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FERTILIZER MANAGEMENT OF GYPSOPHILA (*Gypsophila paniculata*)

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Abstract

A field experiment was conducted at the research field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) Gazipur under AEZ-28 during Rabi season of 2017-18 and 2018-19 to determine the suitable combination of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) for improving growth and cut flower bunch yield of gypsophila. There were 15 treatment combinations comprising four levels of nitrogen (0, 70, 100 and 130 kg ha^{-1}), four levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}), four levels of potassium (0, 60, 90 and 120 kg ha^{-1}) and four levels of sulphur (0, 10, 20 and 30 kg ha^{-1}) along with a blanket dose of $Zn_3B_{1.5}$ kg ha^{-1} and cow dung 5 t ha^{-1}. The experiment was laid out in randomized complete block design with three replications. The combination of $N_{100}P_{40}K_{60}S_{20}$ kg ha^{-1} produced significantly higher cut flower bunch yield. The said treatment produced the maximum mean cut flower bunch yield of 185010 nos. ha^{-1} which was 76.9% higher over control ($N_0P_0K_0S_0$). The maximum number of branches per plant (7.12 nos.) and maximum opened flower per plant (60.2 nos.) were recorded from the treatment combination of $N_{100}P_{40}K_{60}S_{20}$ kg ha^{-1}. Cost and return analysis indicated maximum net return and highest benefit cost ratio (1.91) was estimated from the same treatment. The results suggest that combined application of 100-40-60-20 kg ha^{-1} of N-P-K-S including 3 kg Zn ha^{-1}, 1.5 kg B ha^{-1} and 5 t ha^{-1} cowdung can improve the growth and cut flower bunch yield of gypsophila. From the regression analysis, the optimum treatment combination was calculated as $N_{91.8}P_{44.0}K_{80.7}S_{18.7}$ kg ha^{-1} for experimental area. Therefore, the optimum combination package $N_{91.8}P_{44.0}K_{80.7}S_{18.7}$ kg ha^{-1} along with the blanket dose of $Zn_3B_{1.5}$ kg ha^{-1} and 5 t cowdung ha^{-1} may be recommended for gypsophila cut flower cultivation in Gazipur area.

Keywords: Gypsophila, NPKS, cut flower, bunch yield, fertilizers, B:C ratio

Introduction

Gypsophila (*Gypsophila paniculata* L.) is an important common flower under 'Caryophyllaceae' family found in Eurosia, Africa, Australia, Iran and the Pacific Islands. Most of the gypsophila species are concentrated in Turkey, Caucasia, northern Iraq and northern Iran (Özdemir *et al*., 2010). The genus name is from the Greek gypsos (gypsum, calc) and philos (loving). Plants of the genus are known as baby's breath and used as cut flower to add as a filler to flower bouquets. A few species of gypsophila are commercially cultivated for several

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uses, including floristry, herbal medicine and food (Korkmaz and Özçelik, 2011). It is generally used as cut flower and has gained a great economic value in trade because of its prettiness (Wahome *et al.*, 2011; Petry, 2008). Gypsophila has also become an important commercial ornamental crop in Bangladesh. As a new crop, farmers of Bangladesh are hardly known about its cultivation technique. It is reported that gypsophila is highly exhaustive and responsive to inorganic fertilizers like N, P, K and S. Fertilizer contributes to achieve a high yield of crops (Dass and Mandal, 2016). Balanced doses of inorganic fertilizer improve the flower quality, growth performance and yield of many ornamental crops (Ahmed *et al*., 2017). Therefore, the present study was undertaken to determine the dose of nitrogen, phosphorus, potassium and sulphur for improving the growth and yield maximization of gypsophila.

Materials and Methods

A field experiment was conducted during Rabi season of two consecutive years 2017-18 and 2018-19 at the research field of Floriculture division under Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) Gazipur. Initial nutrient statuses of the experimental plot are presented in Table 1. The initial soil (0-15 cm depth) sample of experimental plot was analyzed as outlined by Page *et al*. (1982). Weather data of Gazipur during the experimental period (2017-18 and 2018-19) are presented in Table 2.

