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Research Article

The Response of Lentil (*Lens culinaris* Medik.) to Variety and Water Management under Old Brahmaputra Floodplain Soil of Bangladesh

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Abstract

Water scarcity is one of the major stresses that limit plant growth. Lentil is cultivated in Bangladesh by using residual soil moisture. Considering this point, the present study was undertaken to determine the effect of water management on the growth and yield of lentil. An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November 2016 to March 2017 to study the growth and yield of lentil varieties as influenced by water management. The variety comprised of BARI Masur- 4, BARI Masur-6 and BINA Masur-4 and water management system comprised of rainfed condition, irrigation at flowering stage, mulching with water hyacinth and mulching with straw. The experimental field was laid out in split plot design with three replications where water management system was in main plot and variety was in sub plot. Regarding growth, plant height (37.13 cm) and nodule number (31.78) were highest in mulching with water hyacinth. Regarding yield and yield contributing characters, the number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed and stover yield (t ha^{-1}) were significantly influenced by water management system. The highest number of seed pod^{-1} was recorded in mulching with water hyacinth condition × BARI Masur- 6 (1.72) followed by BINA Masur- 4 × mulching water hyacinth condition (1.71). The highest seed yield (1.65 t ha^{-1}) was recorded in mulching with water hyacinth × BARI Masur- 6. The lowest yield and yield contributing characters were recorded in rainfed condition in all varieties. Mulching with water hyacinth increases the seed yield up to 40%. Finally, it can be concluded that cultivation of BARI Masur- 6 mulching with water hyacinth may give the best of lentil in Brahmaputra Floodplain Soil.

Introduction

Lentil (*Lens culinaris* Medik.) is a leguminous crop and one of the oldest edible crops (Sandhu and Singh, 2007). The origin of Lentil is the Middle East (Alexander, 2015). The crop is most excellent tailored for production in temperate climates but is at the present produced in various regions of the world (Tullu et al., 2011). The three countries such as Canada, India and Australia produced approximately 68% of global lentil production in 2019 (FAOSTAT, 2021). The cultivation of this legume has progressively enlarged in Bangladesh during the last 20 years. The curiosity in grain legumes, which are a main substitute source of protein to meat for the future, is rising at present (Alandia et al., 2020; Pulvento et al., 2021; Sellami et al., 2021).

Lentil plays an important task in human nutrition and the environment, to decrease dependence on non-renewable resources and chemicals (Ruisi et al., 2017) and progresses the soil fertility (Sarker et al., 2011). It can fix atmospheric nitrogen (N_2) because of its symbiotic association with rhizobium and diminish the requirement for artificial nitrogen fertilizers. Lentil is a high-nutritional food. Its protein content is about 30%; the existence of vitamins is also noticeable, particularly of the B group. Iron is there to a greater amount than in wheat and rice kernels (Muehlbauer et al., 1985). Lentil seeds symbolize a low-cost resource of protein and starch, with the benefit of being resistant to starch as compared to cereal, root, and tuber starch (Tayade et al., 2019).

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Because of diverse biotic and/or abiotic stresses the lentil experiences substantial yield losses, similar to other crops (Sellami et al., 2019). The lentil is usually grown in dry environment and repeatedly faces water deficit during main growth stages (Foti and Abbate, 2000). Lentil also faces temperature limits during its life cycle, mainly heat stress (Shrestha et al., 2006) and is brutally affected by extensive and strong frosts during reproductive growth (Foti and Abbate, 2000). Drought stress is a general concern for successful crop production in many areas of the world. This abiotic stress accrues when the combination of physical and environmental factors causes the inner tension in plant and decrease the yield (Blum, 2002). Water deficit affects almost all morphological and physiological traits that related to growth and decreased even 50% crop yield (Wang et al., 2003). Lentil which is mostly grown as a rainfed crop often faces terminal moisture stress in arid regions that lead to early maturity and low yield. Yield loss of lentil due to drought ranges from 6–54 % related to stress intensity. Supplemental irrigation at the critical stages of plants (flowering stage), is one of the most efficient methods to check fluctuation and to achieve sustainable lentil production in arid and semi-arid regions (Parsa and Bagheri, 2009).

Under rainfed condition, lentil crop usually faces moisture stress due to low rainfall. Although lentils are well-adapted for tolerating dry conditions, a considerable decrease in productivity has been reported by several investigators. Several investigators reported 20% increase in yield, when lentils were grown in irrigated condition. But Saxena and Wasimi (1980) were able to obtain seed yields 60% higher, where no irrigation was provided because of enough stored soil moisture. In Bangladesh, farmers cultivate lentil in winter from late November to February, water limited environment where unfavorable soil moisture at sowing often conditions severely seed germination resulting in an irregular seedling emergence which in turn affects the establishment of a stand with negative effects on the yield (Mwale et al., 2003; Okcu et al., 2005).These results underscore the importance of water requirement of lentil. Therefore, the aim of the present study was to investigate the productivity of lentil varieties under rainfed and irrigated condition in old Brahmaputra floodplain soil of Bangladesh.

Materials and Methods

Site description

The experiment was carried out at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh (latitude: 24°42΄55΄΄, longitude: 90°25΄47΄΄) November 2016 to March 2017. The experimental field was located at an elevation of 18 m above the sea level belonging to non- calcareous dark grey floodplain soil under the Sonatala series of the Old Brahmaputra Floodplain which falls under AEZ-9(Old Brahmaputra Floodplain). The climate is humid subtropical monsoon. Beside this, the soil of the experimental field was more or less neutral in reaction with low in organic matter and its general fertility level was also low (Table 1).

Experimental design and treatment

Two factors were included in the experiment. These include three varieties viz. V_1 - BARI Masur-4, V_2 - BARI Masur-6, V_3-BINA Masur-4 and four water management systems e.g. S_1- rainfed or non irrigated condition, S_2- one irrigation at flowering, S_3-mulching with water hyacinth and S_4 -mulching with straw. The experimental field was laid out in split plot design with three replications assigning water management system in main plot and variety in sub plot. In irrigated condition, irrigations were applied once at critical stage (flowering) of growth. In mulching condition, two types of mulching were applied, one with straw and another one with water hyacinth. In rainfed condition, no irrigation was applied during the crop growth stage. Total rainfall from November 2016 to March 2017 of the experimental site during the crop growth period was 8.57 mm, which indicated that the plants received water stress during the experimental period as the experimental soil was silty (Sarker et al., 2017).

