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Study on Morpho-physiological and Yield Performance of Four Chilli (*Capsicum* spp.) Lines

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Abstract

Concerning the low yield potentiality of chilli in Bangladesh, an experiment was conducted at Horticulture farm of Sher-e-Bangla Agricultural University, Bangladesh to study the morpho-physiological and yield performance of four chilli lines (coded from L_1 to L_4) during November 2013 to May 2014. Maximum number of flowers (49.8/plant), number of fruits (33.0/plant), length of individual fruits (7.5 cm) and number of seeds (69.0/fruit) was found from L_2 , whereas maximum fresh weight of 50-fruits (65.4 g), dry weight of 50-fruits (17.7 g), fruit diameter (0.7 cm) and total yield (149.2 g/plant and 947.3 g/plot) was found from L_3 . Maximum chlorophyll content (57.7%), CO_2 references (383.5 vpm), H_2O references as partial pressure (30.7 $\mu\text{mol m}^{-2} \text{s}^{-1}$) and Vitamin-C (80.5 mg/100 g fruit) was found from L_1 , while maximum photosynthetic rate (5.3 $\mu\text{mol m}^{-2} \text{s}^{-1}$), and P.A.R incident on leaf surface (252.3 $\mu\text{mol m}^{-2} \text{s}^{-1}$) was recorded from L_3 .

Key words: Chilli cultivars, morpho-physiological and yield

I. Introduction

Pepper (*Capsicum* spp.) belongs to the *Solanaceae* family, a year round crop used in variety of ways (Erinle, 1989; Akinyosoye, 1977). There are many varieties of pepper and among these *C. annum* are the sweet or bell peeper while *C. frutescences* are hot pepper. Hot peppers (Chilies) have high content of alkaloid capsaicin ($C_{18}H_{27}O_3$) which is responsible for pungency or heat (Udoh et al., 2005). It is known that nutritional and visual quality of fruit depends both on variety and growing conditions (Pivovarov et al., 2009). A number of cultivars are grown in Bangladesh differing in habit and yield but green chilli production was only 1.69 t/ha during 2010-2011 (BBS, 2011). Low yield in Bangladesh could be attributed to lack of suitable cultivars (Uzo, 1990 and Dinakin et al., 1990). For this reason the current study was undertaken to study the morpho-physiological characteristics and yield performance of four chilli lines.

II. Materials and Method

Experimental site and duration of study: The experiment was conducted at the Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2013 to May 2014.

Genetic materials and experimental design: Experiment consisted four chilli lines coded as L₁, L₂, L₃ and L₄ in a Randomized Complete Block Design with 3 replications. The size of unit plot was 1.6 m x 1.6 m. The distance between both blocks and plots were 0.5 m. Seedlings were planted in plot by maintaining a spacing of both plant to plant and row to row of distance 40 cm x 40 cm.

Fertilization: Cow dung, Urea, TSP, MP and Borax were applied @ 10 t/ha, 210 kg/ha, 330 kg/ha, 200 kg/ha and 5 kg/ha respectively. Entire amount of Cow dung, TSP, Borax and 65 kg MP were applied during the final land preparation. Entire amount of Urea and rest of MP were applied in three installments at 25, 50 and 70 days after transplanting (DAT).

Data collection and measuring procedures: Data were collected on plant height, number of leaves, number of branches, leaf area, leaf chlorophyll content, photosynthetic rate (A), stomatal conductance of H₂O (gs), CO₂ references (C_{ref}), H₂O references as partial pressure (e_{ref}), photosynthetically active radiation (P.A.R) incident on leaf surface (Q_{leaf}), days to first flower bud initiation, number of flower/plant, number of fruit/plant, individual fruit weight, fruit length, fruit diameter, fresh weight of 50-fruits, dry weight of 50-fruits, total yield/plant, total yield/plot and Vitamin C content. Number of flower/plant and number of fruit/plant was counted up to 2 months at every single day interval from the first flower and fruit. Leaf area (using CL-202 Leaf Area Meter by destructive method), chlorophyll content (using SPAD-502), A, gs, C_{ref}, e_{ref}, and Q_{leaf} (using LC pro+) were measured at 80 DAT. Fruit diameter was measured using Digital Caliper-515 (DC-515).

Estimation of Vitamin C (L-Ascorbic acid): Vitamin-C content was estimated by Oxidation Reduction Titration Method.

Statistical analysis: Collected data were statistically analyzed using MSTAT-C computer package programme. Difference between treatments was assessed by Duncan's Multiple Range Test at 5% level of significance (Gomez and Gomez, 1984).

