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Influence of Spacing and Different Level of Macronutrients on Growth and Yield of Garden Pea (*Pisum sativum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KK and TM planned the experiment and lead the research. Authors KF, KK and TM designed and carried out the research. Authors MEH and MMH performed the statistical analysis. Authors KF, SKD and MBB carried out the research on the field. Authors KF, MAS and SSR collected the data. Authors KF and MEH wrote the manuscript. Authors SKD, MAS, MMH and SSR managed the literature searches. All authors provided critical feedback and helped to shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, on garden pea, during the period of November, 2018 to January, 2019. The experiment was outlined in Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of two factors; 3 levels of plant spacing. S_1 (30 cm × 10 cm), S_2 (30 cm ×

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20 cm) and S_3 (30 cm × 30 cm) and 4 levels of macronutrient management viz., T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). Results indicated that the highest seed yield (8.38 t ha^{-1}) and pod yield (10.56 t ha^{-1}) were found from S_1 (30 cm × 10 cm) compared to other plant spacing. Considering macronutrient application, the highest seed yield (7.57 t ha^{-1}) and pod yield (9.12 t ha^{-1}) were recorded from T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}), control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}) showed lowest. In terms of combined the highest seed yield (9.20 t ha^{-1}) and pod yield (11.82 t ha^{-1}) were achieved from S_1T_2, the lowest seed yield (4.64 t ha^{-1}) and pod yield (5.93 t ha^{-1}) were obtained from S_3T_0. In the combination of spacing and macronutrient dose, the highest Benefit Cost Ratio (BCR) (3.00) was recorded from the combination of S_1T_2 treatment and the lowest BCR (1.02) was obtained from S_3T_0 treatment and this combination can be recommended for farmers field evaluation.

Keywords: Benefit-cost ratio; garden pea; macronutrients; spacing & yield.

1. INTRODUCTION

Garden pea (*Pisum sativum* L.) is a valuable vegetable as well as pulse crop all over the world, is also known as 'Matar'. It is a widely spread legume belonging to the sub-family *Papilionaceae*, family *Leguminosae* and is a self-pollinated crop. It is a cool season annual vegetable crop grown during the winter months in Bangladesh. The garden pea is grown mainly for green seeds and it can be eaten without any cooking process due to its sweet taste. It is the second most important legume crop of the world [1]. The green and dry foliage are used as cattle feed and green pods being highly nutritious are preferred for culinary purpose. This legume contains high percentage of digestible protein (7.2 g), carbohydrates (15.8 g), vitamin A (139 I.U.), vitamin C (9 mg), magnesium (34 mg) and phosphorus (139 mg) per 100 g of edible portion [2]. This is supported by [3] who concluded that lower plant density increased the pod number $plant^{-1}$ and the higher plant density, decreased the pod number $plant^{-1}$.

On the other hand, fertilizer management is another important factor that contributes the production and yield of any crop. It also plays an important role on growth and productivity of garden pea. Adequate supply of nutrients increases the yield. Nitrogen (N) is essential for synthesis of chlorophyll, enzymes and protein. Nitrogen is essential for root growth, nodulation, energy storage and transfer necessary for metabolic processes. Phosphorous (P) plays a vital role several key physiological process viz. photosynthesis, respiration, energy storage transfer, cell division and cell enlargement. It stimulates root growth, blooming, fruit setting and root formation [4]. Potassium (K) is essential in photosynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomata opening and growth of meristematic tissue [5]. Sulphur (S) now a days is considered as a macro nutrient and carries out many important functions for plant growth. It is involved in the synthesis of amino acids like cystine, methionine etc [6]. The objective of the present study was to investigate the effects of plant spacing and different levels of macronutrients on growth, productivity and profitability of garden pea. The research program was undertaken to develop the appropriate technology for approaching the highest yield and profitability of garden pea.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Design

The research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level, as per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207. The soil of the experimental area belongs to the Modhupur Tract under AEZ (Agro-ecological Zone) No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon. Soil was having the texture of sandy loam with p^H 5.6. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.The layout of the experiment was prepared for distributing the different combination of macronutrients and spacing. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot was 1.2 m × 0.9 m. The distance between blocks and plots were 0.75 m and 0.5 m, respectively.

The garden pea, variety 'BARI Motorshuti-1' was used for the present study.

