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Varietal Roles on Morpho-physiological and Yield Attributes of Lentil (*Lens culinaris* Medik)

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ABSTRACT

Background: Lentil is the top cultivated pulse crop in Bangladesh. Even if there are a number of modern high yielding varieties (HYV) with all natural favorable conditions and resources for cultivation but due to lack available stress and climate (biotic and abiotic) resilient variety; potential yield of this crop is rarely met. Against huge sum of demand the supply is deficit in the country which is met by importing. Reflecting this situation, the present investigation attained to test the morpho-physiological and yield related attributes of seven HYV of lentil and depict the most suitable variety in terms of growth, yield and maturity.

Methods: Binamasur-5, Binamasur-8, Binamasur-9, Binamasur-10, BARI Masur-5, BARI Masur-6 and BARI Masur-8 was laid in a randomized complete block design during the *rabi* (winter) season of 2019 at BINA sub-station farm, Magura.

Result: Findings divulged that, Binamasur-10 had the most seed yield (2.08 t/ha), harvest index (HI) (25.15%) and with medium duration of maturity (108.94 days). BARI Masur-5 produced maximum stover yield (7.86 t/ha) with delayed maturity (114 days) and least seed yield (1.75 t/ha) among the evaluated varieties. Correlation study exposed that, seed yield had a positive and significant relationship with plant height (0.78*), number of primary and secondary branches (0.76* and 0.75*), total dry mass (0.87**) and HI (0.85**). However, Binamasur-10 might be more suitable than the other varieties in the field due to it's notable performance.

Key words: Binamasur, BARI masur, Magura, Morpho-physiological, Yield.

INTRODUCTION

Lentil is one of the extensive cultivated pulse crops in Bangladesh. It belongs to the family Leguminosae which grows annually in the cool season (*rabi*). It is a source of balanced protein supply. On average lentil grain contains around 59% carbohydrate, 24-26% protein, 0.7% fat, 3% vitamin (β-carotene), 4% minerals (potassium, phosphorus, iron, zinc) and 10% moisture (Rasheed *et al*., 2010). Though the caloric content of lentil is equal to rice, but it provides almost four times the protein and eight times the riboflavin compared to rice (Anonymous, 1966). Lentils are often cooked in the form of *dal* (a food recipe) and consumed with rice. Combination of rice and *dal* provides a complete protein package which is well known as the recipe *khichuri* (Uddin *et al.,* 2008). Thus, it is known as "poor man's meat" because of its high protein content and quality (Bhatty, 1988). Besides human food source, green lentil plants (Gahoonia *et al.,* 2005) and straws (Erskine *et al*. 1994) are excellent feed for animals also. In addition to food and feed lentil plays a key role for soil health improvement in the cropping systems (Anonymous, 1984) through addition of nitrogen, carbon, organic matter (Sarker and Kumar, 2011) for ultimate sustainability of crop production systems (Sarker *et al.,* 2004).

During 2019-20, globally mean seed yield of lentil was about 1.30 t/ha; whereas in Bangladesh the it was nearly 1.25 t/ha (FAOSTAT, 2022). Although there are a good number of modern lentil varieties developed by research institutes which have high yield potential (about 2.0 t/ha) but due selection of appropriate variety (region specific), lack of desired plant population, poor agronomic management, sowing time (delayed/early), drought, excess moisture, disease and weed infestation etc. factors potential yield is seldomly achieved. Furthermore, low yield demotivates farmers to cultivate lentil instead they are keen to grow other staple foods (rice, maize and wheat) which have higher yield thus pulses have been allotted to marginal or less fertile lands where production is minimized (Aktar, 2013). So far Bangladesh institute of nuclear agriculture (BINA) and Bangladesh agricultural research institute (BARI) together has released eighteen high yielding varieties (nine variety by each institute) of lentil (BINA, 2022; Azad *et al.,* 2020). Among them Binamasur-5, Binamasur-8, Binamasur-9, BARI Masur-5, BARI Masur-6, BARI Masur-8 are quite popular.

