The Agriculturists 15(1): 58-67 (2017) ISSN 2304-7321 (Online), ISSN 1729-5211 (Print)
A Scientific Journal of Krishi Foundation ***Indexed Journal***
Impact Factor: 0.568 (GIF, 2015)

Effect of N, P and K fertilizer on the flower yield of Chrysanthemum

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Received: 9 December 2016 Accepted: 12 June 2017

Abstract

An experiment was conducted at the research field of Horticulture Research Centre, BARI, Gazipur during Rabi season of 2012-13 to 2014-15 to evaluate the response of different doses of N, P and K on the yield and yield attributes of chrysanthemum (var. BARI Chrysanthemum-1) and to find out the optimum and economic doses of NPK for maximizing yield of chrysanthemum. Treatments comprising four levels each of N (0, 100, 150 and 200 kg ha^{-1}), P (0, 50, 75 and 100 kg ha^{-1}) and K (0, 90, 135 and 180 kg ha^{-1}) along with blanket dose of 2 kg B and 4 kg Zn ha^{-1} were used. The treatments were assigned in a randomized complete block design with three replications. The combined effect of NPK significantly increased yield and yield attributes of chrysanthemum for each of the yearly experiments as well as the average of three years results. Significantly, the highest flower yield (12.45, 11.47 and 11.96 t/ha) was obtained with the application of $N_{150}P_{75}K_{135}$ kg ha^{-1} (T_3) along with blanket dose of 2 kg B and 4 kg Zn ha^{-1} for the years of 2012-13, 2013-14 and 2014-15, respectively and it was statistically identical with T_4 ($N_{200}P_{75}K_{135}$ kg ha^{-1}) treatment. Application of 150 kg N, 75 kg P and 135 kg K increased yield by 52.76, 42.29 and 36.51%, 152.08, 126.23 and 99.13% and 88.35, 51.30 and 60.75%, respectively, over their control in respect to the years. The highest benefit-cost ratio 5.54 followed by 5.14 was obtained from T_3 ($N_{150}P_{75}K_{135}$ kg ha^{-1}) followed by T_4 treatment, respectively. From the quadratic regression equation averaging three years data the optimum and economic doses 155 and 151.8 kg N, 79.3 and 77.68 kg P and 118.75 and 115.7 kg K, respectively were found which could be recommended for chrysanthemum production in Grey Terrace Soil of Joydebpur under AEZ 28.

Keywords: Chrysanthemum, NPK fertilizer, optimum and economic dose.

1. Introduction

Chrysanthemum is one of the most important commercial flower grown mainly for loose and cut flower production, which are used in floral arrangement and marking garlands, veni and bouquet. In many countries it is next only to rose in value of crop produced. Sustainable flower production requires optimal fertilizer management to attain a high ornamental value of plant and to reduce production costs (Zhang *et al.*, 2012). Nitrogen, phosphorus and potassium play a vital role in the production of good quality flowers. Nitrogen is considered to be the most crucial because it is a constituent of protein and nucleic acid which is helpful in plant growth (Haque, 2001) as well as to promotes rapid growth. This is because of higher concentration of nitrogen, which has tendency to increase leaf cell number and cell size with an overall increase in leaf production as reported by Meyer *et al*. (1973). Potassium has been reported to be involved in synthesis of peptide bond, protein and carbohydrate metabolism and also participates in rapid cell division and differentiation (Belorkar *et al*., 1992). Phosphorus and potash contents resulted in maximum increase in nutrient uptake by virtue of more photosynthesis through more chlorophyll formation with an increased leaf area (Belorkar *et al*., 1992).

Nitrogen is essential for the creation of biomass as well as for the biosynthesis of enzymes in chrysanthemum leaves (Liu *et al*., 2010). Chrysanthemums take up nitrogen at an even rate from the time of planting to the flowering stage and after that time nitrogen uptake decreases (Yoon *et al*., 2000). In chrysanthemum, the need for phosphorus is significantly lower than that of nitrogen (Li *et al*., 2009). Potassium requirements are high, and its presence in the plant favorably affects growth and flower color (Vaněk *et al*., 2012).