2.2 Preparation of the Main Field

The plot selected for the experiment was opened in the first week of October, 2018 (monsoon period) with a power tiller and was exposed to the sun for a few days. After that the land was harrowed, ploughed and cross-ploughed several times, followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally it was obtained a desirable tilth of soil for transplanting. The land operation was completed on 25 October 2018 and sowing was done on 28 October 2018. The individual plots were made by making ridges around each plot to restrict lateral runoff of irrigation water.

2.3 Determined Parameters

Five plants were selected at randomly in such a way that the border effect could be avoided. For this reason, the outer two lines and the outer plants of the middle lines in each unit plot were avoided. Data were collected on plant height, number of branches plant^{-1}, days to 50% flowering, number of pods plant^{-1}, seed pot^{-1}, length of pod, breadth of pod, weight of 10 green pods, weight of green seeds plant^{-1}, weight of 100 seed, seed yield, pod yield etc.

2.4 Statistical Analysis

The recorded data on different parameters were statistically analyzed using Statistic 10 software. The significance of the difference among the treatments means was estimated by the least significant difference test (LSD) at 5% level of probability.

2.5 Economic Analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of spacing and macronutrient management. Cost and return were done in details according to the procedure of [7].

2.6 Benefit Cost Ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination [8] [1 tk = 0.012 USD].

$$BCR = \frac{\text{Gross return per hectare (Tk)}}{\text{Total cost of production per hectare (Tk)}} \times 100$$

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

Different spacing showed significant variation on plant height of garden pea at different growth stages (Table 1). The highest plant height [35.11, 56.59, 79.19 and 86.09 cm at 30, 45, 60 and 75 days after sowing (DAS), respectively was found from the plant spacing S_1 (30 cm × 10 cm) which was significantly different from other treatments. The lowest plant height (25.54, 43.41, 62.75 and 70.73 cm at 30, 45, 60 and 75 DAS, respectively) was recorded from the plant spacing S_3 (30 cm × 30 cm). This result indicated that lower plant spacing showed higher plant height, might be due to cause of lower sunlight intensity. Similar result was also observed by [8] who found higher plant with the spacing of 30 ×10cm compared to 45 × 10 cm.

The highest plant height (32.10, 52.14, 75.93 and 82.98 cm at 30, 45, 60 and 75 DAS, respectively) was recorded from the macronutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) whereas the lowest plant height (27.47, 46.30, 67.44 and 75.63 cm at 30, 45, 60 and 75 DAS, respectively) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}) which was statistically identical with T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}) (Table 2). This result indicated that plant height was increased with the increment of plant nutrients to at a certain level, because excess nutrition might be toxic to plants. Similar result was also observed by [9] for garden pea.

Treatment combination of plant spacing and macronutrients showed significant influence on plant height of garden pea at different growth stages (Table 3). The highest plant height (38.09, 61.22, 87.45 and 96.50 cm at 30, 45, 60 and 75 DAS, respectively) was achieved from the treatment combination of S_1T_2 which was significantly different from other treatment combinations, followed by S_1T_3. The lowest plant height (23.21, 41.39, 60.77 and 68.50 cm at 30, 45, 60 and 75 DAS, respectively) was obtained from the treatment combination of S_3T_0.

Table 1. Plant height of garden pea as influenced by different plant spacing

Treatment	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
S_1	35.113 a	56.598 a	79.192 a	86.091 a
S_2	28.714 b	47.723 b	70.683 b	77.920 b
S_3	25.542 c	43.416 c	62.750 c	70.736 c
CV (%)	6.39	7.31	9.87	10.35
$LSD_{0.05}$	0.54	0.68	0.56	0.62

DAS=days after sowing; S1=30 cm × 10 cm; S2= 30 cm × 20 cm; S3= 30 cm × 30 cm)
Means followed by different letters in a column are significantly different (P< 0.05)

Table 2. Plant height of garden pea as influenced by different level of macronutrients

Treatment	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
T_0	27.477 c	46.303 d	67.442 d	75.638 c
T_1	29.632 b	48.757 c	69.351 c	75.681 c
T_2	32.100 a	52.142 a	75.937 a	82.980 a
T_3	29.950 b	49.781 b	70.770 b	78.697 b
CV(%)	6.39	7.31	9.87	10.35
$LSD_{0.05}$	0.62	0.79	0.65	0.71

T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

Table 3. Plant height of garden pea as influenced by combined effect of plant spacing and macronutrients