Table 1. Initial soil nutrient status of the experimental site

Nutrient	Soil test value	Critical level	*Soil test interpretation
pH	6.5	-	Slightly acidic
Organic matter (%)	1.20	-	Low
Total N (%)	0.061	0.12	Very low
K (meq/100 g soil)	0.13	0.12	Low
Available P (ppm)	12.2	7	Medium
S (ppm)	12.5	10	Low
Zn (ppm)	0.73	0.6	Low
B(ppm)	0.17	0.2	Low

*Anonymous (2018)

Table 2. Weather data during the experiment period

Months	Avg. Temperature (°C)				Avg. Humidity (%)		Rainfall (mm)	
	2017-18		2018-19		2017-18	2018-19	2017-18	2018-19
	Min.	Max.	Min.	Max.				
November	18.1	30.8	18.5	24.0	80.9	78.6	88.6	90.0
December	15.2	26.9	20.5	26.7	84.1	76.4	92.1	91.0
January	13.2	23.9	13.1	23.7	76.6	80.5	0.0	29
February	15.3	29.0	14.3	28.1	70.3	71.3	18	88
March	19.6	33.2	18.8	31.2	68.7	70.6	29	21

Source: Weather centre, BARI, Gazipur

There were 15 treatment combinations comprising each of four levels of nitrogen (0, 70, 100 and 130 kg ha^{-1}), phosphorus (0, 20, 40 and 60 kg ha^{-1}), potassium (0, 60, 90 and 120 kg ha^{-1}) and sulphur (0, 10, 20 and 30 kg ha^{-1}) along with a blanket dose of $Zn_3B_{1.5}$ kg ha^{-1} and cow dung 5 t ha^{-1}over the treatments.

The treatment combinations were T_1=$N_0P_0K_0S_0$, T_2=$N_0P_{40}K_{90}S_{20}$, T_3=$N_{70}P_{40}K_{90}S_{20}$, T_4=$N_{100}P_{40}K_{90}S_{20}$, T_5=$N_{130}P_{40}K_{90}S_{20}$, T_6=$N_{100}P_0K_{90}S_{20}$, T_7=$N_{100}P_{20}K_{90}S_{20}$, T_8=$N_{100}P_{60}K_{90}S_{20}$, T_9=$N_{100}P_{40}K_0S_{20}$, T_{10}=$N_{100}P_{40}K_{60}S_{20}$, T_{11}=$N_{100}P_{40}K_{120}S_{20}$, T_{12}=$N_{100}P_{40}K_{90}S_0$, T_{13}=$N_{100}P_{40}K_{90}S_{10}$, T_{14}=$N_{100}P_{40}K_{90}S_{30}$ and T_{15}=$N_{130}P_{60}K_{120}S_{30}$ kg ha^{-1}. The experiment was laid out in randomized complete block design with three replications. The unit plot size was 3.7 m × 1.5 m. The blanket doses of Zn and B containing fertilizers as zinc sulphate and boric acid and decomposed cow dung were applied during final land preparation. Sources of N, P, K and S were urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum, respectively. Treatment wise 1/3 amount of urea, full of TSP, ½ of MoP, and full of gypsum were applied after final bed preparation while 2/3 of Urea and half of MoP was applied in two equal splits. First split was applied at 20 days after sowing (DAS) and second split was applied at 35 DAS. Seeds of gypsophila (BARI Gypsophila-1) were sown @ 2.5 kg ha^{-1} with a spacing of 25 cm × continuous on 30 November 2017 and 28 November 2018.

