement efforts have achieved higher seed yield by higher growth rate at early growth stages and better assimilate partitioning to economic yield. The bushy plants are unlikely to yield improvement. The variety, Binamasur-5 had short plant stature with increase branches there by produce more pods/plant resulting higher seed yield. This information may be used in future plant breeding programme.**

***Keywords* – Lentil *(Lens culinaris* Medik), Morpho-physiological Traits, Yield.**

I. Introduction

Lentil (*Lens culinaris* Medik.) is the second most important pulse crop based on cultivating area and production in Bangladesh, but stands first in the consumer’s preference in Bangladesh (Uddin *et al*., 2008). Among the pulses, lentil is of special interest with 23.7% content of grain protein. In addition to protein, its seed is a rich source of minerals and vitamins as human food, while the straw serves as high-value animal feed (Rasheed *et al.*, 2010). Not only that, its cultivation enriches soil nutrient status by adding nitrogen, carbon and organic matter, which promotes sustainable crop production system (Mondal *et al.* 2013a). However, lentil yield potential far below than the other pulse crops. 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, 2011). 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). Lentil has been identified as a narrow adapted crop and the principal constraint of lentil production is its low yield potential because of undesirable plant type (Mondal *et al.*, 2013b). Several causes are responsible for low yield of lentil of which the use of traditional local cultivars, low plant density, weed infestation and poor crop management practices constitute the major ones.

Several reports have been made about the contribution of various yield components towards yield (Dutta and Mondal, 1998). The yield components depend on some physiological traits. To understand the physiological basis of yield difference among the genotypes of lentil, it is essential to quantify the components of growth and the variation, if any, may be utilized in crop improvement.

Important physiological attributes such as Leaf Area Index (LAI), Crop Growth Rate (CGR), Net Assimilation Rate (NAR) and photo-assimilate production capacity and its efficient partitioning to economic yield etc. can address various constraints of a variety for increasing its productivity. A plant with optimum LAI may produce higher biological yield (Mondal *et al.,* 2012). The dry matter accumulation may be the highest if the LAI attains its maximum value within the shortest possible time (Mondal *et al.*, 2011). Some authors have reported that in lentil higher performance are achieved by the contribution of various yield components (Anzam *et al*., 2005; Kakde *et al.*, 2005; Tabu and Sakar, 2008; Younis *et al.*, 2008; Karadavut, 2009). But information on identification of important source-sink characters and their correlation with yield is scanty in lentil.

Bangladesh Institute of Nuclear Agriculture (BINA) has developed three lentil varieties through chemical and physical mutagenesis. The special character of these developed mutant varieties is synchronous in pod maturity, which is desirable trait for lentil cultivation in Bangladesh. These mutant varieties need to be evaluated for their physiological and morphological maneuvering that takes place compared to the existing lentil cultivar, BARI masur-5. Therefore, the present research work was conducted to find out the role of physiological and morphological characters on seed yield of recently released lentil varieties of Bangladesh Institute of Nuclear Agriculture (BINA).

II. Materials and Method

The study was conducted at research farm of Bangladesh Institute of Nuclear Agriculture (BINA), Ishurdi during the period from November 2014 to March 2015. The land is medium high having sandy loam textured soil with soil pH 7.65 (BARC, 2012). The experiment was laid out in Randomize Complete Block Design (RCBD) with three replications. The unit plot size was 2.5 m × 2 m and seeds were sown in rows with spacing 30 cm. Four lentil varieties such as Binamasur-3, Binamasur-4 and Binamasur-5 and BARI Masur-5 were

International Journal of Agriculture Innovations and Research
Volume 5, Issue 1, ISSN (Online) 2319-1473

used as planting material. Recommended intercultural practices such as weeding, thinning, irrigation and application of pesticides were done as and when necessary for proper growth and development of the plants. Nitrogen, phosphorus and potassium were provided during final land preparation at the rate of 25, 77 and 32 kg ha^{-1} in the form of Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP), respectively and 4 kg/ha zinc sulphate. For ontogenetic growth characteristics, ten plants were randomly sampled for growth parameters from 42 days after sowing (DAS) and continued at an interval of 10 days up to 102 days after sowing (DAS). The second and third rows of each plot were used for sampling. Plants were separated into roots, stems, leaves and pods, and the corresponding dry weights were recorded after oven drying at 80 ± 2 °C for 72 hours. Absolute growth rate is measured as total increase in plant dry weight over given period of time. The growth analysis was carried out following the formulae of Hunt (1978).