Treatment	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
S_1T_0	31.960 d	52.300 d	75.480 d	83.793 c
S_1T_1	34.103 c	55.420 c	75.480 d	77.727 f
S_1T_2	38.093 a*	61.220 a*	87.457 a*	96.507 a*
S_1T_3	36.297 b	57.453 b	78.350 b	86.337 b
S_2T_0	27.257 ef	45.220 gh	66.070 g	74.613 h
S_2T_1	27.687 e	46.530 g	68.387 f	76.117 g
S_2T_2	31.773 d	50.700 e	76.773 c	81.533 d
S_2T_3	28.140 e	48.443 f	71.503 e	79.417 e
S_3T_0	23.213 h	41.390 j	60.777 j	68.507 k
S_3T_1	27.107 ef	44.320 hi	64.187 h	73.200 i
S_3T_2	26.433 fg	44.507 hi	63.580 hi	70.900 j
S_3T_3	25.413 g	43.447 i	62.45 i	70.337 j
CV(%)	6.39	7.31	9.87	10.35
$LSD_{0.05}$	1.08	1.37	1.13	1.24

S_1 (30 cm × 10 cm), S_2 (30 cm × 20 cm) and S_3 (30 cm × 30 cm)
T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

3.2 Number of Branches Plant^{-1}

Significant variation was found on number of branches plant^{-1} of garden pea at different growth stages affected by different plant spacing (Table 4). The highest number of branches plant^{-1} (4.01, 5.69, 7.15 and 8.15 at 30, 45, 60 and 75 DAS, respectively) was found from the plant spacing S_2 (30 cm × 20 cm) which was significantly different from other treatments. The lowest number of branches plant^{-1} (3.32, 4.89, 6.41 and 6.83 at 30, 45, 60 and 75 DAS, respectively) was recorded from the plant spacing S_1 (30 cm × 10cm).Similar result was also achieved by [8] in black gram.

Different macronutrient treatments showed significant variation on number of branches plant^{-1} of garden pea at different growth stages (Table 5). The highest number of branches plant^{-1}

(4.21, 5.99, 7.63 and 8.36 at 30, 45, 60 and 75 DAS, respectively) was recorded from the macronutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) which was significantly different from other treatments. The lowest number of branches $plant^{-1}$ (2.63, 3.83, 4.75 and 5.47 at 30, 45, 60 and 75 DAS, respectively) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}). Similar result was also observed by [10,11].

Treatment combination of plant spacing and macro nutrients were showed significant influence on number of branches $plant^{-1}$ of garden pea at different growth stages (Table 6). Results revealed that the highest number of branches $plant^{-1}$ (4.81, 6.41, 8.20 and 9.24 at 30, 45, 60 and 75 DAS, respectively) was achieved from the treatment combination of S_2T_2 which was statistically identical with S_2T_3 at 75 DAS. The lowest number of branches $plant^{-1}$ (2.09, 3.43, 4.83 and 5.07 at 30, 45, 60 and 75 DAS, respectively) was obtained from the treatment combination of S_1T_0 which was significantly different from other treatment combinations.

3.3 Yield Contributing Parameters and Yield

3.3.1 Days to 50% flowering (DT50%F)

Signification variation was found on days to 50% flowering of garden pea affected by different plant spacing (Table 7). The highest days to 50% flowering (36.02) was found from the plant spacing S_1 (30 cm × 10 cm) whereas the lowest days to 50% flowering (32.83) was found from the plant spacing S_2 (30 cm × 20 cm). Similar result was also observed by [12] which supported the present study.

Different macronutrient treatments showed significant variation on days to 50% flowering (Table 8). The highest days to 50% flowering (36.64) was from control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}) whereas the lowest days to 50% flowering (32.71) was found from T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) which was statistically identical with T_3. [12] also showed similar result which supported the present study.

Treatment combination of plant spacing and macro nutrients showed significant influence on days to 50% flowering (Table 9). The highest days to 50% flowering (37.24) was achieved from the treatment combination of S_1T_0. The lowest days to 50% flowering (31.11) was obtained from the treatment combination of S_2T_2 which was statistically identical with S_2T_3, S_3T_2 and S_3T_3.

3.3.2 Number of pods $plant^{-1}$(NP/P)

Signification variation was found on number of pods $plant^{-1}$ of garden pea affected by different plant spacing (Table 7).The highest number of pods $plant^{-1}$ (20.44) was found from the plant spacing S_2 (30 cm × 20 cm) followed by S_3 (30 cm × 30 cm). The lowest number of pods $plant^{-1}$ (18.25) was recorded from the plant spacing S_1 (30 cm × 10 cm).Similar result was also observed by [8] who found higher pods $plant^{-1}$ with wider spacing.

