

Research Article

EFFECT OF PHOSPHORUS AND MULCHING ON YIELD OF TOMATO

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ABSTRACT

The field experiment was carried out at Bangladesh Institute of Nuclear Agriculture, Mymensingh during October 2017 to March 2018, to investigate the effect of different levels of phosphorus and mulches on growth, yield attributes and yield of tomato cv. Roma VF. Two factors: (i) Four levels phosphorus viz., 0, 40, 80 and 120 kg P ha⁻¹ and (ii) four different mulches viz., no mulch (control), water hyacinth, rice straw and banana leaves. The experiment was laid out in two factors randomized complete block design with four replications. The effect of phosphorus levels and mulches on morphological characters: plant height, leaf number plant⁻¹, reproductive characters: number of flower clusters plant⁻¹, flowers plant⁻¹, days to flowering and yield contributing characters: number of fruits plant⁻¹, fruit length, single fruit weight and fruit yield both plant⁻¹ and ha⁻¹ was significant. The highest morphological and reproductive characters, yield contributing characters and fruit yield (71.98 t ha⁻¹) were recorded in 120 kg P ha⁻¹ followed by 80 kg P ha⁻¹ (69.76 t ha⁻¹) with same statistical rank. In contrast, the above morphological, reproductive, yield attributes and fruit yield (47.62 t ha⁻¹) was recorded in control plant where no phosphorus was applied. Application of P @ 80 kg ha⁻¹ was found suitable dose for tomato cultivation. Among the three mulches, water hyacinth had remarkable effect on plant growth and yield attributes which resulting the highest fruit yield (68.35 t ha⁻¹) in tomato. So, we may use water hyacinth mulch with application of 80 kg P for maximizing tomato fruit yield during winter season for silty loam soil.

Keywords: Tomato, Phosphorus, Mulching, Yield, Fertilizer

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the popular and nutritious vegetable crops all over the world including Bangladesh. It contains vitamin A, B and C including calcium and carotene. The amount of nutrient is 1.98 g protein, 320 IU vitamin-A, 1.8 mg iron and 31 mg vitamin-C in 100 g edible tomato (Parnell et al., 2004). Lycopene in tomato is a powerful antioxidant and reduces the risk of prostate cancer (Tegen et al., 2016).

Phosphorus (P) fertilizer occupies the second most important input after nitrogen for increasing crop production. Optimum level of P is essential for rapid root development and for good utilization of water and other nutrients by plant. P has pronounced effect on flower cluster production and the number of flowers that increases the yield of tomato (Zhang et al., 2007). Further many researchers reported that P fertilizer significantly increased the yield of tomato (Solaiman and Rabbani, 2006; Etyssa et al., 2013, Kumar et al., 2013). The macronutrient fertilizers including P fertilizer consumption in Bangladesh are still below the level required for normal crop growth and development which resulted lower yield in tomato. To optimize the nutrient supply for proper growth and development of tomato crop, judicious fertilization is essential. Optimum rate of macronutrients including phosphorus not only increases the yield but also increase the quality of tomato (Kumar et al., 2013).

Mulching is a desirable management practice which is reported to regulate soil temperature, improve soil moisture, suppress weed growth and save labor cost (Kayum et al., 2008). The practice has been reported to increase yield by creating favorable temperature and moisture regimes in different parts of the world (Biswas et al., 2015). Water is the single factor which directly affects the tomato yield, because it contains 94% water. For successful crop about 285 mm water is required especially at flowering, fruit setting and enlargement stage (Jain et al., 2000). But irrigation facilities are not sufficient in all the regions of the country. Under the situation mulch play an important role in conserving soil moisture (Kayum et al., 2008). It improves the soil physical conditions by enhancing the biological activity of soil fauna and thus increases the soil fertility (Gordon et al., 2010). Artificial mulches with straw, rice husk, water hyacinth, crop residues or plastic mulch are generally practiced in the production of horticultural crops (Biswas et al., 2015). The present study was undertaken to assess the optimum level of phosphorus and to determine suitable mulch for maximum production of tomato.