Weeding, irrigation and plant protection measures were taken as and when required. Data on growth and yield attributes were recorded from randomly selected 10 plants from each unit plot. Leaf chlorophyll content (SPAD value) was measured by a soil-plant analysis development (SPAD) chlorophyll meter (model: SPAD-502 plus, manufactured by Konica Minolta, Tokyo, Japan) after 45 days of sowing. The cut flower was harvested from two rows of each plot at 66 DAS. The eight to ten cut flowers together were made single flower bunch. Number of cut flower bunch size was made based on the number branches per plant. The bunch yield was converted into number of bunch per plot. Cut flower bunch yield per plot was converted into number of bunch ha^{-1}. Collected data were subjected to statistical analysis of variance (ANOVA) according to Statistix 10 software (www.statistix.com). The means of each treatment were compared using the least significant difference (LSD) test at significant level $p \leq 0.05$ (Statistix-10, 1985). The optimum dose of nitrogen, phosphorus, potassium and sulphur was calculated using the formula: $Y = -b/2c$ (Gomez and Gomez, 1984). Benefit cost ratio (BCR) was calculated for a hectare of land. Treatment wise management cost was calculated by adding the cost incurred for labours, plowing, irrigation and inputs of each treatment. The number of flower bunch (yield) of gypsophila was converted numerical ha^{-1}. This yield was utilized to calculate the gross return. The shadow prices (land rent, straw cost etc.) were not considered. The gross return was measured by multiplying the marketable unit price of flower bunch. Net return was calculated by subtracting management cost from gross return. Benefit cost ratio was calculated the gross return divided by the management cost.

Results and Discussion

Growth and cut flower yield contributing characters of gypsophila

The highest plant height (50.7 cm in 2017-18 and 52.3 cm in 2018-19) was recorded from the treatment T_8 in 2017-18 which was significantly different over the other treatments but statistically identical to T_{10}, T_7 and T_{13} treatments. The result was consistent in 2018-19 (Table 3). Ayemi *et al.* (2017) corroborated the similar result in gerbera. The primary branches per plant varied from 4.91 to 7.14 across the treatments where maximum number of primary branches per plant was noted from the treatment T_{10} followed by T_8, T_{13} and T_{14}. The results were consistent in both consecutive years (Table 3). The lowest plant height and minimum branches per plant were found in control T_1 (Table 3). The highest stem diameter of gypsophila 3.40 cm in 2017-18 was recorded significantly in T_8 treatment and lowest was in control T_1. Comparable trend in result was noted in 2018-19 (Table 3). Similar trend of plant growth was recorded in marigold (Sharma *et al*., 2017) and tulip (Khan *et al*., 2006).

Maximum number of internode per plant (7.57) was found in treatment T_{10} followed by T_5, T_{11}, T_4 and T_{14} treatments in 2017-18. The trend was followed in the 2^{nd} year trial (Table 4). The increased internode length was found in T_8 treatment in 2017-18 which resembled with T_5 treatment in both the years and lesser internode length was in control T_1 (Table 4). As comparison to the growth of control (T_1) it can be assessed that NPK and S stimulated the nodal growth. Similar report was presented by Khan *et al.* (2012). Number of opened flower per plant varied from 33.5 to 59.4 among the treatments in the year 2017-18 where the maximum number was recorded from T_{10} followed by T_8, T_7 and T_{11} treatments. Similar trend in result was noticed in 2018-19 (Table 4). The result is in agreement with the findings of Senapati *et al*. (2020) in chrysanthemum and Sultana *et al.* (2006) in tuberose who reported that maximum number flowers per plant were obtained in combined application of fertilizers N, P and K.

Number of unopened flowers per plant, flower diameter and chlorophyll contents were found almost similar trend and influenced significantly by the application of different doses of N, P, K and S fertilizers. Their trends were consistent in both the years (Table 5). The results are in agreement with the findings of Ahmed *et al*. (2017).