Absolute growth rate = $(W_2-W_1) / (t_1-t_2)$,
Here W_1 = weight at initial time
W_2 = weight at final time
T_1 = Initial time
T_2 = Final time

The yield contributing characters were recorded during harvest from ten competitive plants of each plot. The seed yield was recorded from five rows of each plot (1.5 m × 2.0 m) and converted into seed yield ha^{-1}. The collected data were analyzed statistically in MSTAT program.

III. Result and Discussion

Growth Parameters

The effect of lentil genotypes on ontogenetic growth characters like total dry mass (TDM) and absolute growth rate (AGR) was significant. Total dry mass (TDM) is increased with the age of the plant until maturity but the increment was slow until 62 days after sowing (DAS) and thereafter increased rapidly (Fig. 1). BARI Masur-5 produced the highest total dry mass (TDM) at all growth stages followed by Binamasur-4. The lowest total dry mass (TDM) production at all growth stages was recorded in Binamasur-5 followed by Binamasur-3.

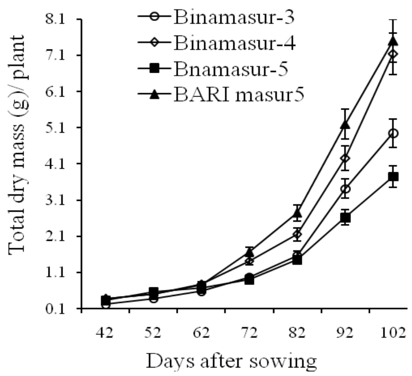

Fig. 1. Changes in total dry mass (TDM) at different growth stages of four lentil varieties. Vertical lines are standard errors of selected data point.

The absolute growth rate (AGR) also increased with the age of the plant until 62-72 days after sowing (DAS) followed by a decline at 72-82 days after sowing (DAS) and then again increased at 82-92 days after sowing (DAS) and thereafter declined at 92-102 days after sowing (DAS) in all genotypes (Fig. 2). The absolute growth rate (AGR) increased at 82-92 days after sowing (DAS) in all varieties because of plants were at pod development stage. The absolute growth rate (AGR) was greater in Binamasur-5 at early and mid growth stages (42-62 DAS) but lower at reproductive stages (72-102 DAS) in comparison to other genotypes and also showed higher seed yield. On the other hand, the absolute growth rate (AGR) was lowest in BARI Masur-5 at early and mid growth stages (42-62 DAS) but greater at early reproductive stages (72-102 DAS) in comparison to other genotypes and also showed higher seed yield but lower than Binamasur-5. At late reproductive stages (82-92 DAS), the higher absolute growth rate (AGR) was recorded in Binamasur-3 followed by Binamasur-4 and it was lowest in Binamasur-5 followed by BARI Masur-5.

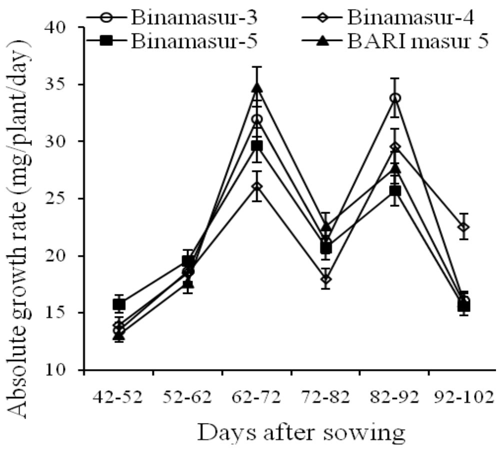

Fig. 2. Changes in absolute growth rate (AGR) at different growth stages of four lentil varieties. Vertical lines are standard errors of selected data point.