MATERIAL AND METHODS

The field experiment was carried out at the Research Farm of the Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period from October 2017 to March 2018. The selected site was a medium high land and the pH of the soil was 6.4 with organic matter content of 1.21%. The analytical data of the soil sample from the experimental area was organic matter 1.67%, N 0.09%, available P

4.81ppm, exchangeable K 0.27 me/100 g and available S 13.9 ppm. The tomato variety Roma-VF was used as planting material in the experiment. The experiment consisted of two factors: Factor A: Four different levels of phosphorus such as 0, 40, 80 and 120 kg ha⁻¹ and Factor B: three mulches such as water hyacinth, rice straw and banana leaves. The experiment was laid out in two factors randomized complete block design with four replications. Seeds were sown in seedbed on 29 October 2017 and 27-day old seedlings were transplanted in the experimental field with recommended spacing of 50 cm × 50 cm. The unit plot size was 4 m × 3 m. Urea, muriate of potash (MoP), gypsum and cow dung were applied at the rate of 280 kg ha⁻¹, 180 kg ha⁻¹, 80 kg ha⁻¹ and 10000 kg ha⁻¹, respectively (BARC, 2012). The triple superphosphate (TSP) was applied according to treatment. Whole amount of TSP, gypsum and half of MoP were applied as basal dose during final land preparation, cow dung also applied before 10 days of final land preparation. The remaining half of MoP was applied as top dressing at 45 days after transplanting (DAT). Half of urea was applied as top dress at 21 DAT and remaining half was applied at 45 DAT. Weeding, pruning, staking, pesticides spray and other intercultural operations were done when required. The first trip irrigation was given 30 days after planting (DAP) followed by irrigation at 45 DAT. Mulching was also done after second irrigation at appropriate time by breaking the soil crust. At harvest, ten plants from each plot were selected randomly for data recording on morphological and reproductive characters, yield and yield related traits. Fruit yield was collected from each plot excluding border line and converted into t ha⁻¹. Harvesting was done at different dates depending on fruit ripening. The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences among treatments were compared by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

RESULTS AND DISCUSSION

The effect of phosphorus (P) on morphological characters such as plant height, number of leaves plant⁻¹, reproductive characters such as number of flower clusters and flowers plant⁻¹, number of flowers cluster⁻¹, days to flowering was significant (Table 1). Results showed that morphological and reproductive characters were higher in phosphorus applied plants than control plants. This result indicates that P has tremendous effect on growth and development in tomato. Results further revealed that plant height, number of leaves, flower clusters and flowers plant⁻¹ increased significantly with increasing P levels till 80 kg ha⁻¹ and further increasing P levels did not increase significantly whereas reverse trend was observed in days required to flowering. The highest plant height (76.1 cm), number of flower clusters plant⁻¹ (21.20) and flower number plant⁻¹ (133.5) was recorded in 120 kg P ha⁻¹ followed by 80 kg P ha⁻¹ with same statistical rank. In contrast, the shortest plant (63.4 cm), the lowest number of leaves (35.43 plant⁻¹), flower clusters plant⁻¹ (15.14) and flowers plant⁻¹ (76.76), longest days required to start flowering (32.55 days) was recorded in

control plot. In control plot phosphorus was not sufficient for normal plant growth and development and resulted in reduction of number of leaves plant⁻¹. This result is in agreement with that of Etissa et al. (2013) who reported that plant height and leaves number increased in applied plants than control plants.

Table 1. Effect of phosphorus levels and mulches on morphological and reproductive characters in tomato cv. Roma VF

Treatment	Plant height (cm)	Leaves plant ⁻¹ (no.)	Days to flowering	Flower clusters plant ⁻¹ (no.)	Flowers cluster ⁻¹ (no.)	Flowers plant ⁻¹ (no.)
P levels						
(kg ha ⁻¹)						
0	63.4 c	35.43 c	32.55 a	15.14 c	5.07 c	76.76 c
40	69.6 b	42.91 b	29.83 b	17.89 b	6.08 b	92.87 b
80	75.0 a	50.96 a	25.85 c	20.42 a	7.07 a	126.4 a
120	76.1 a	50.70 a	25.75 c	21.20 a	7.10 a	133.5 a
F-test	**	**	**	**	**	**
Mulches						
No mulch	66.4 b	36.90 b	29.44 a	16.21 b	5.65 b	81.59 c
Water hyacinth	74.5 a	48.65 a	27.10 b	20.40 a	6.59 a	124.4 a
Rice straw	71.9 a	48.51 a	26.91 b	19.3 a	6.55 a	116.4 a
Banana leaves	69.3 ab	46.00 a	26.80 b	18.70 ab	6.49 a	105.9 b
F-test	*	**	**	**	**	**

Figure (s) in a column, within treatment indicate do not differ significantly at $P \leq 0.05$; ** and * indicate significant at 1% and 5% level of probability, respectively.