Different macro nutrient treatments showed significant variation on number of pods plant-1 of garden pea (Table 8). The highest number of pods plant-1 (24.70) was recorded from the macro nutrient treatment T2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) followed by T3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha-1) whereas the lowest number of pods plant-1 (14.70) was observed from the control treatment T0 ($N_0P_0K_0S_0$ kg ha-1).

Treatment combination of plant spacing and macro nutrients showed significant influence on number of pods $plant^{-1}$ of garden pea (Table 9). The highest number of pods $plant^{-1}$ (26.85) was achieved from the treatment combination of S_2T_2 which was significantly different from other treatment combinations followed by S_3T_2 and S_1T_2. The lowest number of pods $plant^{-1}$ (13.38) was obtained from the treatment combination of S_1T_0.

3.3.3 Number of seeds pod^{-1} (NS/P)

Signification variation was found on number of seeds pod^{-1} of garden pea affected by different plant spacing (Table 7). The highest number of seeds pod^{-1} (7.45) was found from the plant spacing S_2 (30 cm × 20 cm) followed by S_3 (30 cm × 30 cm). The lowest number of seeds pod^{-1} (6.28) was recorded from the plant spacing S_1 (30 cm × 10 cm).Wider spacing ensures more light and nutrients than closer spacing. Similar results were also observed by [13,8] who also found higher pod number with wider spacing.

Different macronutrient treatments showed significant variation on number of seeds $pod^{-1}$of garden pea (Table 8). The highest number of seeds pod^{-1} (7.54) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) which was statistically similar with T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest number of seeds pod^{-1}(5.62) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Table 4. Number of branches plant^{-1}of garden pea as influenced by different plant spacing

Treatment	Number of branches plant^{-1}			
	30 DAS	45 DAS	60 DAS	75 DAS
S_1	3.3258 c	4.8917 b	6.4133 c	6.8383 c
S_2	4.0117 [a*]	5.6967 a*	7.1567 a*	8.1550 a*
S_3	3.6083 b	5.5658 a	6.5392 b	7.4150 b
CV(%)	11.93	10.34	11.25	10.63
$LSD_{0.05}$	0.11	0.13	0.12	0.06

DAS=days after sowing; S1=30 cm × 10 cm; S2= 30 cm × 20 cm; S3= 30 cm × 30 cm)
Means followed by different letters in a column are significantly different (P< 0.05)

Table 5. Number of branches plant^{-1} of garden pea as influenced by different level of macronutrients

Treatment	Number of branches plant^{-1}			
	30 DAS	45 DAS	60 DAS	75 DAS
T_0	2.6389 c	3.8389 c	4.7556 d	5.4778 c
T_1	3.5956 b	5.7489 b	6.9856 c	7.7267 b
T_2	4.2111 a	5.9944 a	7.6333 a	8.3644 a
T_3	4.1489 a	5.9567 a	7.4378 b	8.3089 a
CV(%)	11.93	10.34	11.25	10.63
$LSD_{0.05}$	0.12	0.15	0.13	0.08

T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

Table 6. Number of branches plant^{-1} of garden pea as influenced by combined effect of plant spacing and macro nutrients

Treatment	Number of branches plant^{-1}			
	30 DAS	45 DAS	60 DAS	75 DAS
S_1T_0	2.09 i	3.43 f	4.83 f	5.07 i
S_1T_1	3.63 f	5.29 d	6.86 d	7.12 f
S_1T_2	3.81 def	5.39 d	7.05 cd	7.93 d
S_1T_3	3.77 ef	5.44 d	6.91 d	7.23 f
S_2T_0	2.88 h	4.17 e	5.16 e	6.10 g
S_2T_1	3.89 de	6.03 bc	7.17 c	8.14 c
S_2T_2	4.81 a*	6.41 a*	8.20 a*	9.24 a*
S_2T_3	4.46 b	6.18 abc	8.10 ab	9.12 a
S_3T_0	2.95 h	3.91 e	4.28 g	5.25 h
S_3T_1	3.26 g	5.92 c	6.93 d	7.92 d
S_3T_2	4.01 cd	6.18 abc	7.06 d	7.75 e
S_3T_3	4.21 c	6.25 ab	7.89 b	8.74 b
CV(%)	11.93	10.34	11.25	10.63
$LSD_{0.05}$	0.22	0.26	0.23	0.13

S_1 (30 cm × 10cm), S_2 (30 cm × 20 cm) and S_3 (30 cm × 30 cm)
T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

Treatment combination of plant spacing and macronutrients showed significant influence on number of seeds pod^{-1}of garden pea (Table 9). The highest number of seeds pod^{-1} (8.18) was achieved from the treatment combination of S_2T_2 which was statistically similar with S_2T_3. The lowest number of seeds pod^{-1} (5.03) was obtained from the treatment combination ofS_1T_0.