Cut flower bunch yield of gypsophila

Maximum Cut flower bunch yield 180020 nos. ha^{-1} in 2017-18 was recorded from the treatment T_{10} which was identical to that of T_{15}, T_{13}, T_{14}, T_{11} and T_8 treatments. The trend in result was similar in 2018-19 (Table 6). Similarly Senapati *et al*. (2020), Ghaffoor *et al*. (2000) and Khan et al. (2006) reported maximum flower yield in chrysanthemum, rose and tulip. In the experiment, the highest bunch yield increment over control (76.9%) was calculated from T_{10} treatment and the lowest increment was from T_2 treatment (Table 6).

Table 3. Effect of nitrogen, phosphorus, potassium and sulphur on growth and yield contributing characters of gypsophila

Treatment N-P-K-S (kg ha^{-1})	Plant height (cm)			No. of primary branch plant^{-1}			Stem diameter (cm)		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
$T_1=N_0P_0K_0S_0$	33.7f	34.5f	34.1	4.91f	5.11e	5.01	2.48g	2.52h	2.50
$T_2=N_0P_{40}K_{90}S_{20}$	37.5ef	38.4e	38.0	5.65e	6.02d	5.84	2.94ef	2.96efg	2.95
$T_3=N_{70}P_{40}K_{90}S_{20}$	40.2de	41.5de	40.9	6.23cde	6.23d	6.23	3.09cde	3.09c-f	3.09
$T_4=N_{100}P_{40}K_{90}S_{20}$	40.8de	42.0de	41.4	6.51a-d	6.51bcd	6.51	3.30ab	3.32ab	3.31
$T_5=N_{130}P_{40}K_{90}S_{20}$	44.4bcd	45.0cd	44.7	6.41bcd	6.40cd	6.41	3.27abc	3.27abc	3.27
$T_6=N_{100}P_0K_{90}S_{20}$	44.8bcd	46.0bc	45.4	6.18de	6.18d	6.18	2.89ef	2.91fg	2.90
$T_7=N_{100}P_{20}K_{90}S_{20}$	48.4ab	49.1ab	48.8	6.67a-d	6.81abc	6.74	3.08cde	3.16b-e	3.12
$T_8=N_{100}P_{60}K_{90}S_{20}$	50.7a	52.3a	51.5	6.85ab	6.97ab	6.91	3.40a	3.42a	3.41
$T_9=N_{100}P_{40}K_0S_{20}$	42.5cd	44.2cd	43.4	6.36bcd	6.39cd	6.38	2.81f	2.83g	2.82
$T_{10}=N_{100}P_{40}K_{60}S_{20}$	48.8ab	50.4a	49.6	7.09a	7.14a	7.12	3.31ab	3.35ab	3.33
$T_{11}=N_{100}P_{40}K_{120}S_{20}$	42.5cd	42.8cd	42.7	6.31bcd	6.42cd	6.37	3.17bcd	3.16b-e	3.17
$T_{12}=N_{100}P_{40}K_{90}S_0$	43.2cd	42.9cd	43.1	6.27b-e	6.26d	6.27	2.79f	2.80g	2.80
$T_{13}=N_{100}P_{40}K_{90}S_{10}$	46.2abc	45.9bc	46.1	6.87ab	6.85abc	6.86	3.28abc	3.30ab	3.29
$T_{14}=N_{100}P_{40}K_{90}S_{30}$	42.4cd	41.8de	42.1	6.84abc	6.85abc	6.85	3.23a-d	3.24a-d	3.24
$T_{15}=N_{130}P_{60}K_{120}S_{30}$	41.3de	42.1de	41.7	6.36bcd	6.34cd	6.35	3.03de	3.06def	3.05
CV (%)	6.44	4.87	-	5.78	5.05	-	3.99	4.05	-
LSD (0.05)	4.65	3.58	-	0.62	0.54	-	0.21	0.21	-

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$)

Table 4. Effect of nitrogen, phosphorus, potassium and sulphur on growth and yield contributing characters of gypsophila