Nitrogen applied as fertilizer is the main sources used to meet the N requirements of plant growth (Konnerup and Brix, 2010). The highest level of nitrogen has pronounced effect on number of flowers (Khan *et al*., 1999). High nitrogen with appropriate dose of phosphorus and potassium seemed to have increased vegetative growth as earlier stage also reported by Denisen (1982). The growth and development of stock or production plants largely depend on proper feeding right from the beginning. Chrysanthemum is heavy feeder and has large requirements for nitrogen, phosphorus and potassium. Investigations on the requirement of different nutrients, carried out at various places, resulted in variable recommendations. The nutrient requirements at different growth stages of chrysanthemum was determined by Kazimirova (1975) who observed that requirement of all the basic three nutrients (N, P and K) were the maximum during vigorous growth, especially N, K requirement dose remained high until flowering. Kochkin and Kazimirova (1971) found a high positive correlation between flower production and N and P contents of soil. Lodhi and Tiwari (1993) observed maximum size and number of flowers with 15 kg N along with 8 g P m^{-2}. An application at the rate of 10 g m^{-2} was recommended for both N and P for optimum cut flower production (Jhon and Paul, 1999). However, information regarding nutritional requirement for chrysanthemum cultivation in Bangladesh is meager. Therefore, the present study was undertaken to evaluate the response of N, P and K on the yield and yield attributes of chrysanthemum and to find out the optimum and economic doses of NPK for maximizing yield of chrysanthemum in Grey Terrace soil of Joydebpur, Gazipur.

2. Materials and Methods

Three years experiments were conducted at the Horticultural Research Farm, BARI, Joydebpur, Gazipur during Rabi season of 2012-13 to 2014-15 to evaluate the response of N, P and K on the yield and yield attributes of chrysanthemum and to find out the optimum and economic doses of NPK for maximizing yield of chrysanthemum. The initial soil characteristics were shown in Table 1. The soil test values showed that the experimental soil was deficient in nutrients especially N, P and K. The field experiment was set up in a randomized complete block design with three replications. Treatments comprising four levels of fertilizer nutrients each of N (0, 100, 150 and 200 kg ha^{-1}), P (0, 50, 75 and 100 kg ha^{-1}) and K (0, 90, 135 and 180 kg ha^{-1}) along with a blanket dose of 2 kg B and 4 kg Zn ha^{-1} were used. The unit plot size and plant spacing were 2 m x 1.50 m and 40 cm x 30 cm, respectively. Every plot except control plot had received blanket dose of 2 kg B and 4 kg Zn ha^{-1}. The variety BARI Chrysanthemum-1 was used as the test crop. Urea, TSP, MoP, boric acid and zinc sulphate were used as a source of N, P, K, B and Zn, respectively. Total amount of P, K, B, Zn and 1/3rd N were applied at the time of final land preparation and the remaining N were applied in two equal splits each at 30 and 45 days after planting, respectively. Thirty days old seedlings were transplanted on 27th November, 2012; 2nd December, 2013 and 6th November, 2014, respectively. Intercultural operations such as weeding, irrigation etc. were done as and when required. Flowers were harvested four times from 13th February to 8th March, 2013, 13th February to 12th March, 2014, 24th January to 2nd March, 2015, respectively. Data on growth, yield and yield contributing characters were recorded from ten selected plants at each treatment. The collected data were analyzed statistically using the statistical package MSTAT-C.