3.3.4 Length of pod (PL)

Significant variation was found on of garden pea affected by different plant spacing (Table 7). The highest PL (6.81 cm) was found from the plant spacing S_2 (30 cm × 20 cm) followed by S_3 (30 cm × 30 cm). The lowest length of pod (5.84 cm) was recorded from the plant spacing S_1 (30 cm ×

10 cm). Higher levels of plant nutrients help to increase pod length and wider spacing ensures more plant nutrients than lower spacing. [12] found similar results which supported the present finding.

Different macronutrient treatments showed significant variation on length of pod of garden pea (Table 8). The highest length of pod (7.37 cm) was recorded from the macronutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) followed by T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest length of pod (5.40 cm) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Treatment combination of plant spacing and macro nutrients showed significant influence on length of pod of garden pea (Table 9). The highest length of pod (8.11 cm) was achieved from the treatment combination of S_2T_2 which was statistically identical with S_3T_2. The lowest length of pod (5.09 cm) was obtained from the treatment combination of S_1T_0 which was statistically similar with S_2T_0.

3.3.5 Breadth of pod (BP)

Significant variation was found on BP of pod of garden pea affected by different plant spacing (Table 7). The highest BP (1.47 cm) was found from the plant spacing S_2 (30 cm × 20 cm) followed by S_3 (30 cm × 30 cm). The lowest breadth of pod (1.36 cm) was recorded from the plant spacing S_1 (30 cm × 10cm). Similar result was also observed by [12].

Different macronutrient treatments showed significant variation on breadth of pod of garden pea (Table 8). The highest breadth of pod (1.50 cm) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1})followed by T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest breadth of pod (1.34 cm) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Treatment combination of plant spacing and macro nutrients showed significant influence on breadth of pod of garden pea (Table 9). The highest breadth of pod (1.56 cm) was achieved from the treatment combination of S_2T_2 whereas the lowest breadth of pod (1.26 cm) was obtained from the treatment combination of S_1T_0which was statistically similar with S_1T_1.

3.3.6 Weight of 10 green pods (g) (W10GP)

Significant variation was found on W10GPof garden pea affected by different plant spacing (Table 7). The highest W10GP (44.42 g) was found from the plant spacing S_2 (30 cm × 20 cm).

Table 7. Yield and yield attributes of garden pea influenced by different plant spacing

Treatment	Yield contributing parameters					
	Days to 50% flowering	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Length of pod	Breadth of pod	Weight of 10 green pods(g)
S_1	36.02 a	18.25 c	6.28 c	5.84 c	1.36 c	42.16 b
S_2	32.83 c	20.44 a	7.45 a	6.81 a	1.47 a	44.42 a
S_3	33.17 b	19.81 b	6.95 b	6.29 b	1.43 b	42.19 b
CV(%)	5.88	8.16	9.97	10.58	7.45	8.62
$LSD_{0.05}$	0.31	0.472	0.265	0.226	0.029	0.292

S1=30 cm × 10 cm; S2= 30 cm × 20 cm; S3= 30 cm × 30 cm)
Means followed by different letters in a column are significantly different (P< 0.05)

Table 8. Yield and yield attributes of garden pea influenced by different level of macronutrients

Treatment	Yield contributing parameters					
	Days to 50% flowering	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Length of pod	Breadth of pod	Weight of 10 green pods (g)
T_0	36.64 a	14.70 d	5.62 c	5.40 c	1.34 d	39.91 d
T_1	33.87 b	18.29 c	7.15 b	6.12 b	1.40 c	42.93 c
T_2	32.71 c	24.70 a	7.54 a	7.37 a	1.50 a	45.35 a
T_3	32.80 c	20.31 b	7.25 ab	6.37 b	1.46 b	43.50 b
CV(%)	5.88	8.16	9.97	10.58	7.45	8.62
$LSD_{0.05}$	0.36	0.546	0.306	0.261	0.033	0.337