III. Results and Discussion

Plant growth

Plant height of chilli lines varied significantly at different days after transplanting (DAT). The tallest plant was found from L₃ (69.3 cm), whereas the shortest ones from L₁ (47.4 cm) at 65 DAT (Figure 1a). Hosmani (1982) found that there was a lot of variation in height of Capsicum plants. High phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were found for plant height (Mini and Khader, 2004; Sreelathakumary and Rajamony, 2004; Singh et al., 2009). Number of leaves per plant varied significantly among the chilli lines at different DAT. Maximum number of leaves was found from L₁ (84.2/plant) while minimum from L₃ (48.4/plant) (Figure 1b).

Maximum number of branches was found from L₄ (26.5/plant) while minimum from L₃ (22.5/plant) (Figure 1c). Maximum leaf area was found from L₄ (59.9 cm²) while minimum from L₁ (35.9 cm²) which was statistically similar with L₃ (36.3 cm²) and L₂ (36.5 cm²) (Table 1). Unit leaf area is of course a valid basis for assessing the effects of short term fluctuations in environmental variables on photosynthesis. However, its use as a sole basis of comparing P_{max} of a genotype can be misleading (Charles Edwards and Luding, 1975). The most practical procedure might be to use several parameters in addition to leaf area such as fresh and dry weight. Green leaf area of crop determines the percent of

incident solar radiation intercepted by the crop canopy and there by influences the canopy photosynthesis, evapo-transpiration and final crop yield (Dale et al., 1980).

Morphological characteristics

Maximum chlorophyll content was found from L₁ (57.7%) which was statistically similar with L₃ (55.0%) while minimum from L₂ (47.0%) which was statistically similar with L₄ (47.2%) (Table 1). Maximum photosynthetic rate was found from L₃ (5.3 $\mu\text{molm}^{-2}\text{s}^{-1}$) followed by L₁ (3.7 $\mu\text{molm}^{-2}\text{s}^{-1}$), L₄ (3.3 $\mu\text{molm}^{-2}\text{s}^{-1}$) and L₂ (2.5 $\mu\text{molm}^{-2}\text{s}^{-1}$) (Table 1). It is assumed that net photosynthesis is related to fruit characters at the later phase of flowering and fruit setting (Zou et al., 2007). When pepper plants are exposed to additional stress, strong reduction of net photosynthesis is always followed by lower pepper yields (Takemoto et al., 1988). However, it is still controversial whether higher leaf photosynthesis in optimal growth conditions increases plant yields (Sinclair et al., 2004). Some studies showed that this co-relation depends on the phase of plant development (Oshumiet et al., 2007; Peng et al., 2008). Maximum CO₂ reference was found from L₁ (383.5 vpm) followed by L₂ (3080.3 vpm) while minimum from L₄ (369.3 vpm) (Table 1). Maximum P.A.R. was found from L₁ (30.7 mBar) followed by L₂ (29.7 mBar) and L₄ (29.5 mBar) while minimum from L₃ (26.5 mBar) (Table 1). Stomatal conductance showed statistically identical among chilli lines. Maximum stomatal conductance of H₂O was found from L₄ (0.3 $\mu\text{molm}^{-2}\text{s}^{-1}$) which was statistically similar with L₁, L₂ and L₃ (0.5 $\mu\text{molm}^{-2}\text{s}^{-1}$) (Table 1). Maximum H₂O reference as partial pressure was found from L₃ (252.3 $\mu\text{molm}^{-2}\text{s}^{-1}$) while minimum from L₄ (126.3 $\mu\text{molm}^{-2}\text{s}^{-1}$) (Table 1).

Flowering and fruiting

Early flower bud initiation was found from L₁ (30 days) whereas late from L₄ (42 days) which was statistically similar with L₂ (42 days) and L₃ (37 days) (Table 2). Days required to flowering in chilli crop mainly depend on the variety (Veerapa, 1980; Hosmani, 1982) and the sweet pepper variety flowered at 27 days after transplanting while Ruby King took 43 days for flowering (Veerapa, 1980). Maximum number of flower was found from L₂ (49.8/plant) while minimum from L₁ (22.3/plant) (Table 2). Maximum number of fruit was found from L₂ (33.0/plant) which was statistically similar with L₃ (28.3/plant) and L₄ (26.0/plant) while minimum from L₁ (14.3/plant) which was statistically similar with L₄ (26.0/plant) (Table 2). Red hot pepper was significantly different from others in number of fruit (Obidiebube et al., 2012). According to Sharma et al. (1981) small fruit size associated with more number of fruits and reverse is the relationship in large sized fruit varieties.