Treatment N-P-K-S (kg ha^{-1})	No. of internodes plant^{-1}			Internode length (cm)			No. of opened flower plant^{-1}		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
$T_1=N_0P_0K_0S_0$	5.18fg	5.82h	5.50	4.15i	4.18f	4.17	33.5e	36.3g	34.9
$T_2=N_0P_{40}K_{90}S_{20}$	6.34d-g	6.36e-h	6.35	4.67h	4.72e	4.70	45.0cd	45.9def	45.5
$T_3=N_{70}P_{40}K_{90}S_{20}$	6.79a-e	6.81b-f	6.80	5.13g	5.16d	5.15	45.1cd	45.8ef	45.5
$T_4=N_{100}P_{40}K_{90}S_{20}$	7.30abc	7.31a-d	7.31	6.32bcd	6.30c	6.31	44.0d	44.9f	44.5
$T_5=N_{130}P_{40}K_{90}S_{20}$	7.51a	7.48ab	7.50	6.76a	6.77a	6.77	43.2d	44.2f	43.7
$T_6=N_{100}P_0K_{90}S_{20}$	6.58c-f	6.60d-g	6.59	6.26c-f	6.30bc	6.28	44.2d	45.4f	44.8
$T_7=N_{100}P_{20}K_{90}S_{20}$	6.64b-e	6.71c-f	6.68	6.37bc	6.42bc	6.40	54.4ab	54.5abc	54.5
$T_8=N_{100}P_{60}K_{90}S_{20}$	7.05a-d	7.06b-e	7.06	6.86a	6.87a	6.87	59.1a	59.7ab	59.4
$T_9=N_{100}P_{40}K_0S_{20}$	5.76g	5.88gh	5.82	5.15g	5.34d	5.25	52.5abc	53.1b-e	52.8
$T_{10}=N_{100}P_{40}K_{60}S_{20}$	7.57a	7.86a	7.72	6.18c-f	6.73a	6.46	59.4a	60.9a	60.2
$T_{11}=N_{100}P_{40}K_{120}S_{20}$	7.41ab	7.40abc	7.41	6.28cde	6.36bc	6.32	54.5a	58.8ab	56.7
$T_{12}=N_{100}P_{40}K_{90}S_0$	6.05efg	6.13fgh	6.09	6.14def	6.22c	6.18	48.1bcd	48.7c-f	48.4
$T_{13}=N_{100}P_{40}K_{90}S_{10}$	6.90a-d	6.93b-e	6.92	6.52b	6.59ab	6.56	52.5abc	53.2bcd	52.9
$T_{14}=N_{100}P_{40}K_{90}S_{30}$	7.29abc	7.30a-d	7.30	6.10ef	6.17c	6.14	52.6abc	53.4bc	53.0
$T_{15}=N_{130}P_{60}K_{120}S_{30}$	6.47d-g	6.48e-h	6.48	6.05f	6.14c	6.10	48.8bcd	49.6c-f	49.2
CV (%)	6.97	6.68	-	2.19	2.90	-	9.51	8.75	-
LSD (0.05)	0.79	0.76	-	0.22	0.29	-	7.81	7.35	-

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$)

Table 5. Effect of nitrogen, phosphorus, potassium and sulphur on yield contributing characters of gypsophila