T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

Table 9. Yield and yield attributes influenced by combined effect of plant spacing and macro nutrients

Treatment	Yield contributing parameters				
	Days to 50% flowering	No. of seeds pod^{-1}	Length of pod	Breadth of pod	Weight of 10 green pods (g)
S_1T_0	37.24 a	5.03 h	5.09 e	1.26 f	39.13 h
S_1T_1	35.80 cd	6.42 ef	5.69 d	1.31 ef	42.23 e
S_1T_2	35.21 d	7.03 cd	6.26 c	1.47 b	44.23 c
S_1T_3	35.79 cd	6.62 de	6.31 c	1.40 cd	43.17 d
S_2T_0	36.54 b	6.08 fg	5.53 de	1.40 cd	40.42 g
S_2T_1	32.33 f	7.52 bc	7.03 b	1.44 bc	45.36 b
S_2T_2	31.11 g	8.18 a	8.11 a	1.56 a	46.29 a
S_2T_3	31.34 g	8.01 ab	6.57 c	1.49 b	45.59 b
S_3T_0	36.16 bc	5.74 g	5.58 d	1.35 de	40.17 g
S_3T_1	33.46 e	7.52 bc	5.62 d	1.45 bc	41.22 f
S_3T_2	31.58 g	7.41 c	7.73 a	1.47 b	45.53 b
S_3T_3	31.51 g	7.12 cd	6.23 c	1.48 b	41.74 ef
CV(%)	5.88	9.97	10.58	7.45	8.62
$LSD_{0.05}$	0.62	0.530	0.453	0.058	0.585

S_1 (30 cm × 10 cm), S_2 (30 cm × 20 cm) and S_3 (30 cm × 30 cm)
T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

The lowest weight of 10 green pods (42.16 g) was recorded from the plant spacing S_1 (30 cm × 10 cm) which was statistically identical with S_3 (30 cm × 30 cm). The present study showed that wider spacing showed higher pod weight compared to lower spacing which might be due to cause of nutrient deficiency occurred with closer spacing. [14] also found similar result with the present study.

Different macro nutrient treatments showed significant variation on weight of 10 green pods of garden pea (Table 8). The highest weight of 10 green pods (45.35 g) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1})followed by T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest weight of 10 green pods (39.91 g) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Treatment combination of plant spacing and macro nutrients showed significant influence on weight of 10 green pods of garden pea (Table 9). The highest weight of 10 green pods (46.29 g) was achieved from the treatment combination of S_2T_2which was significantly different from other treatment combinations. The lowest weight of 10 green pods (39.13 g) was obtained from the treatment combination of S_1T_0.

3.3.7 Weight of green seeds plant^{-1} (g) (WGS/P)

Signification variation was found on WGS/P of garden pea affected by different plant spacing (Table 10). The highest WGS/P (18.16 g) was found from the plant spacing S_2 (30 cm × 20 cm) which was statistically identical with S_3 (30 cm × 30 cm). The lowest weight of green seeds plant^{-1} (17.15 g) was recorded from the plant spacing S_1 (30 cm × 10 cm). Similar result was also observed by [13] and [14] which supported the present study.

Different macronutrient treatments showed significant variation on weight of green seeds plant^{-1}of garden pea (Table 11). The highest weight of green seeds plant^{-1} (19.53 g) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) which was statistically identical with T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest weight of green seeds plant^{-1} (16.36 g) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Treatment combination of plant spacing and macro nutrients showed significant influence on weight of green seeds plant-1 of garden pea (Table 12). The highest weight of green seeds plant-1 (20.92 g) was achieved from the treatment combination of S2T2 which was significantly different from other treatment combinations. The lowest weight of green seeds plant-1 (15.36 g) was obtained from the treatment combination of S1T0.

3.3.8 Weight of 100 seeds (g) (W100S)

Significant variation was found on 100 seed weight of garden pea affected by different plant

spacing (Table 10). Results showed that the highest 100 seed weight (4.36 g) was found from the plant spacing S_2 (30 cm × 20 cm) whereas the lowest 100 seed weight (3.71 g) was recorded from the plant spacing S_1 (30 cm × 10 cm). The result obtained from the present study was similar with the findings of [14] and [8] who reported that higher spacing showed higher 1000 seed weight.