Desirable yield of a variety primarily dependent on yield contributing characters as well on physiological traits (Mondal *et al.,* 2013). Important physiological attributes *viz*.

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leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), total dry mass (TDM), absolute growth rate (AGR) are some of the key determinants to find out the limitations and causes of low yield of particular variety (Mondal *et al.,* 2012). Hence to depict the major source sink characters and their relation in contributing yield is essential to evaluate the overall performance a specific lentil variety. Magura district of Bangladesh is very much favorable for pulses specially lentil production due to prevailing weather and soil condition during the *rabi* season. Our experiment focused on the physiological, morphological and yield characteristics of some BINA and BARI released modern lentil varieties and their relationship with yield.

MATERIALS AND METHODS

Location of the experiment

Experiment was setup at Bangladesh institute of nuclear agriculture, Sub-station farm, Magura which was under the Agro Ecological Zone 11 (AEZ) the site was characterized by high Ganges river flood plain; with high to medium land type. Soils were calcareous dark grey to brown floodplain. Organic matter content in brown ridge soils is low but higher in dark grey soils. Soils were slightly alkaline with deficit in fertility (FRG, 2012). An overview of the weather parameters during the experimental period is demonstrated in Fig 1.

Crop establishment and cultural practices

Field experimentation was conducted in *Rabi* (winter) season of 2019. Plot preparation was done according to the procedures described by Chowhan and Nahar (2022). Fertilizers were applied considering low soil analysis interpretation level and applied on soil in accordance with Ahmmed *et al.* (2018). Unit plot size was 3 m × 1.5 m; where line to line and plot to plot distance was 30 cm and 60 cm respectively. Seeds were line broadcasted at the rate of 40 kg/ha on 21st November 2019. Before sowing of seeds they were treated with Provax 200 WP (Carboxin 17.5%) + Thiram 17.5%) of Hossain Enterprise C.C. Limited at rate of 3 g/kg of seeds. After sowing no fungicide or insecticide was applied up to harvest. Hand weeding and thinning was done 30 days after sowing (DAS). Crops were harvested when pods along with plants attained brownish color.

Experimental design

Randomized complete block design (RCBD) with 3 replicates was followed for experimentation. Distance between replications were 1m. Variety was the only treatment. The 7 lentil varieties were-

V_1 = Binamasur-5, V_2 = Binamasur-8, V_3 = Binamasur-9, V_4 = Binamasur-10, V_5 = BARI Masur-5, V_6 = BARI Masur-6 V_7 = BARI Masur-8.

Data collection and analysis

For ontogenetic growth characteristics, five plants were randomly sampled for growth parameters from 30 days after sowing (DAS) and continued at an interval of 15 days up to harvest. 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.

Morpho-physiological and yield features

Plant height (cm), number of branches (primary) per plant, number of secondary branches per plant was recorded 15 days interval up to harvest. Data on plant population, number of pods per plant, number of seeds per pod, thousand grain weight (TGW) (g), crop duration (days to maturity) was recorded during final crop cutting. The following physiological attributes were noted according to Hunt *et al.* (2002):

Total dry mass (TDM) = $D_1 - D_2$ (g/plant)

$$\text{Absolute growth rate (AGR)} = \frac{W_2 - W_1}{t_2 - t_1} \text{ (mg/plant/day)}$$

$$\text{Relative growth rate (RGR)} = \frac{\ln W_2 - \ln W_1}{t_2 - t_2} \text{ (mg/g/day)}$$

$$\text{Crop growth rate (CGR)} = \frac{1}{A} \times \frac{W_2 - W_1}{t_2 - t_1} \text{ (g/m}^2\text{/day)}$$

Where,

D_1= Fresh weight of the plant (g).
W_1= Total plant dry matter at initial time t_1 (g).
D_2= Oven dry weight of the plant (g).
W_2= Total plant dry matter at final time t_2 (g).
t_2= Final time (day).
t_1= Initial time (day). } $t_2 > t_1$
A = Ground area (m^2).
ln= Natural logarithm.

Yield

All yield related data like- seed yield (calculated by adjusting 10% moisture), stover yield and harvest index were collected after harvesting the whole crop.