3. Results and Discussion

Effect of different levels of NPK on the yield and yield contributing characters of chrysanthemum are presented in Table 2. Different fertilizer management packages showed a significant influence on yield and yield attributes of chrysanthemum. The highest plant height, number of flowers plant^{-1}, flower length, flower diameter, individual flower weight and yield per hectare were recorded in T_3 treatment which received 150 kg N 75 kg P and 135 kg K ha^{-1} and the lowest from control (T_{11}) in each of the three years (Table 2). The maximum plant heights (46.60, 46.20 and 48.40 cm) which were recorded from T_3 ($N_{150}P_{75}K_{135}$ kg ha^{-1}) treatment that was statistically identical with T_4 ($N_{200}P_{75}K_{135}$ kg ha^{-1}) for 2012-13 and T_4 ($N_{200}P_{75}K_{135}$ kg ha^{-1}) and T_2 ($N_{100}P_{75}K_{135}$ kg ha^{-1}) for 2013-14 and 2014-15, respectively. These results were in agreement with the findings of Khankhane *et al.* (1997) who reported the highest growth of chrysanthemum obtained from 15 g N m^{-2} (150 kg ha^{-1}) and 16 K m^{-2} (160 kg ha^{-1}). Nitrogen promotes rapid growth as a constituent of protein and nucleic acid (Haque, 2001). This rapid growth is because of higher concentration of nitrogen, which has tendency to increase leaf cell number and cell size with an overall increase in leaf production as reported by Meyer *et al*. (1973). Potassium enhances the synthesis and translocation of carbohydrate; whereas, phosphorus encourages cell walls and length of plant (Henry, 1982). The highest number of flowers plant^{-1} (25.72, 23.02 and 24.37), flower diameter (7.78, 7.10 and 7.44 cm) and individual flower weight (6.05, 5.98 and 5.97 g) were also found in the treatment T_3 ($N_{150}P_{75}K_{135}$ kg ha^{-1}), respectively for the years and it was statistically identical with treatment T_4 ($N_{200}P_{75}K_{135}$ kg ha^{-1}). As the number of branches were higher in the treatments with NPK that resulted in more photosynthesis and food accumulation, which might have resulted in better growth and converted vegetative growth in early stages due to balanced nutrition and also had sufficient food material to produce the flower earlier, while in control treatments took more days to flower which might be due to late emergence of flower buds. These findings are in close conformity with those reported by Mishra (1998) in gaillardia. Ahmad *et al*. (2004) reported early flowering in dahlia by applying urea, DAP and farm yard manure in a combination.

Table 1. Initial soil nutrient status of the experimental site of HRC Farm, Joydebpur, Gazipur

Nutrient	Soil test value	Critical level	Soil test interpretation
pH	6.2	-	Slightly acidic
Organic matter (%)	0.95	-	Low
Ca (c-mol/kg soil)	1.12	2.0	Low
Mg (c-mol/kg soil)	0.60	0.5	Medium
Total N (%)	0.08	0.12	Medium
Available P (µg/g)	9	7	Low
K (c-mol/kg soil)	0.17	0.12	Low
S (µg/g)	11.2	10	Low
Zn (µg/g)	1.4	0.6	Low
B (µg/g)	0.10	0.2	Low

Table 2. Effect of different fertilizer treatments on different yield attributes of chrysanthemum

Treatments (Kg ha^{-1})	Plant height (cm)			Flower/plant (nos.)			Stalk length (cm)		
	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
T_1= $N_0P_{75}K_{135}$	34.26f	30.05gh	34.15de	16.45g	13.87f	15.16ef	10.36g	10.55 de	10.51 bc
T_2= $N_{100}P_{75}K_{135}$	44.60b	42.47abc	45.54ab	22.05bc	20.65b	21.35bc	11.15c	11.10 a-d	11.43 ab
T_3= $N_{150}P_{75}K_{135}$	46.60a	46.20a	48.40a	25.72a	23.02a	24.37a	11.88a	11.50 a	11.68 a
T_4= $N_{200}P_{75}K_{135}$	45.53ab	44.87ab	47.20a	23.98ab	21.95a	22.97ab	11.55b	11.12 a-c	11.20 ab
T_5= $N_{150}P_0K_{135}$	36.60e	31.55gh	36.08cde	16.75fg	14.13f	15.44ef	10.48fg	10.49 e	10.94 ab
T_6= $N_{150}P_{50}K_{135}$	39.48d	34.77efg	39.13bcd	18.65def	16.45de	17.55de	10.72def	10.76 b-e	10.49 bc
T_7= $N_{150}P_{100}K_{135}$	40.28d	36.55def	40.42bcd	19.75cde	17.55cd	18.65cd	10.82cde	10.87 b-e	10.95 ab
T_8= $N_{150}P_{75}K_0$	37.15e	33.03fg	37.09cde	17.35efg	15.75e	16.55de	10.55efg	10.99 a-e	10.97 ab
T_9= $N_{150}P_{75}K_{90}$	42.40c	38.55cde	42.48abc	20.45cd	18.02c	19.24cd	10.95cd	10.93 b-e	10.96 ab
T_{10}= $N_{150}P_{75}K_{180}$	43.80bc	40.95bcd	44.38ab	21.33c	19.55b	20.44bc	11.05cd	11.17 ab	10.98 ab
T_{11}= Native fertility	31.55g	27.06h	31.31e	14.05h	11.89g	12.97f	10.02h	10.58 c-e	9.970 c
CV (%)	8.42	9.42	7.95	9.25	10.45	8.25	6.85	2.67	4.40

Means having common letter in a column are not significantly different by DMRT at 5% level.