Different macro nutrient treatments showed significant variation on 100 seed weight of garden pea (Table 11). The highest 100 seed weight (4.32 g) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) whereas the lowest 100 seed weight (3.64 g) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Treatment combination of plant spacing and macro nutrients showed significant influence on 100 seed weight of garden pea (Table 12). The highest 100 seed weight (5.20 g) was achieved from the treatment combination of S_2T_2 which was statistically identical with S_2T_3 and S_3T_3. The lowest 100 seed weight (3.33 g) was obtained from the treatment combination of S_1T_0.

3.3.9 Seed yield (t ha^{-1}) (SY)

Significant variation was found on SY of garden pea affected by different plant spacing (Table 10). The highest seed yield (8.38 t ha^{-1}) was found from the plant spacing S_1 (30 cm × 10cm) followed by S_2 (30 cm × 20 cm). The lowest seed yield (6.09 t ha^{-1}) was recorded from the plant spacing S_3 (30 cm × 30 cm). Mainly seed yield depends on yield contributing parameters like number of plant populations per square meter, pods per plant, seeds per pod etc. Under the present study lower plant spacing showed highest yield which might be due to cause of higher plant population. Similar result was also observed by [8,13,14].

Different macro nutrient treatments showed significant variation on seed yield of garden pea (Table 11). The highest seed yield (7.57 t ha^{-1}) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) which was statistically identical with T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest seed yield (6.01 t ha^{-1}) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).Generally it is known that excess plant nutrients are toxic to plant. So, optimum nutrition is essential for higher production.

Treatment combination of plant spacing and macro nutrients showed significant influence on seed yield of garden pea (Table 12). The highest seed yield (9.20 t ha^{-1}) was achieved from the treatment combination of S_1T_2 which was

Table 10. The effect of spacing on yield and yield attributes of garden pea

Treatment	Yield contributing parameters and yield			
	Weight of green seeds $plant^{-1}$ (g)	100 seed weight (g)	Seed yield (t ha^{-1})	Pod yield (t ha^{-1})
S_1	17.15 [b]	3.71 [b]	8.38 a	10.65 a
S_2	18.16 a	4.36 a	6.69 b	8.16 b
S_3	17.98 a	4.19 a	6.09 c	6.43 c
CV(%)	10.35	11.93	11.25	12.72
$LSD_{0.05}$	0.34	0.18	0.23	0.13

S1=30 cm × 10 cm; S2= 30 cm × 20 cm; S3= 30 cm × 30 cm)
Means followed by different letters in a column are significantly different (P< 0.05)

Table 11. The effect of macronutrients on yield and yield attributes of garden pea

Treatment	Yield contributing parameters and yield			
	Weight of green seeds $plant^{-1}$ (g)	100 seed weight (g)	Seed yield (t ha^{-1})	Pod yield (t ha^{-1})
T_0	16.36 c	3.64 c	6.01 b	7.76 d
T_1	17.56 b	3.87 b	7.31 a	8.25 c
T_2	19.53 a	4.32 a	7.57 a	9.12 a
T_3	17.60 b	4.52 a	7.30 a	8.52 b
CV(%)	10.35	11.93	11.25	12.72
$LSD_{0.05}$	0.39	0.21	0.26	0.15

T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

Table 12. The combined effect of spacing and macronutrients on yield and yield attributes of garden pea

Treatment	Yield contributing parameters and yield			
	Weight of green seeds plant^{-1} (g)	100 seed weight (g)	Seed yield (t ha^{-1})	Pod yield (t ha^{-1})
S_1T_0	15.36 h	3.33 e	7.83 cd	9.66 d
S_1T_1	17.27 efg	3.99 bc	8.44 b	10.35 c
S_1T_2	18.49 bc	4.03 b	9.20 a	11.82 a
S_1T_3	17.48 def	3.50 de	8.04 bc	10.76 b
S_2T_0	17.07 fg	3.58 de	5.57 h	7.70 g
S_2T_1	17.26 efg	3.64 cde	7.42 de	8.10 f
S_2T_2	20.92 a	5.20 a	6.67 f	8.63 e
S_2T_3	17.38 ef	5.04 a	7.10 ef	8.21 f
S_3T_0	16.65 g	4.00 bc	4.64 i	5.93 k
S_3T_1	18.16 cd	3.99 bc	6.08 g	6.29 j
S_3T_2	19.17 b	3.73 bcd	6.84 f	6.91 h
S_3T_3	17.94 cde	5.03 a	6.78 f	6.59 i
CV(%)	10.35	11.93	11.25	12.72
$LSD_{0.05}$	0.68	0.36	0.46	0.27