Statistical analysis

Data obtained from the parameters were analyzed statistically with ANOVA (analysis of variance) technique by Statistix 10 and the mean differences were adjudged by LSD (least significant difference) test (Russel, 1986) at 5% or 10% level of probability.

RESULTS AND DISCUSSION

Morpho-physiological and yield properties

Plant height increase of all the varieties followed a similar trend up to 75 DAS (Fig 2). But a variation was seen between 90 DAS to harvest. Though at harvest the plant height remained statistically similar among the varieties but at 90 DAS, longest height was observed with BARI Masur-8 (V_7) and the shortest was noted in BARI Masur-5 (V_5). Deviation in plant height might be due to genetic attributes and soil fertility status. Khatun *et al.* (2016) reported variations in plant height in different BINA and BARI lentil varieties.

In case number of branches (primary) per plant, all the seven varieties exhibited a rising trend up to 75 DAS except BARI Masur-8 (V_7) (Fig 3). After 75 DAS the number of branches gradually declined. Whereas, except for BARI Masur-5 (V_5) and BARI Masur-6 (V_6) rest five varieties showed an upward tendency in secondary number of branches per plant up to harvest (Fig 4). In order to build vegetative structure, plants developed branches but when it commenced reproductive growth cessation in some parts occurred and the primary branches might have been converted in secondary branches thus a reduction was noticed; which gave rise number of secondary branches with elapse to time. Zahan *et al.* (2009) observed varietal differences in branch number in BARI varieties.

Initially up to 75 DAS TDM demonstrated a slow increase (Fig 5). From 75 DAS to 90 DAS the rise was very slow. But from 90 DAS to harvest TDM boosted rapidly. Though significant differences were noted among the varieties in dry mass accumulation up to 75 DAS but at harvest it was non-significant. Shrestha *et al.* (2005) reported an increase in the amount of dry matter accumulation with elapse of time (with increasing DAS) on lentil genotypes.

AGR followed a divergent trend in the lentil varieties (Fig 6). Varieties Binamasur-8 (V_2) and Binamasur-10 (V_4) showed downward trend in AGR at 45 DAS to 60 DAS but other five varieties showed upward trend. Though at 60 DAS to 75 DAS a rise in AGR of all the varieties were noticed but it again declined at 75 DAS to 90 DAS. During final harvest all varieties showed increased and similar AGR. Dissimilarities in AGR among the varieties might be ascribed to varied physiological factors among the varieties. Greater growth rates during the vegetative and blooming stages are preferred for improved grain production in lentil. Yield properties are reflected by the crop's capacity to capture solar energy early on and then use it for biomass production later on (Hanlan *et al.,* 2006). Similar findings were also narrated by Mondal *et al.* (2013).

RGR ensued a zigzag pattern in the lentil varieties excluding Binamasur-9 (V_3) (Fig 7); which appeared a straight decline up to 75 DAS to 90 DAS. During harvest highest RGR was obtained from Binamasur-8 (V_2) and the lowest was found with BARI Masur-5 (V_5). Khanam *et al.* (2018) spotted similar patterns in RGR among four lentil genotypes in Magura district at *rabi* season.

Preliminary rise in CGR was extremely slow up to 60 DAS to 75 DAS; but after that RGR dropped remarkably at 75 DAS to 90 DAS (Fig 8). Afterward all the seven varieties displayed a mounting at 90 DAS to harvest. At this time utmost CGR was shown by Binamasur-9 (V_3) and the least with BARI Masur-8 (V_7). Maximum utilization of environmental resources aided lentil varieties to peak CGR