Yield contributing attributes

Maximum fresh weight was found from L₃ (65.4 g/50-fruits) whereas minimum from L₁ (56.0 g/50-fruits) which was statistically similar with L₂ (56.3 g/50-fruits) (Table 2). Red hot pepper was significantly different from others in fresh weight (Obidiebube et al., 2012). This therefore confirms that the differentials in yields of cultivars are genetically influenced. This varietal difference is corroborated by the findings of Akinfosoye et al. (1997) and Odeye and Odeye (2001) who reported that difference in yield of crops has been ascribed to the cultivars grown and genetic make-up. Maximum dry weight was found from L₃ (17.7 g/50-fruits) whereas minimum from L₂ and L₄ (12.6 g/50-fruits) (Table 2). Red hot pepper was significantly different from others in dry fruit weight (Obidiebube et al., 2012). Maximum individual fruit weight was found from L₃ (1.3 g) while minimum from L₄ (0.9 g) (Table 2). Longest fruit was found from L₂ (7.5 cm) followed by L₄ (7.2 cm) while shortest from L₃ (5.2 cm) (Table 3). Padma et al. (1970), Hosmani (1973) and Pillai and Bellukuty (1978) observed the varietal variation in fruit length in chilli. In case of chilli fruits, length is having market value because normally medium to long fruits are preferred by customers (Hosmani, 1982). Maximum fruit diameter was found from L₃ (0.7 cm) while minimum from L₄ (0.5 cm) (Table 3). Fruit breadth provides a good selection index for fruit yield (Sharma et al., 1981). Veerapa (1980) studied varietal performances of bell pepper and recorded 3.1 to 5.2 cm varietal variation in fruit breadth. Maximum yield was found from L₃ (149.2 g/plant) whereas minimum from L₁ (45.0 g/plant) (Table 3).

L₃ had given the maximum total yield (947.3 g/plot) whereas minimum from L₁ (522.5 g/plot) (Table 3).

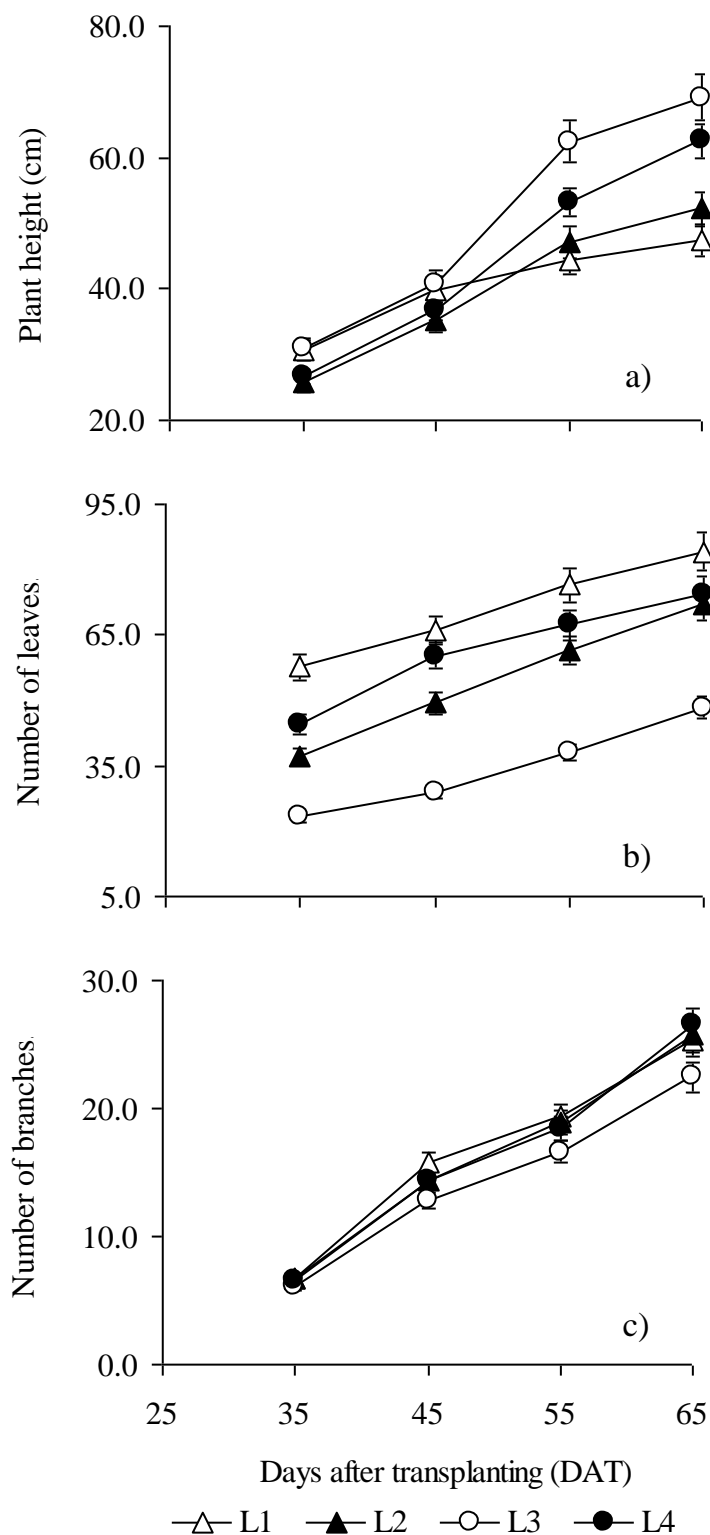


Figure 1(a, b, c). Performance of four chilli lines on a) plant height, b) number of leaves per plant and c) number of branches per plant at different days after transplanting.