Seed sowing and intercultural operations

Seeds were sown in the field on 22nd November, 2016 at the rate of 30 kg ha^{-1}. First weeding and thinning of seedlings were done at 20 days after sowing (DAS) for maintaining uniform plant stands. Second weeding was done at 35 DAS. The experimental plots were frequently observed to notice any change in plant characters and attack of pests and diseases on the crop.

Data collection

Data on growth at different dates after sowing (15, 30, 45 and 60 DAS) were collected. Crop was harvested when about 80% pods of the plants became mature at first plants were uprooted and bundled separately pot-wise. Bundles were tagged and brought to the threshing floor. All of the harvested pods were kept separately in properly tagged gunny bags. The crop bundles were sun-dried for three days on the threshing floor. Seeds were separated from the plants by beating them with bamboo stick. Seeds thus collected were sun dried for reducing the moisture. Seed yield and stover yield were recorded.

Statistical Analysis

The collected data were analyzed statistically using the Analysis of Variance (ANOVA) technique with the help of computer package M-STAT and mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Growth Parameters

Plant height

Variety did not show significant effect on plant height at all the sampling dates except 15 DAS (Table 1). It was observed that plant height significantly affected at 15 days after sowing. At 15 DAS, BARI Masur- 6 produced the tallest plant (8.19 cm) among the varieties and the shortest plants were produced from BINA Masur- 4 (7.91 cm). The water management had significant effect on the height of plant at all growth stages (Table 2).Ullah et al. (2017) reported that difference in plant height could be due to variation in genetic make-up or the hormonal balance and cell division rate that result in changes in the plant height of the diverse varieties. It was observed at 15 DAS the highest plant height was observed by mulching with water hyacinth (9.33 cm) and at 30, 45, 60 and 75 DAS the highest plant height was also obtained from mulching with water hyacinth (15.88 cm, 21.55 cm, 29.00 cm and 36.29 cm). At 15, 30, 45, 60 and 75 DAS the lowest plant height was observed in rainfed or no-irrigation condition (7.26 cm, 11.73 cm, 17.42 cm, 22.86 cm and 28.57 cm). Plant height was not significantly influenced by the interaction between variety and planting system at 30, 45, 60 and 75 DAS (Table 3). The highest plant height (9.65 cm) was recorded in S_3V_3 which was statistically similar those of S_3V_2 (9.59 cm) at 15 DAS. At all interaction, the lowest plant height was produced at 30 (S_1V_3, 9.48cm), 45 (S_1V_2, 15.60 cm), 60 (S_1V_2, 22.46 cm which are identically similar to S_1V_1, 22.57cm) and 75 DAS (S_1V_1, 26.94cm which are identically similar to S_1V_2, 27.20 cm).

Number of nodules plant^{-1}

Variety had no significant effect on the number of nodules plant^{-1} at all the sampling dates except 75 DAS (Table 1). It was observed that number of nodules plant^{-1} significantly affected at 75 days after sowing. At 75 DAS BINA Masur-4 produced the highest number of nodule (24.83), among the varieties and the lowest number of nodule were produced from BARI Masur-6 (22.06). BARI Masur-4 produced the similar number of nodule close to BARI Masur-6 (22.37). Rahman (2007) also found that varieties significantly affect the nodule number of plant. The water management had significant effect on the nodule number at all growth stages (Table 2).The highest nodule number was observed by mulching with water hyacinth at 15, 30, 45, 60 and 75 DAS and the result was (1.77, 7.78, 16.90, 23,86 and 29.35). At 15, 30, 45, 60 and 75 DAS the lowest nodule number was observed in rainfed or no-irrigation condition (0.91, 4.91, 11.57, 14.48 and 19.08).Nodule number was not significantly influenced by the interaction between variety and planting system at all the sampling dates except 75 DAS (Table 3).

Table 1. Effect of variety on plant height and number of nodules plant^{-1} at different days after sowing

Variety	Plant height(cm)					Number of nodules plant^{-1}				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
V_1	7.97b	12.94	19.64	26.90	31.38	1.31	5.98	13.63	20.49	22.37b
V_2	8.19a	13.21	18.79	26.71	31.58	1.40	5.90	15.09	18.73	22.06b
V_3	7.91b	13.12	19.21	25.48	33.39	1.26	6.74	14.76	18.22	24.83a
Level of sig.	**	NS	NS	NS	NS	NS	NS	NS	NS	**
CV (%)	3.96	18.71	6.98	8.66	8.37	7.53	15.18	15.27	19.16	13.13

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, NS=Not significant, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Table 2. Effect of water management on plant height and number of nodules plant^{-1} at different days after sowing

Water management	Plant height (cm)					Number of nodules plant^{-1}				
	15DAS	30DAS	45DAS	60DAS	75DAS	15DAS	30DAS	45DAS	60DAS	75DAS
S_1	7.26c	11.73b	17.42c	22.86c	28.57c	0.91d	4.91c	11.57b	14.48c	19.08b
S_2	7.65b	12.82b	18.49 bc	27.63ab	32.60b	1.38b	6.46b	15.10a	20.21ab	21.25b
S_3	9.33a	15.88a	21.55a	29.00a	36.29a	1.77a	7.78a	16.90a	23.86a	29.35a
S_4	7.86b	11.92b	19.39b	25.95b	31.00bc	1.23c	5.67bc	14.41a	18.04bc	22.65b
Level of sig.	**	*	**	**	**	**	**	**	**	**
CV (%)	2.50	11.87	10.69	11.40	9.22	12.82	13.77	10.01	09.26	5.90

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, *=Significant at 5% level of probability. S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw

Table 3. Effect of interaction between variety and water management on plant height and number of nodules plant^{-1} at different days after sowing