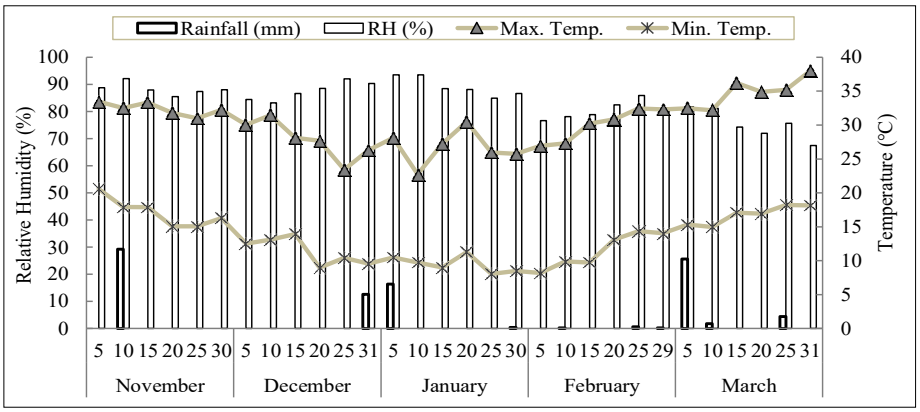

Fig 1: Weather data of BINA Sub-station, Magura between November 2019 to March 2020 (Source: BINA, 2020).

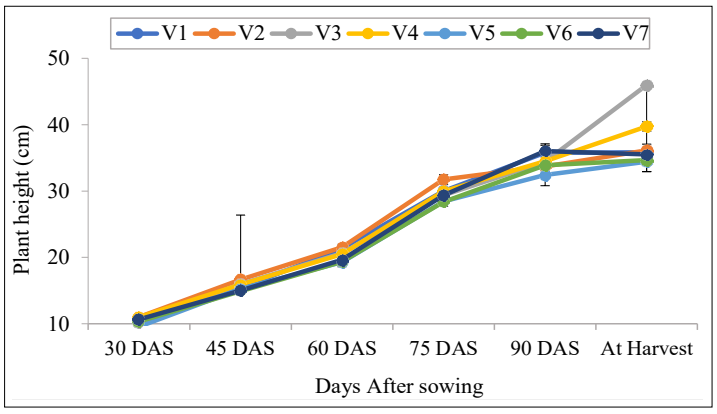

Fig 2: Plant height of the lentil varieties at different days after sowing.

at the reproductive phase. During harvest CGR was supposed to decline but the varieties might still be accumulating dry mass thus CGR did not drop. Singh *et al.* (2016) noticed a downward trend of CGR in lentil treated with phosphorus and biofertilizers. Khan *et al.* (2015) reported similar results in soyabean genotypes.

Amongst the varieties abundant plant population in the unit plots (4.5 m^2) was noticed with BARI Masur-6 (V_6); whereas Binamasur-5 (V_1) had the scarce number of plants. Reason of heterogenous number of plants was due to insect pest and disease infestation (Table 1). Tolerant varieties showed satisfactory plant population over susceptible varieties. Adhikari *et al.* (2018) narrated deviations in plant population among the lentil genotypes.

Number of pods per plant and seeds per pod was most in Binamasur-5 (V_1) and Binamasur-10 (V_4) (Table 1). Contrary the least pods and seed per plant was recorded with BARI Masur-6 (V_6). Dissimilarities in number of pods and seeds per plant might be due to genetic variability among the varieties. Ouji *et al.* (2021) found the existence of significant genetic variability among the lentil lines.

Heaviest TGW was noticed in Binamasur-9 (V_3) conversely, lightest was noted with BARI Masur-6 (V_6) (Table 1). Disparities in TGW was may be due to seed size, shape

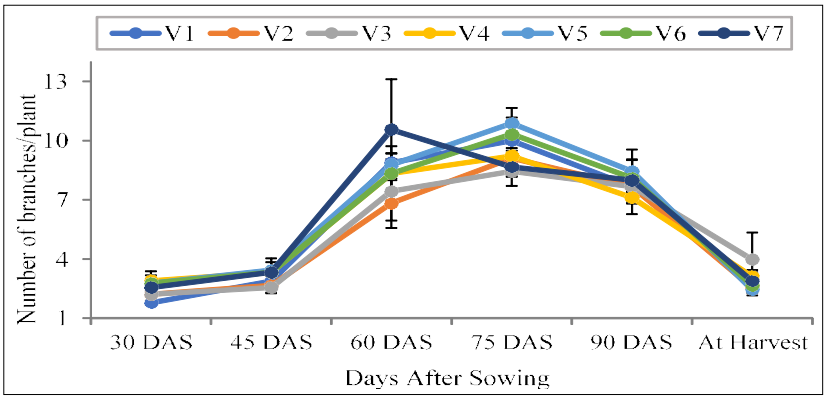

Fig 3: Number of branches per plant at different days after sowing.