Table 3. Effect of different fertilizer treatments on yield and yield attributes of chrysanthemum

Treatments (Kg ha^{-1})	Flower diameter (cm)			Individual flower weight (g)			Flower yield (t ha^{-1})			Average flower yield (t ha^{-1})
	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	
$T_1 = N_0P_{75}K_{135}$	6.45e	4.78gh	5.62ef	3.85e	3.32gh	3.59ef	8.15i	4.88 i	6.02 h	6.35 g
$T_2 = N_{100}P_{75}K_{135}$	7.52a-c	6.55a-c	7.03a-c	5.45b	5.32bc	5.38abc	11.35bc	9.48c	9.92 bc	10.25 c
$T_3 = N_{150}P_{75}K_{135}$	7.78a	7.10a	7.44a	6.05a	5.98a	5.97a	12.45a	11.80a	11.63 a	11.96 a
$T_4 = N_{200}P_{75}K_{135}$	7.65ab	6.72ab	7.19ab	5.75ab	5.63ab	5.69ab	11.95ab	10.62 b	10.79 ab	11.12 b
$T_5 = N_{150}P_0K_{135}$	6.95de	5.01fg	5.98de	3.95e	3.46f-h	3.71def	8.75hi	5.40 hi	7.57 fg	7.24 f
$T_6 = N_{150}P_{50}K_{135}$	7.21cd	5.52d-g	6.37b-e	4.55d	3.98ef	4.27c-f	9.55fg	6.58 fg	8.23 ef	8.12 e
$T_7 = N_{150}P_{100}K_{135}$	7.25cd	5.78c-f	6.52a-e	4.65d	4.26e	4.46b-f	10.15ef	7.31 ef	9.12 c-e	8.86 d
$T_8 = N_{150}P_{75}K_0$	7.15cd	5.25efg	6.2cde	4.05e	3.63fg	3.84def	9.12gh	6.09 gh	7.11 g	7.44 ef
$T_9 = N_{150}P_{75}K_{90}$	7.38bc	6.02b-e	6.7a-d	4.85cd	4.56de	4.71a-e	10.55de	7.78 de	8.62 de	8.98 d
$T_{10} = N_{150}P_{75}K_{180}$	7.44a-c	6.28a-d	6.86a-d	5.05c	4.95cd	4.99a-d	11.05cd	8.39 d	9.22 cd	9.55 cd
T_{11}= Native fertility	5.65f	4.05h	4.85f	3.53f	2.95h	3.24f	7.35j	3.25 j	4.80 i	5.13 h
CV (%)	8.77	9.65	8.95	8.08	8.90	9.10	10.55	7.40	6.18	4.78

Means having common letter in a column are not significantly different by DMRT at 5% level.

The longest stalk lengths (11.88, 11.50 and 11.68 cm) were found from T_3 treatment for each of the 3 years and it was significantly different from all other treatments for 1st year but statistically identical with T_4, T_2 and T_{10} for 2nd year. In 3rd year it was statistically identical with all other treatments except T_1, T_6 and T_{11}. Flower yield was also significantly influenced by different levels of N, P and K fertilizers (Table 3) and it was increased to a maximum of 12.45, 11.80 and 11.63 ton ha^{-1}, respectively for 1st, 2nd and 3rd year with NPK fertilizer application. Highest flower yield (12.45, 11.80 and 11.63 ton ha^{-1} respectively for the years) was obtained from the T_3 ($N_{150}P_{75}K_{135}$ kg ha^{-1}) treatment which were statistically similar to the treatment T_4 ($N_{200}P_{75}K_{135}$ kg ha^{-1}) for 1st and 3rd year but significantly different from all other treatment for 2nd year. Average flower yield was also affected by the different nutrient levels and the maximum (11.96 ton ha^{-1} was obtained from T_3 treatment that was significantly different from all other treatments. These results are in agreement with the findings of Chezhiyan *et al.* (1986), Lodhi and Tiwari (1993) and Rao *et al*. (1992). Application of 150 kg N ha^{-1}, 75 kg P ha^{-1} and 135 kg K ha^{-1} individually performed the highest yield of chrysanthemum (Table 3). Addition of nitrogen increased flower yield of 39.26, 52.76 and 46.63% by 100, 150 and 200 kg N ha^{-1}, respectively for the years over control. Balanced dose of nitrogen, phosphorus and potassium seemed to have increased the vegetative growth, favorable for the synthesis of peptide bond, protein and carbohydrate metabolism that are essential for flower development (Boodly and Meyer, 1965). The effect of nitrogen was more pronounced as compared to that of P and K. Flower yield of chrysanthemum was also increased progressively with added P and K fertilizer up to 75 and 135 kg ha^{-1}, respectively and further increase in P and K fertilizer tended to decrease flower yield. The average yield difference between the highest and the lowest yielding treatment was 65.19% and 60.75% in case of P and K, respectively. The increased nutrient availability from phosphorus through *phosphobacteria* might have increased the various endogenous hormonal levels in the plant tissue, which was responsible for the enhanced pollen germination and tube growth, which ultimately increased the number of fruit $plant^{-1}$ according to Rajagopal and Rao (1974).