Interaction	Plant height (cm)					Number of nodules Plant^{-1}				
	15DAS	30DAS	45DAS	60DAS	75DAS	15DAS	30DAS	45DAS	60DAS	75DAS
S_1xV_1	7.16ef	13.42	17.91	22.57	26.94	0.89	4.15	12.18	17.22	19.43de
S_1xV_2	7.65d	12.30	15.60	22.46	27.20	1.11	4.99	11.23	12.78	16.04f
S_1xV_3	6.97f	9.48	18.75	23.56	31.56	0.73	5.59	11.29	13.44	21.78cd
S_2xV_1	7.48de	11.77	16.19	29.41	30.11	1.22	7.29	13.45	20.51	21.73cd
S_2xV_2	8.12c	11.37	20.17	27.34	31.54	1.46	5.96	17.00	18.34	18.38ef
S_2xV_3	7.37de	15.33	19.12	26.15	36.14	1.48	6.11	14.84	21.78	23.64bc
S_3xV_1	8.74b	15.50	22.80	31.54	35.02	1.84	6.99	16.03	25.06	25.80b
S_3xV_2	9.59a	16.48	21.44	28.79	36.72	1.63	7.43	15.26	24.37	30.47a
S_3xV_3	9.66a	15.65	20.40	26.68	37.13	1.84	8.92	19.40	22.16	31.78a
S_4xV_1	8.51b	11.07	21.65	24.09	33.46	1.29	5.48	12.85	19.18	22.51c
S_4xV_2	7.43de	12.69	17.95	28.24	30.84	1.41	5.21	16.88	19.44	23.33c
S_4xV_3	7.65d	12.01	18.59	25.52	28.71	1.017	6.33	13.51	15.48	22.11c
Level of sig.	**	NS	NS	NS	NS	NS	NS	NS	NS	**
CV%	2.50	11.87	10.69	11.40	9.22	12.82	13.77	10.01	09.26	5.90

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, NS=Not significant. S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Plant dry weight

Plant dry weight was significant for all the varieties at all sampling dates (Table 4). The plant dry weight showed an increasing trend and attained the peak for in BARI Masur-4 (5.06g), in BARI Masur-6 (3.74g) and BINA Masur-4 (4.40g) (Table 4).The increasing dry weight of plant over time mainly depend on leaf dry weight and stem dry weight and photosynthetic organs would be also increased over time that causes improvement in plant dry weight. Varietal differences regarding the plant dry weight might be due to their differences in genetic Constituents. Water management has significant effect of plant dry weight for all the varieties at all sampling dates (Table 5). The plant dry weight showed an increasing trend and attained the peak for rainfed condition (3.40 g) and three water management systems such as one irrigation at flowering (3.71g), mulching with water hyacinth (6.36g), mulching with straw (4.12g) (Table 5). Among them lowest plant dry weight was observed in rainfed condition and highest was recorded at mulching with water hyacinth condition. This is due to the water shortage at flowering and supply or conservation of water can solve this problem. A comparable result was founded by Latif (2006), where two irrigations produced more dry matter plant^{-1} compared to one irrigation. It was observed plant dry weight (Table 6) production was significantly affected by interaction of variety and water management system. At 15 DAS maximum plant dry weight was produced in S_3V_3 (0.24g) and the minimum plant dry matter was produced in S_1V_3 (0.05g) followed by S_2V_2 (0.05g) and S_2V_1 (0.06g). At 30 DAS the highest value was obtained from S_3V_1 (0.67g) and the lowest value was from S_3V_1 (0.67g). At 45 DAS the highest amount of dry matter was found in S_3V_3 (1.34g) followed by S_3V_2 (1.25g) and S_3V_1 (1.24g) and the lowest from S_1V_1 (0.33g). At 60 DAS the highest amount of dry matter was found in S_3V_2 (3.63g) and the lowest from S_1V_2 (1.43g) followed by S_1V_1 (1.52g). At 75 DAS the highest amount of dry matter was found in S_3V_1 (6.90g) and the lowest from S_2V_2 (2.29g).

Root dry weight

Root dry weight was not significant for all the varieties at all sampling dates (Table 4) except 45 and 75 DAS. The highest root dry weight was recorded in BARI Masur- 4 (0.35g) at 45 DAS and BINA Masur- 4 (0.30g) at 45 and 75DAS (Table 4).Rahman (2007) also reported that varieties significantly affect the root dry weight of plant. Water management has significant effect of root dry weight for all the varieties at all sampling dates (Table 5). The root dry weight showed an increasing trend and attained the peak for a certain period (60 DAS) and then started to decrease (Table 5). Among them lowest root dry weight was observed in rainfed condition (0.14g) and highest recorded at mulching with water hyacinth condition (0.44g). This is due to the water shortage at flowering stage of plant growth and supply or conservation of water can solve this problem. It was observed root dry weight production was significantly affected by interaction of variety and water management system at 15, 30 and 75 DAS but non-significant for 45 and 60 DAS (Table 6). At 15 DAS maximum root dry weight was produced in S_3V_2 (0.08g) and the minimum root dry weight was produced in S_1V_3 (0.03g). At 30 DAS the highest value was obtained from S_3V_1 (0.17g) followed by S_3V_2 (0.17g) and S_3V_3 (0.17g) and the lowest value was from S_1V_1 (0.06g) followed by S_1V_3 (0.07g) and S_2V_1 (0.07g). At 75 DAS the highest amount of root dry matter was found in S_3V_1 (0.47g) and the lowest from S_1V_1 (0.11g).

Table 4. Effect of variety on the dry matter production of lentil

Variety	Plant Dry Weight (g)					Root Dry Weight (g)				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	15 DAS	30 DAS	45 DAS	60DAS	75DAS
V_1	0.08	0.40a	0.69c	2.48b	5.06a	0.048	0.11	0.35a	0.25	0.24b
V_2	0.09	0.32b	0.86b	2.90a	3.74c	0.046	0.10	0.31b	0.25	0.25b
V_3	0.10	0.41a	1.05a	2.49b	4.40b	0.046	0.11	0.30b	0.26	0.30a
Level of sig.	NS	*	**	**	**	NS	NS	**	NS	**
CV (%)	12.34	11.66	9.13	7.45	13.83	10.00	12.56	11.34	10.47	8.23

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, *=Significant at 5% level of probability, NS=Not significant. V_1 = BARI Masur-4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Table 5. Effect of water management on the dry matter production of lentil