This result indicates that higher growth rate at vegetative and flowering stage is desirable for getting higher seed yield in lentil. Plant growth and yield are represented by the crop's early ability to intercept solar radiation and its subsequent utilization for biomass production (Hanlan *et al.,* 2006). In lentil, increased interception of solar radiation at early seedling stages enable plant to make rapid early growth, resulting in higher yield (Purcell *et al.,* 2002). In the present study, similar phenomenon occurred in Binamasur-5 giving higher production of total dry mass (TDM) and absolute growth rate (AGR) at early growth stage, resulting maximum seed yield finally.

Morphological Characters and Yield Attributes

Lentil genotypes show significant differences in morphological and yield attributes (Table 1). Among the genotypes, Binamasur-4 was the highest (38.1 cm) and statistically similar with BARI Masur-5 (38.9 cm) and Binamasur-3. Whereas, Binamasur-5 was the shortest (33.6 cm) and statistically alike with Binamasur-3 (37.8

International Journal of Agriculture Innovations and Research
Volume 5, Issue 1, ISSN (Online) 2319-1473

cm). Maturity duration is lowest in Binamasur 5 which is statistically similar with Binamasur 4. But maturity duration is maximum in Binamasur 3 which is statistically alike to BARI Masur-5. Binamasur-5 produced highest number of primary branches (5.8 branches plant^{-1}) but lowest number of that was found in BARI Masur-5 (3.6 branches plant^{-1}) which was followed by Binamasur-3 (4.2 branches plant^{-1}) and Binamasur-4 (4.0 branches plant^{-1}). Number of pod plant^{-1}, number of seed pod^{-1}, 1000 seed weight, seed yield and harvest index also varied significantly among four lentil varieties (Table 1). Maximum number of pod was produced in Binamasur-5 (102.3 pods plant^{-1}) followed by BARI Masur-5 (87.2 pods plant^{-1}), Binamasur-4 (83.8 pods plant^{-1}) and Binamasur-3 (64.7 pods plant^{-1}). Similarly highest number of seed per pod was counted in Binamasur-5 (1.83 seed pod^{-1}) followed by BARI Masur-5 (1.63 seed pod^{-1}), Binamasur-4 (1.43 seed pod^{-1}) and Binamasur-3 (1.37 seed pod^{-1}). Binamasur-5 showed bolder seed thus 1000 seed weight found maximum (22.0 g) followed by BARI Masur-5 (19.20 g) with similar statistic rank. On the other hand, the lowest 1000 seed weight was recorded in Binamasur-4 (16.47 g) followed by Binamasur-3 (16.83 g) with same statistical rank. Highest amount of seed yield was collected from Binamasur- 5 (2.33 tha^{-1}) as the number of primary branch per plant, number of pod per plant, number of seed per pod and seed weight was maximum in this genotype and it was followed by BARI Masur-5 (2.00 tha^{-1}), Binamasur-4 (1.91 tha^{-1}) and Binamasur-3 (1.90 tha^{-1}). This result indicating that primary branch production is more important than plant height in achieving higher seed yield in lentil. More primary branches ensure more pod number which also increase seed number and finally produce more seed yield. So, it can be concluded that seed yield is positively correlated with branch production. Similar result was also reported by many workers in lentil (Yadav *et al*., 2003; Anzam *et al*., 2005, Kakde *et al*., 2005; Karadavut, 2009; Mondol *et al.*, 2013a) who reported that seed yield was positively and significantly correlated with branch number.

Maximum harvest index recorded in Binamasur-5 (27.82%) which was statistically similar with BARI Masur-5 (26.08%) and minimum of that Binamasur-3 (24.12%) which was statistically identical to Binamasur-4 (24.95%).

The high yielding variety BARI Masur-5 produced higher total dry mass whereas another high yielding mutant variety, Binamasur-5 produced lower total dry mass which intern indicated that total dry matter production is not obligatory for achieving higher seed yield in lentil. But dry matter partitioning to economic yield is more important than total dry matter production. However, the mutant variety Binamasur-5 produced lower total dry mass with highest dry matter partitioning to economic yield (27.82%) and resulting higher seed yield. Greater biomass production is unlikely to improve harvest index in lentil (Mondal *et al*., 2012). The authors also opined that plants having moderate biomass with reduced branching would carry more pods, have a lesser tendency to lodge, and result in improved harvest index and yield in lentil.