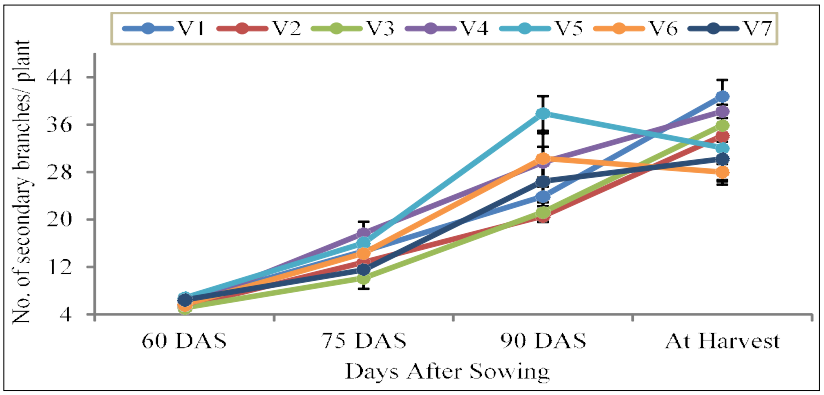

Fig 4: Number of secondary branches per plant at different days after sowing.

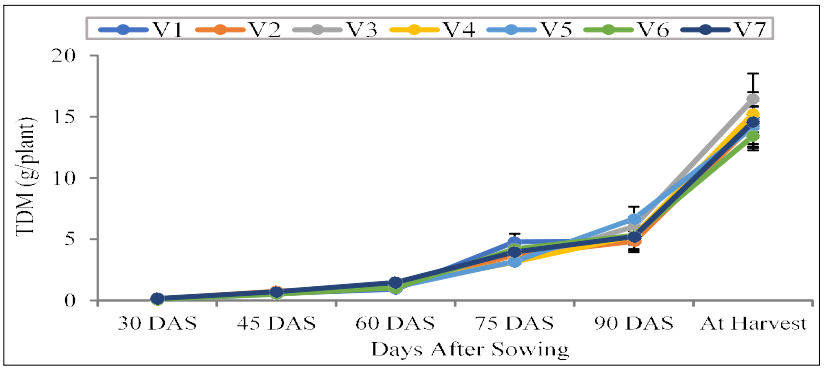

Fig 5: Total dry mass (TDM) of lentil varieties at different days after sowing.

and boldness. Varied TGW due to genotypes were previously annotated by Yadav *et al.* (2016).

In terms of maturity, BARI Masur-5 (V_5) matured most late while earliest days to maturity was marked in Binamasur-8 (V_2) (Fig 9). Duration of a variety is mostly genetic character but it may also be influenced by environmental factors. Sarkar *et al.* (2021) stated that, cultivation in medium low land may delay lentil maturity.

Yield

Highest seed yield and HI was obtained from Binamasur-10 (V_4) (Table 1, Fig 9). However, the lowest seed yield was gained with BARI Masur-6 (V_6) but least HI was produced by BARI Masur-5 (V_5). Stover yield was maximum in BARI Masur-5 (V_5) and minimum at BARI Masur-5 (V_5). Seed yield was relied on better assimilate partitioning to economic yield, genetic potentiality, insect disease tolerance, better utilization of natural resources, inputs etc. factors. Varieties which build up more vegetative growth yielded less seed, HI and vice versa. Roy *et al.* (2019) found maximum yield of Binamasur-10 (LG-208 line) among numerous lentil accessions in Magura grown in winter. Singh and Sharma (2021) indicated that nutrient uptake significantly improved