Water management	Plant Dry Weight (g)					Root Dry Weight (g)				
	15DAS	30DAS	45DAS	60DAS	75DAS	15DAS	30DAS	45DAS	60DAS	75DAS
S_1	0.07b	0.26c	0.67b	1.89c	3.40c	0.03	0.07b	0.17c	0.22b	0.14d
S_2	0.06b	0.28c	0.69b	2.47b	3.71bc	0.04	0.09b	0.36ab	0.20b	0.26b
S_3	0.17a	0.57a	1.27a	3.41a	6.36a	0.07	0.17a	0.47a	0.38a	0.44a
S_4	0.08b	0.39b	0.84b	2.71b	4.12b	0.04	0.10b	0.28b	0.22b	0.21c
Level of sig.	**	**	**	**	**	**	**	**	**	**
CV (%)	11.42	12.50	10.08	9.10	10.83	12.00	10.05	12.72	12.52	10.32

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, **=Significant at 1% level of probability

Table 6. Effect of interaction between variety and water management on the dry matter production of lentil

Interaction (SxV)	Plant Dry Weight (g)					Root Dry Weight (g)				
	15DAS	30DAS	45DAS	60DAS	75DAS	15DAS	30DAS	45DAS	60DAS	75DAS
S_1xV_1	0.06	0.08e	0.33e	1.52f	4.14cde	0.046	0.06c	0.23	0.22	0.11f
S_1xV_2	0.08	0.25d	0.80cd	1.43f	2.63fg	0.040	0.08bc	0.17	0.19	0.19cd
S_1xV_3	0.05	0.44bc	0.90bc	2.71d	3.44ef	0.026	0.07c	0.10	0.24	0.13ef
$S_{2x}V_1$	0.06	0.31cd	0.45e	2.08e	4.34cde	0.043	0.07c	0.37	0.22	0.20cd
S_2xV_2	0.05	0.19de	0.65d	3.26abc	2.29g	0.033	0.09bc	0.32	0.19	0.17de
S_2xV_3	0.07	0.34cd	0.98b	2.09e	4.49cd	0.043	0.12abc	0.40	0.20	0.41b
S_3xV_1	0.12	0.67a	1.22a	3.49ab	6.90a	0.060	0.17a	0.51	0.36	0.47a
S_3xV_2	0.17	0.51b	1.25a	3.63a	6.20ab	0.076	0.17a	0.45	0.39	0.43ab
S_3xV_3	0.24	0.54ab	1.34a	3.12bcd	5.97b	0.073	0.17a	0.45	0.39	0.42ab
S_4xV_1	0.09	0.52b	0.77cd	2.83cd	4.85c	0.043	0.14ab	0.29	0.22	0.20cd
S_4xV_2	0.07	0.33cd	0.75cd	3.28ab	3.84de	0.036	0.08c	0.30	0.22	0.21cd
S_4xV_3	0.06	0.33cd	1.00b	2.04e	3.69de	0.043	0.08bc	0.24	0.22	0.23c
Level of sig.	NS	**	**	**	**	*	**	NS	NS	**
CV (%)	11.42	12.50	10.08	9.10	10.83	12.00	10.05	12.72	12.52	10.32

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, *=Significant at 5% level of probability, NS=Not significant. S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Yield attributes and yield

Plant height

Among the yield and yield contributing characters of lentil, plant height was significantly influenced by these three varieties (Table 7).The tallest plants were found in the variety BINA Masur- 4 (38.14 cm) while the shortest plants in BARI Masur-4 (34.52 cm). BARI Masur- 6 plants were medium in height (35.04 cm) among these three varieties. Among the yield and yield contributing characters of lentil, plant height was significantly influenced by water management (Table 8). The tallest plants were found in the mulching with water hyacinth (46.20 cm) while the shortest plant was in no irrigation condition (28.98 cm). This variation is due shortage of water in flowering stage of growth and it can overcome through water management. Latif (2006), Piri *et al.* (2011) and Hosseini *et al.* (2011) have found related results when applying two irrigations for the period of branching and pod development stage. Plant height was significantly influenced by the interaction between variety and planting system (Table 9). The highest plant height (47.72 cm) was recorded in S_3xV_1 (mulching with water hyacinth and BARI Masur-4). The lowest plant height (26.43 cm) was recorded from the combination S_1xV_2 (no irrigation and BARI Masur-6).

Number of branches plant^{-1}

Variety has significant effect on total number of branches per plant (Table 7). Among these three varieties, the highest branches number were recorded in the variety BINA Masur-4 (5.50) while the lowest branches number in plant recorded in the variety BARI Masur- 4 (5.11).Number of branches recorded in BARI Masur-6 (5.31) , for that reason it belongs to the middle position among these three varieties. This difference in branches number might be due to the genetic makeup as realized under the field condition. Water management has significant effect on total number of branches plant^{-1} (Table 8). The highest number of branches was recorded in mulching with water hyacinth (6.51) while the lowest number of branches in plant recorded in rainfed condition (4.50).This variation is due to supply of water at flowering stage of growth. Hosseini *et al.* (2011) also stated that two irrigations gave the highest number branches per plant and the lowest was originated in case of without irrigation. Number of branches plant^{-1} was significantly influenced by the interaction between variety and planting system (Table 9). The highest number of branches plant^{-1} (6.70) was recorded in S_3xV_2 (mulching with water hyacinth and BARI Masur-6). The lowest number of branches plant^{-1} (4.16) was recorded from the combination S_1xV_1 (no irrigation and BARI Masur-4 followed by S_1xV_2 (4.30) (no irrigation and BARI Masur-6).

Number of pods plant^{-1}

Total number of pods plant^{-1} was significantly affected by different varieties (Table 7). The number of pods ranged from 52.71 to 55.85. The highest pod (55.85) was obtained in the variety BARI Masur-6 and the lowest number of pod was recorded in the variety BARI Masur-4 (54.93). BARI Masur- 4 (59.16) had the medium number of grain. This difference might be due to the genetic variation, climatic and edaphic factors. In the same way Mohammadjanloo et al. (2009) and Rahman et al. (2015) reported that variation for number of pods per plant among various lentil varieties. Water management has significant effect on total number of pod plant^{-1}(Table 8). The highest pod number were recorded in mulching with water hyacinth condition (57.2) while the lowest branch number in plant recorded in rainfed condition (51). Interaction between variety and planting system (Table 9) has significant effect on number of pods plant^{-1}. The highest number of pods plant^{-1} was recorded from the combination S_3xV_2 (66.20) while the lowest number of pods plant^{-1} recorded from the combination S_1xV_1 (42.70).