Treatment N-P-K-S (kg ha^{-1})	No. of unopened flower $plant^{-1}$			Flower diameter (cm)			Chlorophyll (SPAD)		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
$T_1=N_0P_0K_0S_0$	26.1h	26.7h	26.4	0.57i	0.58j	0.58	37.2f	36.6e	36.9
$T_2=N_0P_{40}K_{90}S_{20}$	34.0efg	34.7ef	34.4	0.75h	0.76i	0.76	35.8f	36.1e	36.0
$T_3=N_{70}P_{40}K_{90}S_{20}$	35.8e	36.1de	36.0	0.81g	0.82h	0.82	43.2de	43.7bcd	43.5
$T_4=N_{100}P_{40}K_{90}S_{20}$	38.4d	38.7d	38.6	0.89cde	0.89c-f	0.89	45.7bcd	46.3bcd	46.0
$T_5=N_{130}P_{40}K_{90}S_{20}$	31.7g	32.1g	31.9	0.85ef	0.86e-h	0.86	50.0a	51.5a	50.8
$T_6=N_{100}P_0K_{90}S_{20}$	28.0h	28.6h	28.3	0.84fg	0.84fgh	0.84	47.3b	46.6bcd	47.0
$T_7=N_{100}P_{20}K_{90}S_{20}$	35.5ef	36.2de	35.9	0.92bcd	0.93bcd	0.93	46.0bcd	46.5bcd	46.3
$T_8=N_{100}P_{60}K_{90}S_{20}$	33.2fg	33.5fg	33.4	0.93bc	0.94bc	0.94	47.0bc	47.3bc	47.2
$T_9=N_{100}P_{40}K_0S_{20}$	36.0de	36.6de	36.3	0.89de	0.88d-g	0.89	43.5de	43.8bcd	43.7
$T_{10}=N_{100}P_{40}K_{60}S_{20}$	41.3c	41.9c	41.6	0.95b	0.96ab	0.96	47.9ab	47.8ab	47.9
$T_{11}=N_{100}P_{40}K_{120}S_{20}$	33.1fg	34.1efg	33.6	0.92bcd	0.92bcd	0.92	43.9cde	46.9bcd	45.4
$T_{12}=N_{100}P_{40}K_{90}S_0$	44.2b	43.9bc	44.1	0.80g	0.84gh	0.82	43.0de	43.5bcd	43.3
$T_{13}=N_{100}P_{40}K_{90}S_{10}$	47.6a	47.0a	47.3	0.92bcd	0.93bc	0.93	41.9e	42.9d	42.4
$T_{14}=N_{100}P_{40}K_{90}S_{30}$	33.0g	34.2efg	33.6	1.00a	0.99a	1.00	41.4e	43.4cd	42.4
$T_{15}=N_{130}P_{60}K_{120}S_{30}$	45.2ab	45.5ab	45.4	0.90cd	0.91cde	0.91	47.5b	47.0bc	47.3
CV (%)	4.02	4.15	-	2.78	3.29	-	4.46	5.51	-
LSD (0.05)	2.43	2.55	-	0.04	0.05	-	3.27	4.12	-

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$)

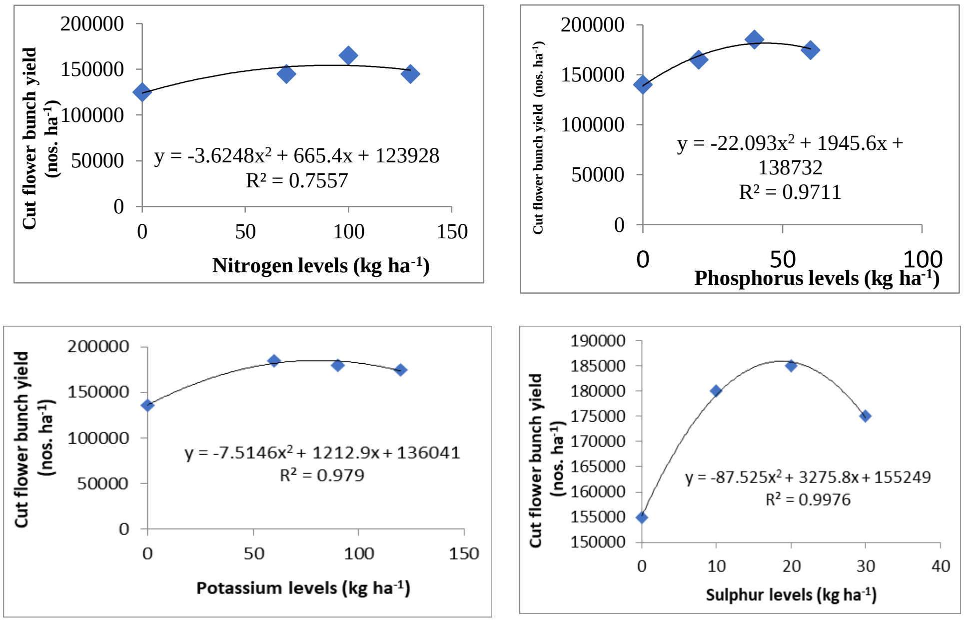
Table 6. Effect of nitrogen, phosphorus, potassium and sulphur on cut flower bunch yield of gypsophila