Use of different mulches had significant influence on morphological characters i.e. plant height, number of leaves plant⁻¹, and reproductive characters such as number flower clusters and flowers plant⁻¹, number of flowers cluster⁻¹ (Table 1). Result indicated that morphological and reproductive characters were higher in mulches plots over non-mulch plots. The plant height and leaf number were higher in mulches than control because of might be moisture percentage was higher in those mulches plots compared to control plot. It increased nutrient availability and plants uptake more nutrients resulting higher growth and development (Biswas et al., 2015). Among the mulches, the tallest plant (74.5 cm), the highest number of leaves plant⁻¹ (48.65), flower cluster plant⁻¹ (20.40) and flowers plant⁻¹ (124.4.92) was recorded in water hyacinth mulch followed by rice straw and the lowest was recorded in no mulch. The highest flower number was recorded in water hyacinth and rice straw mulches due to production of highest flower clusters plant⁻¹ (Table 1). However, the

shortest plant (66.4 cm) and the lowest number of leaves plant⁻¹ (36.90) as well as flower cluster number and flowers number plant⁻¹ (81.59) was recorded in control plot. In control plot, soil moisture may be less than the mulches plots that causes lesser amount of nutrient availability (Tegen et al., 2016). As a result, plant growth and development hampered and ultimately plant height was short. The highest plant height was observed in water hyacinth mulch than the other mulches as reported by Singh et al. (2006) in tomato which supported the present experimental result.

The effect of P levels on yield contributing characters such as number of fruits plant⁻¹, fruit length and single fruit weight and fruit yield both plant⁻¹ and ha⁻¹ was significant (Table 2). Results revealed that yield contributing characters were higher in P applied plants over control plants. The number of fruits plant⁻¹, fruit length, single fruit weight and fruit yield increased with increasing P levels. However, application of P at the rate of 120 kg ha⁻¹, the yield contributing characters increased non-significantly over 80 kg ha⁻¹ P. The highest fruit number plant⁻¹ (34.07), fruit length (7.20 cm), single fruit weight (62.24 g), fruit weight plant⁻¹ (1.91 kg) and fruit yield ha⁻¹ (71.98 t) was recorded in 120 kg P ha⁻¹ followed by 80 kg P ha⁻¹ with same statistical rank. This result indicates that 80 kg P ha⁻¹ is sufficient for getting maximum fruits plant⁻¹ in tomato. The lowest number of fruits plant⁻¹ (24.24), smallest fruit size and lowest fruit yield (1.19 kg plant⁻¹ and 47.62 t ha⁻¹) was recorded in control plot due to production of lowest flower cluster and fruits plant⁻¹. The lowest number of fruits plant⁻¹ was recorded in control plot due to insufficient P for normal plant growth and development and resulted in reduction of number of fruits plant⁻¹. This result is in full agreement with that of Kumar et al. (2013) who stated that the number of fruits plant⁻¹ increased with increasing phosphorous levels from 50 to 150 kg ha⁻¹ in tomato. Similar result was also reported by many workers (Groot et al., 2004; Nawaz et al., 2012; Etissa et al., 2013) in tomato. The highest fruit yield was found in 120 and 80 kg P ha⁻¹ applied plants due to production of highest number of flower cluster and fruits plant⁻¹ (Table 2).

Use of different mulches had significant influence on yield attributes and fruit yield of tomato over control (Table 2). Among the mulches, the highest fruit yield was recorded in water hyacinth mulch (1.98 kg plant⁻¹ and 68.35 t ha⁻¹) followed by rice straw mulch (1.92 kg plant⁻¹ and 64.60 t ha⁻¹). The highest fruit yield was recorded in water hyacinth mulch due to production of highest number of fruits plant⁻¹. Further, among the mulches, banana leaves mulch performed the lowest in case of yield attributes and yield in tomato. However, within the mulch treatments, there had no significant different in single fruit weight. The lowest yield attributes and fruit yield was recorded in control plot.