3.1. Economic comparison

Average data pertaining to economic comparison is presented in Table 4. Maximum gross return (Tk. 5083000.00 ha^{-1}) was achieved with the treatment combination $N_{150}P_{75}K_{135}$ kg ha^{-1} (T_3). The highest benefit cost ratio (5.54) was also found in the treatment T_3 followed by T_4 and T_2 and the lowest benefit cost ratio (2.44) was found in control treatment. It could be said that the treatment T_3 with 150 kg N, 75 kg P and 135 kg K was the most economically viable doses for chrysanthemum production.

3.2. Regression analysis

Single effect of N, P and K on yield of chrysanthemum were shown in Table 5. From this table it was clearly observed that the maximum average yield (11.12 ton ha^{-1}) was found with the application of NPK @ 150, 75 and 135 kg ha^{-1}, respectively and similarly the maximum average yield increase also were 88.35, 65.19 and 60.75% for those NPK doses, respectively over control. Regression analysis of average yield of chrysanthemum was done to fit the quadratic functions for estimating the optimum levels of each nutrient over the different levels of NPK fertilizer (Fig.1). Dobermann *et al.* (2000) stated that the optimum rate of fertilizer application to a crop is that rate which produces the maximum economic returns at the minimum cost and can be derived from a nutrient response curve. It is evident from figure. 1 that yields of chrysanthemum increased with increasing level of fertilizer nutrients to a certain level and then decreased with further increase of nutrient level. The yield increment was prominent in case of N fertilizer application and the highest yield (12.45, 11.80 and 11.63 ton ha^{-1}, respectively for the years) as well as the average highest yield (11.96 t ha^{-1}) was obtained from 150 kg N, 75 kg P and 135 kg K ha^{-1}, respectively. From Fig.1.a optimum and economic doses were found as 155 and 151.80 kg ha^{-1} for N, 79.30 and 77.68 kg ha^{-1} for P and it was 118.75 and 115.70 kg ha^{-1} for K, respectively which could be suggested as a recommended doses for chrysanthemum production.

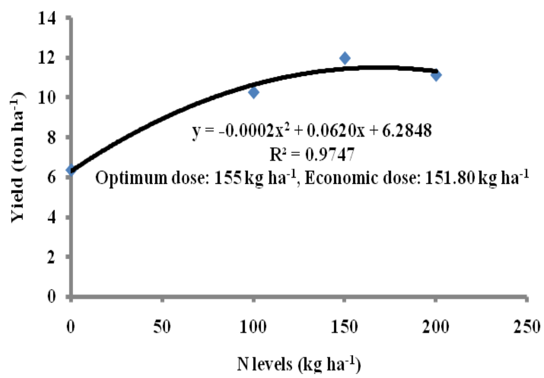
Table 4. Economic analysis of chrysanthemum production under different fertilizer treatments