Number of seeds pod^{-1}

Total number of seed pod^{-1} was significantly affected by different varieties (Figure 1). The number of seed pod^{-1} ranged from 1.49 to 1.57. The highest number of seed in pod was recorded (1.57) in the variety BARI Masur- 6 and the lowest number of seed pod^{-1} was recorded in the variety BARI Masur- 4 (1.49). This difference might be due to the genetic variation, climatic and edaphic factors. In contrary, Sharar et al. (2003) who had reported significant genotypic variation in the varieties of lentil for production of seeds pod^{-1}.Water management has significant effect on total number of seed pod^{-1}(Figure 2). The highest branch number were recorded in mulching with water hyacinth (1.71) while the lowest number of seed pod^{-1} recorded in rainfed condition (1.34).This variation is due to supply of water at flowering stage of growth. These results were conformity by Biswajit and Pal (2005), Hossain et al. (2007), Sila et al. (2005), Saha et al. (2004) respectively. Interaction between variety and planting system has significant effect on total number of seeds pod^{-1} (Figure 3). The highest number of seeds pod^{-1} were recorded from the combination S_1xV_2 (1.72) followed by the combination S_3xV_3 (1.713). While the lowest number of seeds pod^{-1} recorded from the combination of S_1xV_1 (1.30) (no irrigation and BARI Masur-4).

Table 7. Effect of variety on the yield and yield contributing characters of lentil

Variety	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Stover Yield (t ha^{-1})
V_1	34.52c	5.11c	52.71c	1.02b
V_2	35.04b	5.31b	55.85a	0.99c
V_3	38.14a	5.50a	54.01b	1.14a
Level of sig.	**	**	**	**
CV (%)	0.85	4.69	1.02	0.48

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) , **=Significant at 1% level of probability, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Table 8. Effect of water management on the yield and yield contributing characters of lentil

Water management	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Stover Yield (tha^{-1})
S_1	28.98d	4.50c	57.26a	0.94 d
S_2	32.38c	5.15b	0.18d	1.04b
S_3	46.20a	6.51a	55.85b	1.23a
S_4	36.04b	5.08b	54.01c	1.01c
Level of sig.	**	**	**	**
CV (%)	1.09	3.28	0.75	1.14

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT),**= Significant at 1% level of probability, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw

Table 9. Effect of interaction between variety and water management on the yield and yield contributing characters of lentil

Interaction	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Stover Yield (t ha^{-1})
S_1xV_1	27.10hi	4.16g	42.70j	0.92i
S_1xV_2	26.43i	4.30g	46.07h	0.88j
S_1xV_3	33.40g	5.03de	45.02i	1.01g
S_2xV_1	27.27h	4.63f	49.90g	1.03ef
S_2xV_2	34.27f	5.33cd	52.95e	1.02fg
S_2xV_3	35.60e	5.50c	51.8of	1.07cd
S_3xV_1	47.72a	6.53ab	61.66b	1.09bc
S_3xV_2	44.77c	6.70a	66.20a	1.10b
S_3xV_3	46.13b	6.30b	62.20b	1.50a
S_4xV_1	36.00e	5.13de	56.59d	1.05de
S_4xV_2	34.7of	4.93e	58.20c	0.98h
S_4xV_3	37.43d	5.20cde	57.00d	1.03gh
Level of sig.	**	**	**	**
CV (%)	1.09	3.28	0.75	1.14

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

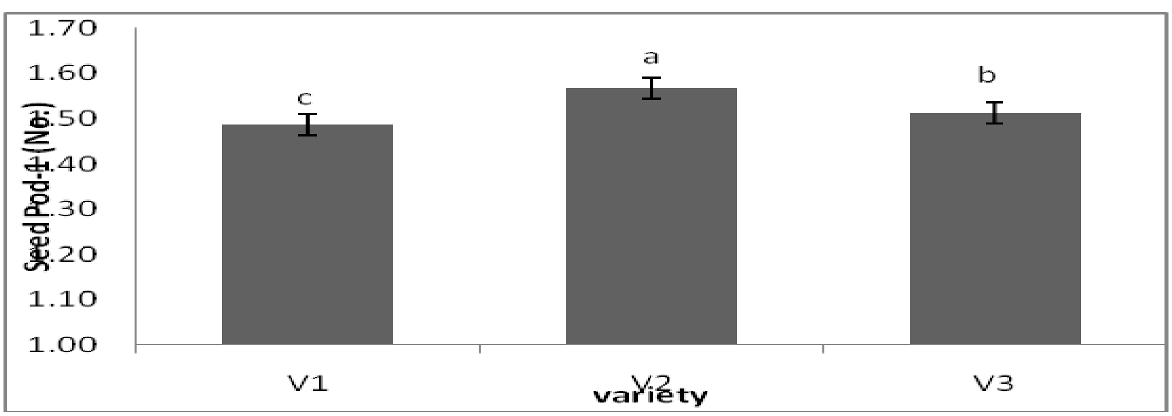

Figure 1. Effect of variety on number of seeds pod^{-1} of lentil V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

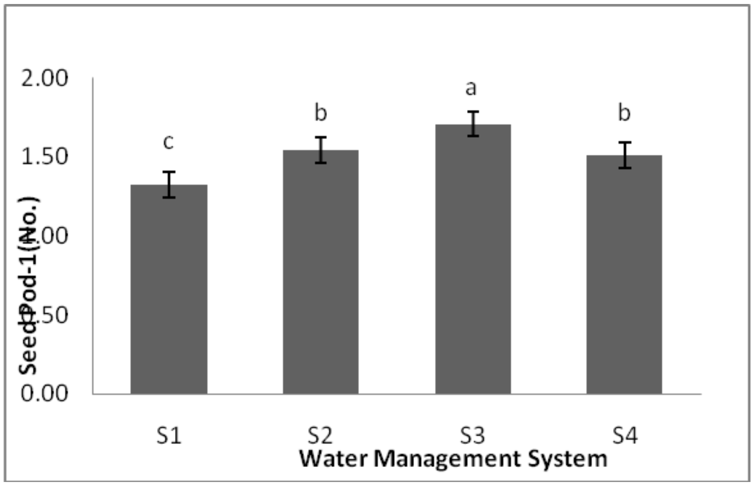

Figure 2. Effect of water management system on number of seeds pod^{-1} of lentil, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw

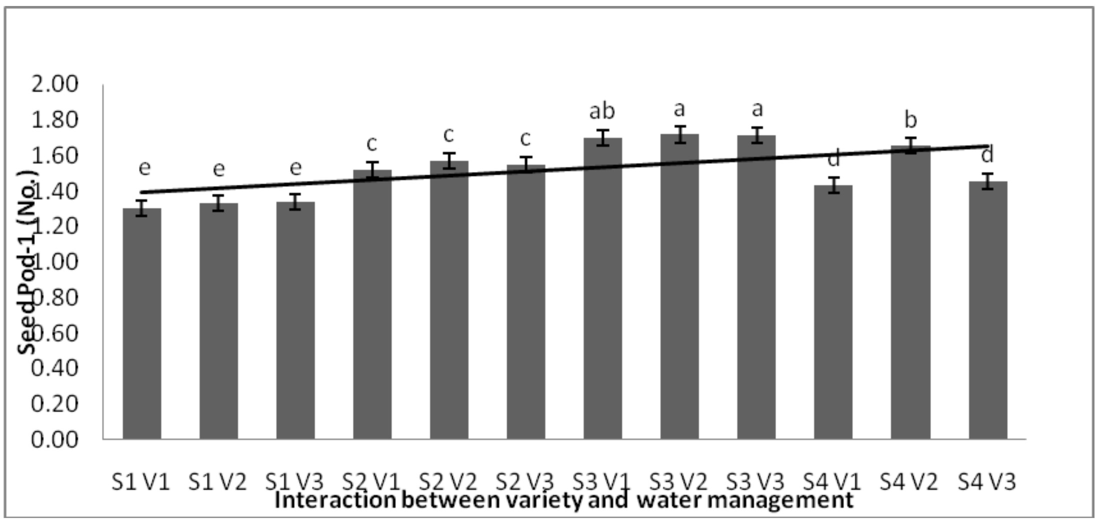

Figure 3. Effect of interaction between variety and water management on number of seeds pod^{-1} of lentil, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_3 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur-6, V_3 = BINA Masur- 4

1000-seed weight

It is evident from Figure 4 that 1000 -seed weight was not significantly influenced by lentil varieties. The highest seed weight (25.34g) was weighed in the variety BARI Masur- 4 and lightest seed weight was observed in BARI Masur-6. Similarly, Singh et al. (2011) reported significant difference for thousand seed weight among lentil genotypes. Water management has significant effect on 1000seed weight of plant (Figure 5). The highest 1000seed yield were recorded in mulching with water hyacinth (25.51g) while the lowest 1000seed weight in plant recorded in rainfed condition (25.25g). Thousand seed weight was not significantly influenced by the interaction between variety and planting system (Figure 6). The highest 1000seed weight (25.57g) was recorded in S_3xV_3 (mulching with water hyacinth and BINA Masur-4) followed by combination S_3xV_1 (mulching with water hyacinth and BARI Masur-4). The lowest thousand seed weight (25.07g) was recorded from the combination S_1xV_3 (no irrigation and BINA Masur-4) followed by combination S_4xV_2 (25.07g) (mulching with straw and BARI Masur-6)..

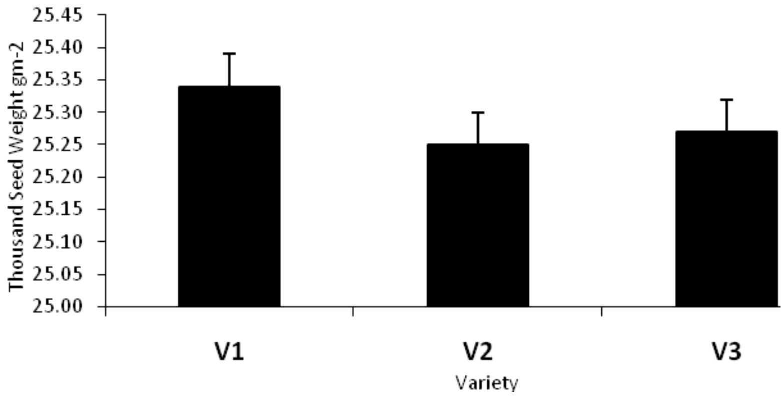

Figure 4. Effect of variety on thousand seed weight (g) of lentil, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

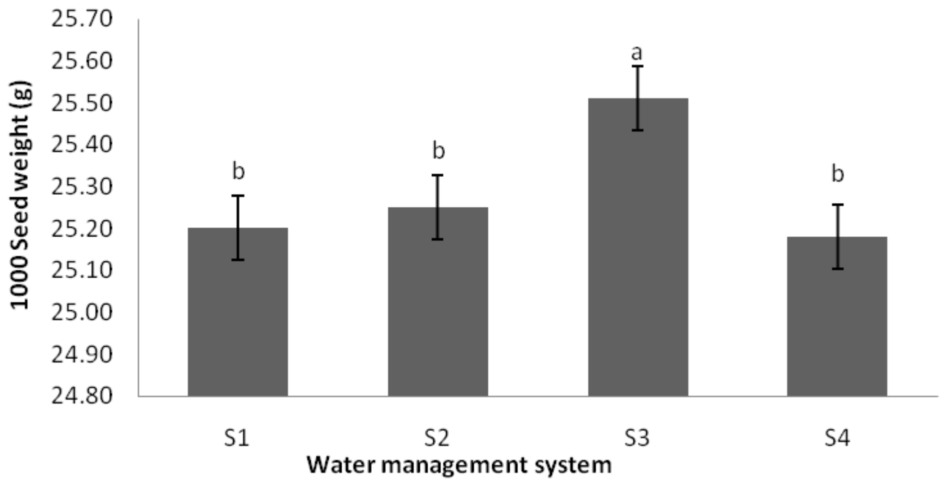

Figure 5. Effect of water management system on thousand seed weight of lentil, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw

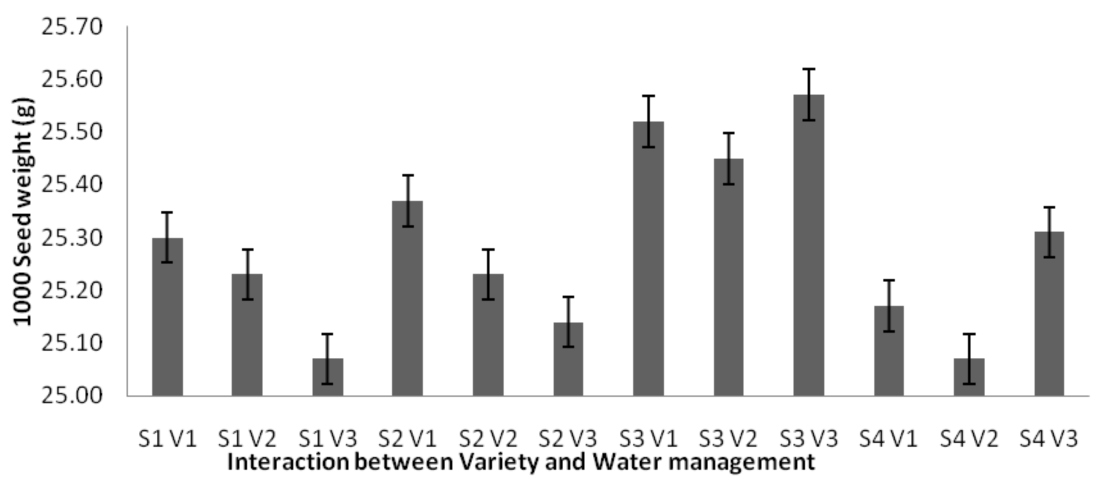

Figure 6. Effect of interaction between variety and water management on thousand seed weight (g) of lentil, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Seed yield

Significant variation was found in grain yield (Figure 7) due to different varieties. The highest yield (1.41 t ha^{-1}) was obtained in the variety BARI Masur-6 and the lowest (1.25 t ha^{-1}) yield was recorded from the variety BARI Masur-4. Differences in grain yield among the varieties might be due to the inherent quality of varieties. Water management had significant effect on seed yield of lentil (Figure 8). The highest seed yield was recorded in mulching with water hyacinth (1.59 t ha^{-1}) while the lowest seed yield was recorded in rainfed condition (1.03 t ha^{-1}). This variation is due to supply of water at flowering stage of growth. Hamdi et al. (1992) indicated 20% rise in seed yield $plant^{-1}$ in two supplemental irrigations (50 mm each) in Syrian growth conditions. Zhang et al. (2000) showed 70% increase in lentil grain yield on 1 or 2 applications of irrigation at flowering or pod-filling stage. After conducting a four years experiment, *Oweis* et al. (2004) found that supplemental irrigation (SI) increased the lentil grain and biomass yield by raising its values from 1.04 t ha^{-1} and 4.27 t ha^{-1} (under rainfed conditions) to 1.81 t ha^{-1} and 6.2 t ha^{-1} (under full SI conditions), respectively. Mulching is a desirable management practice which regulates farm environment and thereby enhances crop production through regulating soil temperature (Khan, 2001), by reducing leaching and evapotranspiration (Liu et al., 2000), by increasing the soil organic matter content (Roldan et al., 2003) and by reducing nutrient loss due to run off (Smart and Bradford, 1999). Seed yield of lentil was significantly influenced by the interaction between variety and water management system of lentil (Figure 9). The highest seed yield (1.65 t ha^{-1}) was recorded in S_3xV_2 (mulching with water hyacinth and BARI Masur-6).The lowest seed yield (0.85 t ha^{-1}) was recorded from the combination S_1xV_1 (no irrigation and BARI Masur-4).

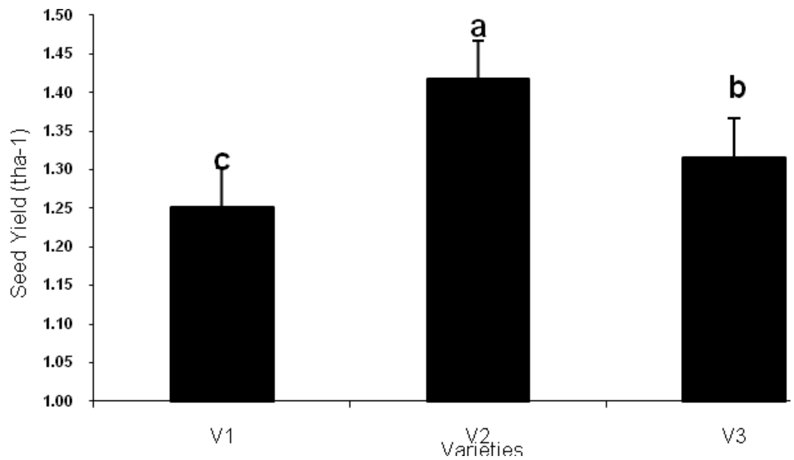

Figure 7. Effect of variety on seed yield of lentil, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

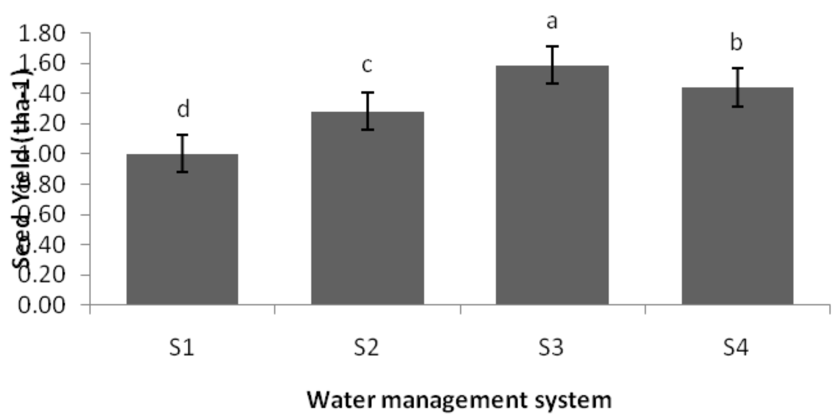

Figure 8. Effect of water management system on seed yield of lentil, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw

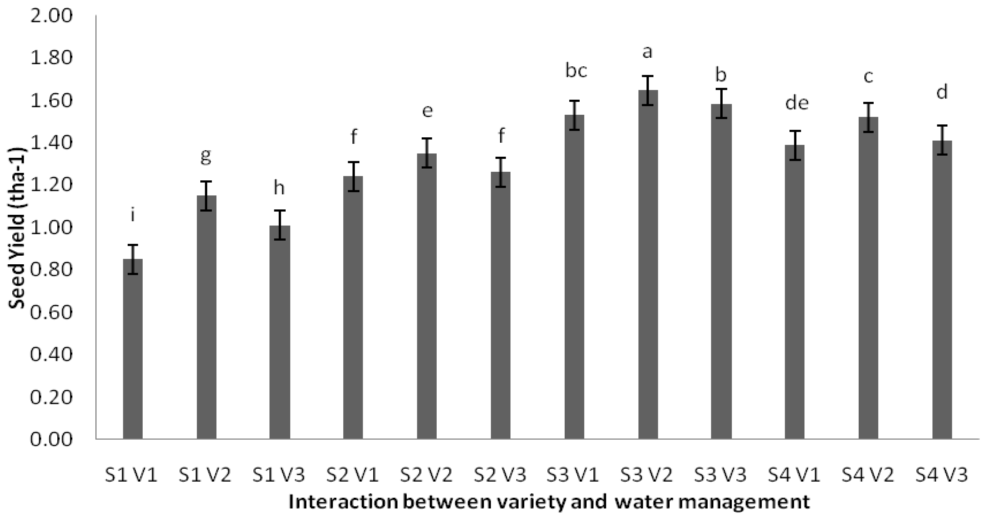

Figure 9. Effect of interaction between variety and water management on seed yield of lentil, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Stover yield

Among the yield and yield contributing characters of lentil, stover yield was significantly influenced by variety (Table 7). The highest stover yield of plants was found in the variety BINA Masur- 4 (1.146 t ha^{-1}) while the lowest stover yield was recorded in BARI Masur- 6 (0.99 t ha^{-1}). Stover yield of BARI Masur- 4 plants were medium (0.99 t ha^{-1}) among these three varieties. This difference in plant height might be due to the genetic makeup as realized under the field condition. Water management has significant effect on stover yield of plant (Table 8). The highest stover yield were recorded in mulching with water hyacinth (1.22 t ha^{-1}) while the lowest stover yield number in plant recorded in rainfed condition (0.93 t ha^{-1}). Stover yield was significantly influenced by the interaction between variety and planting system of lentil (Table 9). The highest stover yield (1.50 t ha^{-1}) was recorded in S_3xV_3. The lowest stover yield (0.88 t ha^{-1}) was recorded from the combination S_1xV_2 (no irrigation with BARI Masur-6).

Table 7. Effect of variety on the yield and yield contributing characters of lentil

Variety	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Stover Yield (t ha^{-1})
V_1	34.52c	5.11c	52.71c	1.02b
V_2	35.04b	5.31b	55.85a	0.99c
V_3	38.14a	5.50a	54.01b	1.14a
Level of sig.	**	**	**	**
CV (%)	0.85	4.69	1.02	0.48

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) , **=Significant at 1% level of probability, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Table 8. Effect of water management on the yield and yield contributing characters of lentil

Water management	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Stover Yield (tha^{-1})
S_1	28.98d	4.50c	57.26a	0.94 d
S_2	32.38c	5.15b	0.18d	1.04b
S_3	46.20a	6.51a	55.85b	1.23a
S_4	36.04b	5.08b	54.01c	1.01c
Level of sig.	**	**	**	**
CV (%)	1.09	3.28	0.75	1.14

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT),**= Significant at 1% level of probability, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw

Table 9. Effect of interaction between variety and water management on the yield and yield contributing characters of lentil

Interaction	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Stover Yield (t ha^{-1})
S_1xV_1	27.10hi	4.16g	42.70j	0.92i
S_1xV_2	26.43i	4.30g	46.07h	0.88j
S_1xV_3	33.40g	5.03de	45.02i	1.01g
S_2xV_1	27.27h	4.63f	49.90g	1.03ef
S_2xV_2	34.27f	5.33cd	52.95e	1.02fg
S_2xV_3	35.60e	5.50c	51.8of	1.07cd
S_3xV_1	47.72a	6.53ab	61.66b	1.09bc
S_3xV_2	44.77c	6.70a	66.20a	1.10b
S_3xV_3	46.13b	6.30b	62.20b	1.50a
S_4xV_1	36.00e	5.13de	56.59d	1.05de
S_4xV_2	34.7of	4.93e	58.20c	0.98h
S_4xV_3	37.43d	5.20cde	57.00d	1.03gh
Level of sig.	**	**	**	**
CV (%)	1.09	3.28	0.75	1.14

In a column, mean values with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), **=Significant at 1% level of probability, S_1 = No irrigation, S_2 = One irrigation at flowering, S_3 = Mulching with water hyacinth, S_4 = Mulching with straw, V_1 = BARI Masur- 4, V_2 = BARI Masur- 6, V_3 = BINA Masur- 4

Conclusion

Based on the results of the present study it can be concluded that the highest dry matter of lentil was found in mulching with water hyacinth. Performance of yield and yield contributing character showed much better in with water hyacinth condition than the other water management treatments. Among the three varieties BARI Masur- 6 performed the best than the other two varieties. Finally cultivation of BARI Masur- 6 mulching with water hyacinth may give the best of lentil in Brahmaputra Floodplain Soil.

Authors contribution

MMA and AKH developed the concept and designed the experiments. MMA and RRC collected the data and wrote the manuscript. UKS evaluated the result, analyzed data statistically and contributed to writing the manuscript. MRU, MAK and AKH contributed to revising manuscript critically for important intellectual content. All authors read the article and approved the final version to be published.

Competing interests

The authors have declared that no competing interests exist.

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