Table 2. Effect of phosphorus levels and mulches on yield attributes and fruit yield in tomato cv. Roma VF

Treatments	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Single fruit weight (g)	Fruit weight plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
P levels					
(kg ha ⁻¹)					
0	24.24 c	5.04 c	54.28 c	1.32 c	47.62 c
40	29.25 b	6.41 b	59.26 b	1.54 b	58.65 b
80	33.00 ab	7.18 a	61.80 ab	1.82 a	69.76 a
120	34.07 a	7.20 a	62.24 a	1.91 a	71.98 a
F-test	**	**	**	**	**
Mulches					
No mulch	27.37 c	5.84 c	57.78 b	1.60 b	53.75 d
Water hyacinth	32.56 a	6.80 a	60.38 a	1.98 a	68.35 a
Rice straw	31.11 ab	6.69 ab	59.73 a	1.92 a	64.60 b
Banana leaves	29.51abc	6.52 b	59.70 a	1.78 a	61.30 c
F-test	**	**	*	**	**

Figure (s) in a column, within treatment indicate do not differ significantly at $P \leq 0.05$;

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

Table 3. Combined effect of phosphorus levels and different mulches on yield attributes and fruit yield in tomato cv. Roma VF

Interaction (P level × mulches)	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Single fruit weight (g)	Fruit weight plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
P ₀ M ₀	21.68 h	4.55 h	51.73 f	1.12 e	40.32 h
P ₀ M ₁	25.58 g	5.35 f	55.28 e	1.41 d	50.76 g
P ₀ M ₂	25.55 g	5.23 fg	55.22 e	1.41 d	51.50 g
P ₀ M ₃	24.15 gh	5.02 g	54.92 e	1.33 de	47.88 g
P ₄₀ M ₀	26.46 g	5.96 e	57.92 de	1.53 d	49.57 g
P ₄₀ M ₁	31.48 cde	6.75 c	60.33 bc	1.90 c	64.98 de
P ₄₀ M ₂	30.30 def	6.60 c	59.46 cd	1.80 c	61.56 ef
P ₄₀ M ₃	28.76 ef	6.40 d	59.32 cd	1.71 c	58.48 f

Interaction (P level × mulches)	Fruits plant ⁻¹ (no.)	Fruit length (cm)	Single fruit weight (g)	Fruit weight plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
P ₈₀ M ₀	30.14 def	6.37 d	60.35 bc	1.82 c	62.24 ef
P ₈₀ M ₁	36.20 ab	7.55 ab	62.70 ab	2.27 a	77.63 ab
P ₈₀ M ₂	34.00 abc	7.47 ab	62.05 ab	2.11 b	72.16 c
P ₈₀ M ₃	31.62 cd	7.35 ab	61.94 ab	1.96 c	67.03 d
P ₁₂₀ M ₀	31.20 de	6.48 cd	61.10 ab	1.91 c	62.88 de
P ₁₂₀ M ₁	37.00 a	7.60 a	63.22 a	2.34 a	80.03 a
P ₁₂₀ M ₂	34.57 abc	7.45 ab	62.09 ab	2.14 ab	73.19 bc
P ₁₂₀ M ₃	33.51 bcd	7.31 ab	62.60 ab	2.10 b	71.82 c
F-test	*	*	*	*	*

* indicate significant at 5% level of probability; P₀ = 0kg Pha⁻¹; P₄₀ = 40kg Pha⁻¹; P₈₀ = 80kg Pha⁻¹; P₁₂₀ = 120kg Pha⁻¹; M₀ = No mulch; M₁ = Water hyacinth; M₂ = Rice straw; M₃ = Banana leaves.

The combined effect of phosphorus level and mulches had significant effect on fruit number, fruit length, single fruit weight and fruit yield both plant⁻¹ and ha⁻¹ in tomato (Table 3). The highest yield attributes were observed in the treatment combination of 120 kg P ha⁻¹ with water hyacinth mulch which resulted highest fruit yield in tomato. The lowest number of fruits plant⁻¹ and fruit yield both plant⁻¹ and ha⁻¹ was observed in control plot.

CONCLUSION

Tomato growth and yield were affected by different levels of phosphorus application and use of mulches. Application of P @ 80 kg ha⁻¹ was found suitable dose for tomato cultivation. Among the three mulches, water hyacinth had remarkable effect on plant growth and yield attributes which resulting the highest fruit yield in tomato. So, we may use water hyacinth mulch with application of 80 kg P for maximizing tomato fruit yield during winter season for silty loam soil.

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