S_1 (30 cm × 10 cm), S_2 (30 cm × 20 cm) and S_3 (30 cm × 30 cm)
T_0 ($N_0P_0K_0S_0$ kg ha^{-1}), T_1 ($N_{15}P_{25}K_{25}S_5$ kg ha^{-1}), T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) and T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1})
Means followed by different letters in a column are significantly different (P< 0.05)

Table 13. Economic analysis of garden pea regarding cost of production per hectare basis

Treatment	Garden pea yield ha^{-1} (t)	Total cost of production	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
S_1T_0	9.66	112837	289800	176963	2.57
S_1T_1	10.35	115521	310500	194979	2.69
S_1T_2	11.82	118204	354600	236396	3.00
S_1T_3	10.76	120888	322800	201912	2.67
S_2T_0	7.70	110600	231000	120400	2.09
S_2T_1	8.10	113284	243000	129716	2.15
S_2T_2	8.63	115968	258900	142932	2.23
S_2T_3	8.21	118652	246300	127648	2.08
S_3T_0	5.93	109482	177900	68418	1.62
S_3T_1	6.29	112166	188700	76534	1.68
S_3T_2	6.91	114850	207300	92450	1.80
S_3T_3	6.59	117533	197700	80167	1.68

S_1 =30 cm × 10 cm, S_2 =30 cm × 20 cm, S_3 =30 cm × 30 cm
T_0 = $N_0P_0K_0S_0$ (control), T_1 = $N_{15}P_{25}K_{25}S_5$ (kg ha^{-1}), T_2 = $N_{30}P_{50}K_{50}S_{10}$ (kg ha^{-1}), T_3 = $N_{45}P_{75}K_{75}S_{15}$ (kg ha^{-1})

significantly different from other treatment combinations followed by S_1T_1. The lowest seed yield (4.64 t ha^{-1}) was obtained from the treatment combination of S_3T_0.

3.3.10 Pod yield (t ha^{-1}) (PY)

Significant variation was found on PY of garden pea affected by different plant spacing (Table 10).The highest PY (10.56 t ha^{-1}) was found from the plant spacing S_1 (30 cm × 10 cm)followed by S_2 (30 cm × 20 cm). The lowest pod yield (6.43 t ha^{-1}) was recorded from the plant spacing S_3 (30 cm × 30 cm). Similar result was also observed by [13], [12] and [14] which supported the present study.

Different macro nutrient treatments showed significant variation on pod yield of garden pea (Table 11). The highest pod yield (9.12 t ha^{-1}) was recorded from the macro nutrient treatment T_2 ($N_{30}P_{50}K_{50}S_{10}$ kg ha^{-1}) followed by T_3 ($N_{45}P_{75}K_{75}S_{15}$ kg ha^{-1}). The lowest pod yield (7.76 t ha^{-1}) was observed from the control treatment T_0 ($N_0P_0K_0S_0$ kg ha^{-1}).

Treatment combination of plant spacing and macro nutrients showed significant influence on

pod yield of garden pea [12]. The highest pod yield (11.82 t ha^{-1}) was achieved from the treatment combination of S_1T_2 which was significantly different from other treatment combinations followed by S_1T_3. The lowest pod yield (5.93 t ha^{-1}) was obtained from the treatment combination of S_3T_0 which was significantly different from other treatment combinations.

3.4 Economic Analysis of Garden Pea Production

The economic analysis is presented under the following headings-

3.4.1 Gross return

The highest gross return (BDT 354600/ha) was recorded from the treatment combination $S_1T_2$and the lowest gross return (BDT 177900/ha) was recorded from the treatment combination - S_3T_0.

3.4.2 Net return per hectare

The highest net return (BDT 236396/ha) was found from the treatment combination S_1T_2. The lowest net return (BDT 68418/ha) was obtained from S_3T_0 treatment.

3.4.3 Benefit cost ratio (BCR)

In the combination of spacing and macronutrient dose, the highest BCR (3.00) was recorded from the combination of S_1T_2 treatment (Table 10). The lowest BCR (1.02) was obtained from S_3T_0 treatment.

4. CONCLUSION

Both crop yield and economic benefit of crop are important for the crop production. Considering yield contributing parameters and yield, the highest seed yield (9.20 t ha^{-1}) and pod yield (11.82 t ha^{-1}) were achieved from the treatment combination of S_1T_2. From the above result it was concluded that the treatment combination of S_1T_2 can be considered as the best treatment combinations compared to other treatment combinations in respect of yield and economic point of view.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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