Treatment N-P-K-S (kg ha^{-1})	Cut flower bunch yield (number ha^{-1})			Bunch yield increment over control
	2017-18	2018-19	Mean	(%)
$T_1=N_0P_0K_0S_0$	100000g	109122g	104561	-
$T_2=N_0P_{40}K_{90}S_{20}$	120000f	130000f	125000	19.5
$T_3=N_{70}P_{40}K_{90}S_{20}$	140000de	149344de	144672	38.3
$T_4=N_{100}P_{40}K_{90}S_{20}$	160000bc	170123bc	165062	57.8
$T_5=N_{130}P_{40}K_{90}S_{20}$	140000de	150001de	145001	38.6
$T_6=N_{100}P_0K_{90}S_{20}$	135000e	145000d-f	140000	33.9
$T_7=N_{100}P_{20}K_{90}S_{20}$	160000bc	170000bc	165000	57.8
$T_8=N_{100}P_{60}K_{90}S_{20}$	170000ab	179321ab	174661	67.0
$T_9=N_{100}P_{40}K_0S_{20}$	130000ef	141000ef	135500	29.6
$T_{10}=N_{100}P_{40}K_{60}S_{20}$	180020a	190000a	185010	76.9
$T_{11}=N_{100}P_{40}K_{120}S_{20}$	170000ab	180000ab	175000	67.3
$T_{12}=N_{100}P_{40}K_{90}S_0$	150000cd	160000cd	155000	48.2
$T_{13}=N_{100}P_{40}K_{90}S_{10}$	175000a	185002ab	180001	72.1
$T_{14}=N_{100}P_{40}K_{90}S_{30}$	170000ab	180000ab	175000	67.3
$T_{15}=N_{130}P_{60}K_{120}S_{30}$	180000a	189000a	184500	76.4
CV (%)	4.56	5.95	-	-
LSD (0.05)	11596	16112	-	-

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$)

Response of yield to to N, P, K and S fertilization

Regression analysis showed positive and quadratic response to mean cut flower bunch yield of gypsophila and applied N, P, K and S (Figure 1). The optimum estimated doses of N, P, K and S were calculated from the quadratic response function and were 91.8, 44.0, 80.7 and 18.7 kg ha^{-1}, respectively could be expected for Gazipur area (Table 7). However, the optimum economic doses of N, P, K and S were calculated as 96.6, 43.9, 80.6 and 18.7 kg ha^{-1}, respectively (Table 7).



Fi. 1. Response of cut flower bunch yield of gypsophila to N, P, K and S fertilization

Table 7. Response function of gypsophila to N, P, K and S application for cut flower bunch yield

Regression equation	Co-efficient of determination (R^2)	Optimum dose (kg ha^{-1})	Economic dose (kg ha^{-1})	Maximum bunch yield (nos. ha^{-1}) for optimum dose
N				
$y = 123928 + 665.4x - 3.6248x^2$	0.7557	91.8	91.6	154464
P				
$y = 138732 + 1945.6x - 22.093x^2$	0.9711	44.0	43.9	181572
K				
$y = 136041 + 1212.9x - 7.5146x^2$	0.979	80.7	80.6	184983
S				
$y = 155249 + 3275.8x - 87.525x^2$	0.9976	18.7	18.7	185899

Note: Gypsophila cut flower bunch = BDT 10 $number^{-1}$; N fertilizer = BDT 16 Tk. kg^{-1}; P fertilizer = BDT 24 Tk. kg^{-1}; K fertilizer = BDT 22 Tk. kg^{-1}; S fertilizer = BDT 12 Tk. kg^{-1}

Cost and return analysis

Maximum gross return BDT 1850100 ha^{-1} for cut flower bunch of gypsophila was counted from T_{10} treatment followed by T_{15} treatment. The minimum gross return was calculated from control (T_1) treatment. The highest benefit cost ratio 1.91 was recorded from T_{10} treatment. The lowest benefit cost ratio was recorded from control (T_1) treatment (Table 8).