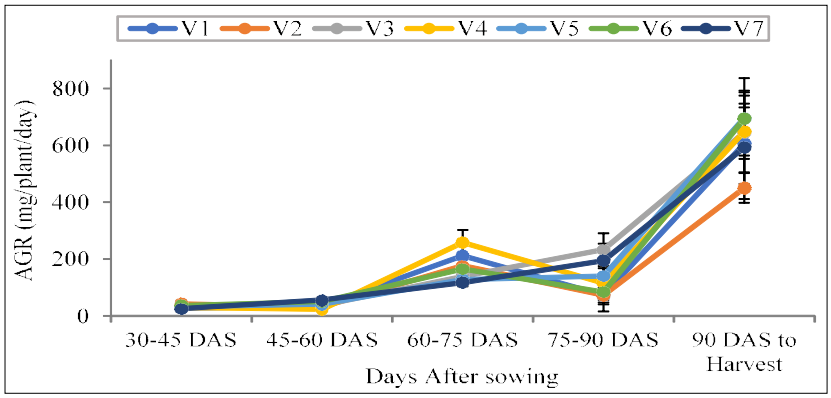

Fig 6: Absolute growth rate (AGR) of lentil varieties at different days after sowing.

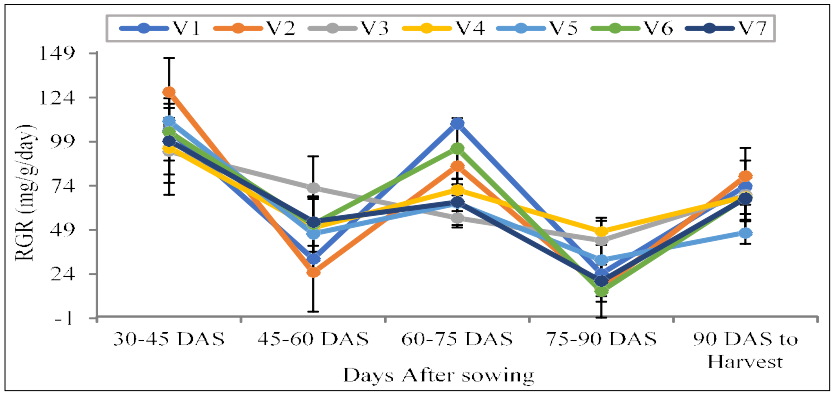

Fig 7: Relative growth rate (RGR) of lentil varieties at different days after sowing.

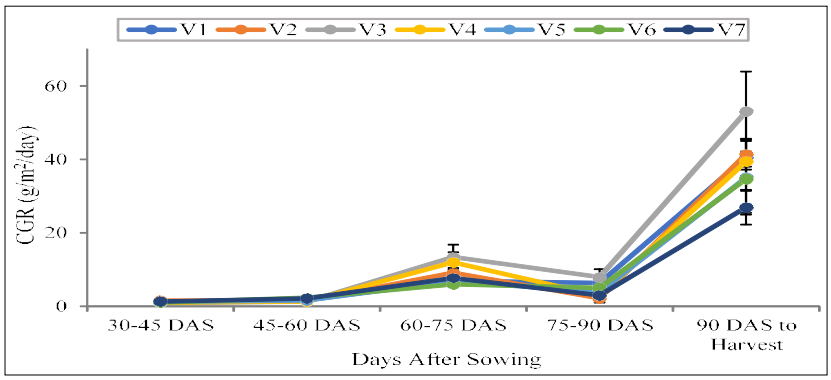

Fig 8: Crop growth rate (CGR) of lentil varieties at different days after sowing.