In the present experiment, the mutant variety Binamasur-5 had short plant stature with lower biomass production capacity and improved Harvest Index thereby increased yield that is the desirable character in lentil. Results indicated that Binamasur-5 produced the highest seed yield (2.33 tha^{-1}) due to its good assimilate partitioning to economic yield (Table 1).

Table 1. Morphological character and yield attributes of four lentil varieties

Variety	Plant height (cm)	Days to maturity	Primary branches plant^{-1}	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000 seed wt (g)	Seed yield (tha^{-1})	Harvest Index (%)
Binamasur-3	37.8ab	100b	4.2b	64.7c	1.37c	16.83b	1.90b	24.12b
Binamasur-4	38.1a	97a	4.0b	83.8b	1.43c	16.47b	1.91b	24.95b
Binamasur-5	33.6b	96a	5.8a	102.3a	1.83a	22.00a	2.33a	27.82a
BARI Masur-5	38.9a	98b	3.6b	87.2b	1.63b	19.20a	2.00b	26.08a
F- test	*	**	*	**	**	**	*	*
CV (%)	6.43		25.15	7.10	6.38	3.31	14.16	15.9

In a column figures with same letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly (as per DMRT, $p \leq 0.05$), * = Significant at 5% level of probability, ** = Significant at 1% level of probability.

Table 2. Simple correlation among the different quantitative characters in lentil

Characters	Plant height	No. of branch	Total dry mass	Seed yield	Harvest index
Pod number	-0.23^{NS}	0.32*	0.62 **	0.66**	0.51**
1000 seed wt	-0.59*	0.14*	0.06^{NS}	0.35*	0.17^{NS}
Seed yield	-0.49*	0.47**	0.80**	-	0.52 **

*, ** indicate significant at 5% and 1% level of probability, respectively; NS indicates not significant.

International Journal of Agriculture Innovations and Research
Volume 5, Issue 1, ISSN (Online) 2319-1473

Table 3. Correlation between absolute growth rate (AGR) and seed yield

Character	Absolute growth rate	
	At vegetative stage (42-52 DAS)	At fruiting stage (82-92 DAS)
Seed yield	0.35*	-0.39*

* indicate significant at 5%

In contrast, the lowest seed yield was recorded in Binamasur-3 (1.90 tha^{-1}) and Binamasur-4 (1.91t ha^{-1}) due to lower number of pods plant^{-1}. The second highest seed yield was recorded in BARI Masur-5 (2.0 t ha^{-1}) which was statistically alike to Binamasur-3 and Binamasur-4.

Correlation Study

Pod number is the prime yield attributes in lentil and it showed significantly and positively correlation with number of branch (r = 0.32*), total dry mass (r = 0.62**) and harvest Index (r = 0.51**) thereby seed yield (r = 0.66**) (Table 2).

Similarly, seed yield was significant and positively correlated with number of branch (r = 0.47**), total dry mass (r = 0.80**) and harvest Index (r = 0.52**) but significant and negatively correlated with plant height (r = -0.49*). In contrast, plant height had no relation with pod number and seed yield. Positive and significant correlation of 1000 seed weight also found with number of branch (r= 0.14*) and seed yield (r= 0.35*) but negatively with plant height (r= -0.59*).

This suggests that increasing sink (pod number) production and increasing seed weight would increase seed yield and pod production depend on total dry matter (TDM) production. These results are in agreement with the result of many authors who also observed that seed yield increased with increased number of pods plant^{-1} in lentil (Yadav *et al.*, 2003; Anzam *et al.*, 2005; Tabu and Sakar, 2008; Younis *et al.*, 2008; Karadavut, 2009). Seed yield found significantly and positively correlated with absolute growth rate at vegetative/early growth stage (r = 0.35*) (Table 3). But seed yield is negatively correlated with absolute growth rate of fruiting stage (r = -0.39*). This result indicates that early rapid vegetative growth is pre-requisite for getting higher seed yield in lentil.