Table 8. Cost and return analysis of cut flower of gypsophila cut flower cultivation as influenced by N, P, K and S application and other inputs (mean data of two years)

Treatment N-P-K-S (kg ha^{-1})	Cut flower bunch yield (nos. ha^{-1})	Gross return (BDT. ha^{-1})	Cultivation cost ((BDT. ha^{-1})	Net return (BDT. ha^{-1})	BCR
T_1=$N_0P_0K_0S_0$	104561	1045610	954500	91110	1.09
T_2=$N_0P_{40}K_{90}S_{20}$	125000	1250000	964235	285765	1.29
T_3=$N_{70}P_{40}K_{90}S_{20}$	144672	1446720	966735	479985	1.49
T_4=$N_{100}P_{40}K_{90}S_{20}$	165062	1650620	967707	682913	1.70
T_5=$N_{130}P_{40}K_{90}S_{20}$	145001	1450010	968749	481261	1.49
T_6=$N_{100}P_0K_{90}S_{20}$	140000	1400000	962907	437093	1.45
T_7=$N_{100}P_{20}K_{90}S_{20}$	165000	1650000	965407	684593	1.70
T_8=$N_{100}P_{60}K_{90}S_{20}$	174661	1746610	970407	776203	1.80
T_9=$N_{100}P_{40}K_0S_{20}$	135500	1355000	964647	390353	1.40
T_{10}=$N_{100}P_{40}K_{60}S_{20}$	185010	1850100	966687	883413	1.91
T_{11}=$N_{100}P_{40}K_{120}S_{20}$	175000	1750000	968747	781253	1.80
T_{12}=$N_{100}P_{40}K_{90}S_0$	155000	1550000	965832	584168	1.60
T_{13}=$N_{100}P_{40}K_{90}S_{10}$	180001	1800010	966832	833178	1.86
T_{14}=$N_{100}P_{40}K_{90}S_{30}$	175000	1750000	968731	781269	1.80
T_{15}=$N_{130}P_{60}K_{120}S_{30}$	184500	1845000	972473	872527	1.89

Note: nos.= numbers

Input prices: Urea= BDT 16 kg^{-1}, T.S.P= BDT 24 kg^{-1}, MoP= BDT 22 kg^{-1}, Gypsum= BDT 12 kg^{-1}, Zinc sulphate= BDT 140 kg^{-1}, Boric acid= BDT 150 kg^{-1}, Plowing = BDT 3000 $pass^{-1}$, Wage rate= BDT 600 day^{-1}, Bavistin= BDT 200/100g, Cowdung= BDT 2.0 kg^{-1}, Gypsophila seed= BDT 10000 kg^{-1}

Output price: Cut flower bunch = BDT 10 $bunch^{-1}$.

Gross returns were calculated on the farm gate price (Gazipur, Bangladesh)

Conclusion

The results of the present study indicated that gypsophila achieved higher cut flower bunch yield and exhibited better performance of growth and yield contributing characters in the plot receiving 100-40-60-20 kg NPKS ha^{-1}

including a blanket dose of 3.0-1.5 kg ZnB ha^{-1} and cowdung 5 t ha^{-1}. This combination of NPKS was also most economic. The results suggest that combination of NPKS levels of 100-40-60-20 kg ha^{-1} could be suitable for improving growth and cut flower bunch yield of gypsophila in terrace soils of Bangladesh.

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