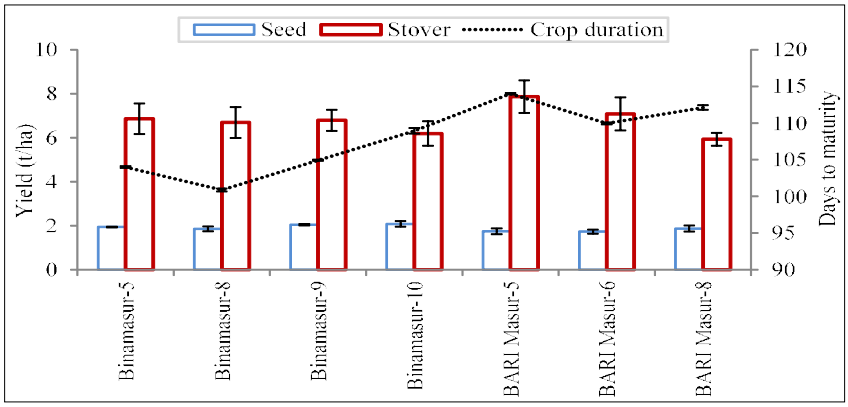

Fig 9: Mean yield and life duration of the studied lentil varieties.

Table 1: Yield and morpho-physical attributes of lentil varieties.

Variety	Plant population @ 4.5 m^2	No. of pods/plant	No. of seeds/pod	Seed yield/ plot (g)	TGW (g)	HI (%)
Binamasur-5 (V_1)	180.67c	207.11a	1.66ab	874.00ab	22.14e	22.06ab
Binamasur-8 (V_2)	238.67ab	190.89ab	1.74a	841.33bc	23.31c	21.75ab
Binamasur-9 (V_3)	239.00ab	205.77a	1.74a	921.33ab	26.28a	23.60ab
Binamasur-10 (V_4)	251.67ab	191.11ab	1.75a	940.00a	24.43b	25.15a
BARI Masur-5 (V_5)	255.67ab	160.89b	1.56b	788.67c	20.25f	18.21b
BARI Masur-6 (V_6)	275.00a	158.66c	1.56b	780.00c	19.26g	19.64ab
BARI Masur-8 (V_7)	224.33bc	195.11a	1.74a	843.33bc	22.39d	23.78ab
LSD	46.56	32.17	0.16	84.82	0.13	10.34
Level of significance	0.10	0.10	0.05	0.10	0.05	0.10
SEm	26.12	18.05	0.07	47.59	0.06	2.36
CV	13.45%	11.82%	5.23%	6.81%	0.33%	11.06%

Figures in a column having different letter (s) differ significantly at 5% or 10% level of probability according to LSD.

Table 2: Simple correlation among different quantitative characters of the lentil varieties.

Characters	Plant height	Number of primary branches	Number of secondary branches	TDM	Seed yield	HI
No. of pods	0.56NS	0.63NS	0.71*	0.78*	0.79*	0.75*
TGW	0.88**	0.81*	0.57^{NS}	0.93**	0.90**	0.75*
Seed yield	0.78*	0.76*	0.75*	0.87**	-	0.85**

*, ** and NS indicate significant at 5%, 1% and Non-significant level of probability respectively.

grain and biomass yield of lentil. Current outcomes are in conformity with the previous findings.

Correlation study among different attributes

Number of pods per plant is the main seed yielding indicator that has a positive relationship with plant height. The pod number showed significant positive correlations with secondary branch number (r = 0.71*), TDM (r = 0.78*), seed yield (r = 0.79*) and HI (r = 0.755*). TGW showed significant positive correlations with plant height (r = 0.88**), primary branch number (r = 0.81*), TDM (r = 0.93**), seed yield (r = 0.90**) and HI (r = 0.75*). The seed yield was also significantly correlated with plant height (r = 0.78*), primary branch number (r = 0.76*), secondary branch number (r = 0.75*), TDM (r = 0.87**) and HI (r = 0.85**). Hence seed yield was 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 Kumar *et al.* (2017).

CONCLUSION

Besides satisfactory yield component characters a variety should also bear the ability to develop a higher growth rate during it's vegetative stage and utilize effective partitioning of dry matter for delivering better economic yield. It should also possess some tolerance to biotic and abiotic stresses. Here, Binamasur-10 performed better over the other varieties in terms of seed and stover yield following moderate life duration. Thus, for Magura district cultivation of Binamasur-10 as a new and promising variety may give higher yield over the existing variety or cultivars.

Conflict of interest

We don't have known conflict of interest to declare regarding the publication of this article.

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