Table 1. Response of four chilli lines on different physiological characters^x

Chilli lines	Leaf area (cm ²)	Chlorophyll content (%)	A (μmol m ⁻² s ⁻¹)	g _s (μmol m ⁻² s ⁻¹)	C _{ref} (vpm)	e _{ref} (mBar)	Q _{leaf} (μmol m ⁻² s ⁻¹)
L ₁	35.9 b	57.7 a	3.7 b	0.5 a	383.5 A	30.7 a	201.3 b
L ₂	36.5 b	47.0 b	2.5 c	0.5 a	380.3 B	29.7 b	143.5 c
L ₃	36.3 b	55.0 a	5.3 a	0.5 a	377.5 C	26.5 c	252.3 a
L ₄	59.9 a	47.2 b	3.3 b	0.6 a	369.3 D	29.5 b	126.3 d
LSD0.05	3.1	2.8	0.7	0.2	2.7	0.4	8.8
CV%	4.6	3.4	10.0	8.7	0.4	0.8	3.1

^xIn a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

Table 2. Response of four chilli lines on yield contributing characters^x

Chilli lines	Days to first flower bud initiation	No. of flower/plant	No. of fruit/plant	Fresh weight of 50-fruits (g)	Dry weight of 50-fruits (g)	Individual fruit weight (g)
L ₁	30.0 B	22.3 c	14.3 b	56.0 c	13.5 b	1.1 b
L ₂	40.0 A	49.8 a	33.0 a	56.3 c	12.6 c	1.0 b
L ₃	36.8 A	35.5 b	28.3 a	65.4 a	17.7 a	1.3 a
L ₄	42.0 A	34.3 bc	26.0 ab	61.0 b	12.6 c	0.9 c
LSD0.05	5.5	12.9	13.5	0.3	0.3	0.1
CV%	9.3	2.8	3.2	0.4	1.2	5.9

^xIn a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

Number of seed/fruit

Number of seed/fruit was varied significantly among the chilli lines. Maximum number of seeds/fruit was found from L₂ (69.0) which was statistically similar with L₃ (67.3) while minimum from L₄ (46.8) (Table 3).

Vitamin C content

Maximum Vit-C was found from L₁ (80.5 mg/100 g fruit) followed by L₃ (77.2 mg/100 g fruit) whereas minimum from L₄ (65.6 mg/100 g fruit) which was statistically similar with L₂ (68.2 mg/100 g fruit) (Table 3). The ascorbic acid and vitamin C, besides nutritional potential, contain antioxidant properties and it is present in high concentrations in several types of peppers. Maturation and storage conditions can also affect the stability and accumulation of Vit-C in fruits of Capsicum besides genetic diversity (Howard et al., 2000; Jimenez et al., 2003).

Table 3. Response of four chilli lines on yield contributing characters, yield seed number and Vit-C content^x

Chilli lines	Fruit length (cm)	Fruit diameter (cm)	Total yield (g)/plant	Total yield (g)/plot	Number of seed/fruit	Vit-C content (mg/100 g fruit)
L ₁	5.6 c	0.6 b	45.0 d	522.5 d	61.6 b	80.5 a
L ₂	7.5 a	0.6 b	138.9 b	842.2 b	69.0 a	68.2 c
L ₃	5.2 d	0.7 a	149.2 a	947.3 a	67.3 a	77.2 b
L ₄	7.2 b	0.5 c	80.5 c	783.8 c	46.8 c	65.6 c
LSD0.05	0.2	0.005	2.5	24.6	3.8	2.9
CV%	2.4	0.1	1.5	2.0	3.9	2.5

^xIn a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

IV. Conclusion

Chilli lines that were studied in this experiment showed variations in plant height, leaf number, branches number, leaf area, chlorophyll content, photosynthetic rate, CO₂ references, H₂O references as partial pressure, fruit number, fresh fruit weight, dry fruit weight, fruit length, fruit diameter, yield/plant, yield/plot, number of seed/fruit and vitamin C content. Among different growth, morphological and yield contributing characters line-2 and line-3 were performed better, thus these lines could be suggested for further wider experiment on yield potentials and or recommend as potential yield increasing line compared other two low yielding chilli lines of this study.

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