IV. Conclusion

In addition to superior morpho-physiological growth characters and yield components, 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 economic yield. Among four varieties Binamasur-5 produced the highest seed yield ha^{-1}and HI with higher growth at vegetative stage and earliest maturity time.

V. Recommendation

Based on the superior morpho-physiological growth characters and yield, two varieties such as Binamasur-5 and BARI Masur-5 may be recommended country wide cultivation for increasing lentil production in Bangladesh.

VI. Acknowledgment

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References

[1] Anzam M S, Ali A, Iqbal S M and Haqqani A M (2005). Evaluation and correlation of economically important traits in exotic germplasm of lentil. Int. J. Agric. Biol., 7: 959-961.
[2] BARC (2012). Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC). Farmgate, Dhaka. p. 98.
[3] Dutta R K and Mondal M M A (1998). Evaluation of lentil genotypes in relation to growth characteristics, assimilate distribution and potential. Lens Newsl., 25: 51-55.
[4] Hanlan T G, Ball R A and Vandenberg A (2006). Canopy growth and biomass partitioning to yield in short-season lentil. Candian J. Plant Sci., 86: 109-119.
[5] Hunt R (1978). Plant growth analysis studies in biology. Edward Arnold Ltd., London. p. 67
[6] Kakde S S, Sharma R N, Khilkre A S and Lambade B M (2005). Correlation and path analysis studies in lentil. J. Soil Crops, 15: 67-71.
[7] Karadavut U (2009). Path analysis for yield and yield components in lentil. Turkish J. Field Crops, 14: 97-104.
[8] Mondal M M A, Fakir M S A, Islam M N and Samad M A (2011). Physiology of seed yield in mungbean: growth and dry matter production. Bangladesh J. Bot., 40: 133-138.
[9] Mondal M M A, Puteh A B, Malek M A, Ismail M R, Rafii M Y and Latif M A (2012). Seed yield of mungbean (*Vigna radiata* (L.)Wilczek) in relation to growth and developmental aspects. Sci. World J. Volume 2012, Article ID 425168, 7 pages, doi:10.1100/2012/425168.
[10] Mondal M M A, Puteh A B, Malek M A, Roy S and Rafii (2013a). Contribution of morpho-physiological traits on yield of lentil (*Lens culinaris* Medik). Australian J. Crop Sci., (8): 1167-1172.
[11] Mondal M M A, Puteh A B, Malek M A and Kabir A K M R (2013b). Flowering pattern and reproductive efficiency in lentil. Legume Res., 36 (2): 153-157.
[12] Purcell L C, Ball R A, Reaper J D and Vories E D (2002). Radiation use efficiency and biomass production in soybean at different plant densities. Crop Sci., 42: 172-177.
[13] Rahman M A and Ali M O (2011). The causes of decrement in pulse production and its possible remedy. Proceedings of the International Conference on 'Pulses in South Asia' held at the Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh during 17 -19 February 2011. pp. 91-94.
[14] Rasheed M, Jilani G, Shah I A, Najeeb U and Iqbal T (2010). Genotypic variants of lentil exhibit differential response to phosphorus fertilization for physiological and yield attributes. Acta Agriculturae. Scandania., Section-B: Soil Plant Sci., 60: 485-493.
[15] SAIC (2011). Annual report of SAARC Agricultural Information Centre (SAIC), Farmgate, Dhaka-1215.
[16] Tuba B D, Sakar D (2008). Studies on variability of lentil genotypes in southern Anatolia of Turkey. Not Bot Hort Agrobot Cluj 36: 20-24.
[17] Uddin J, Sarker A, Podder R, Afzal A, Rashid H and Siddique K H M (2008). Development of new lentil varieties in Bangladesh. "Global Issues. Paddock Action." Edited by M. Unkovich. Proc.

14th Agron. Conf. 21-25 September 2008, Adelaide, South Australia. pp. 26-32.

[18] Yadav S S, Phogat D S, Solanki I S and Tomer T S (2003). Character association and path analysis in lentil. Indian J. Pulse Res., 16: 22-24.

[19] Younis N, Hanif M, Sadiq S, Abbas G, Asghar M J and Haq M A (2008). Estimation of genetic parameters and path analysis in lentil. Pak. J. Agric. Sci., 45: 44-48.

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