Treatments	Fixed cost (Tk. ha^{-1})	Variable cost (Tk. ha^{-1}) (Fertilizer only)	Total cost (Tk. ha^{-1})	Yield (t ha^{-1})	Price of Chrysanthemum (Tk. ton^{-1})	Gross return (Tk. ha^{-1})	BCR
T_1	8,92,500	18,300	9,10,800	6.35	4,25,000	26,98,750	2.96
T_2	8,92,500	22,700	9,15,200	10.25	4,25,000	43,56,250	4.76
T_3	8,92,500	24,900	9,17,400	11.96	4,25,000	50,83,000	5.54
T_4	8,92,500	27,100	9,19,600	11.12	4,25,000	47,26,000	5.14
T_5	8,92,500	16,650	9,09,150	7.24	4,25,000	30,77,000	3.38
T_6	8,92,500	22,150	9,14,650	8.12	4,25,000	34,51,000	3.77
T_7	8,92,500	27,650	9,20,150	8.86	4,25,000	37,65,500	4.09
T_8	8,92,500	18,690	9,11,190	7.44	4,25,000	31,62,000	3.47
T_9	8,92,500	22,830	9,15,330	8.98	4,25,000	38,16,500	4.17
T_{10}	8,92,500	26,970	9,19,470	9.55	4,25,000	40,58,750	4.41
T_{11}	8,92,500	-	8,92,500	5.13	4,25,000	21,80,250	2.44

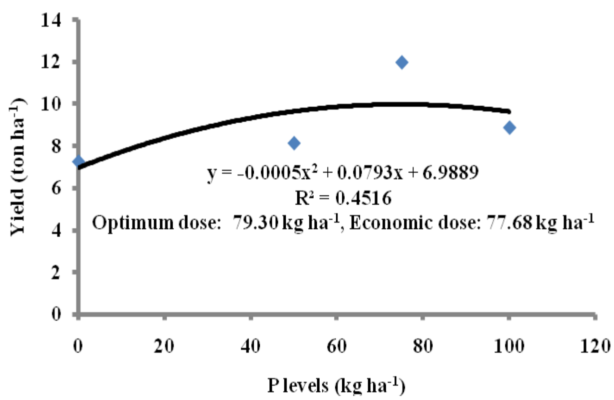
Labor + Seedling + Pesticide/insecticide + Irrigation (37500 + 835000+5000+15000=357500/-)
Labor = 150 × 250/- =37500/-, Seedlings= 83500 × @10/- =835000/- , Urea= Tk. 20 kg^{-1}, TSP= Tk. 22 kg^{-1}, MoP= Tk. 23 kg^{-1}, Boric Acid = Tk. 195 kg^{-1}, Zinc Sulphate = Tk. 125 kg^{-1} , Price of flower=@ Tk. 425 kg^{-1} flower

Table 5. Single effect of N, P and K on yield of chrysanthemum

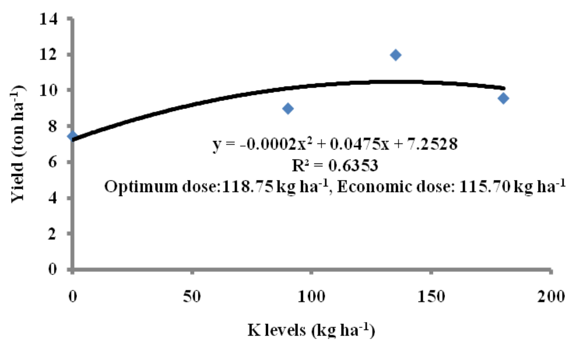
Nutrient level (kgha^{-1})	Flower yield (t ha^{-1})				% yield increase over control			
	2012-13	2013-14	2014-15	Average	2012-13	2013-14	2014-15	Average
N level								
0	8.15	4.88	6.02	6.35	-	-	-	-
100	11.35	9.48	9.92	10.25	39.26	94.26	64.78	61.42
150	12.45	11.80	11.63	11.96	52.76	141.80	93.19	88.35
200	11.95	10.62	10.79	11.12	46.63	117.62	79.24	75.12
P level								
0	8.75	5.40	7.57	7.24	-	-	-	-
50	9.55	6.58	8.23	8.12	9.14	21.85	8.72	12.15
75	12.45	11.80	11.63	11.96	42.29	118.52	53.63	65.19
100	10.15	7.31	9.12	8.86	16.00	35.37	20.48	22.38
K level								
0	9.12	6.09	7.11	7.44	-	-	-	-
90	10.55	7.78	8.62	8.98	15.68	27.75	21.24	20.70
135	12.45	11.80	11.63	11.96	36.51	93.76	63.57	60.75
180	11.05	8.39	9.22	9.55	21.62	37.77	29.68	28.36



a. Optimum and economic dose of N for chrysenthemum production



b. Optimum and economic dose of P for chrysenthemum production



c. Optimum and economic dose of K for chrysenthemum production

Figure 1. Functional relationship between mean yield of chrysanthemum and different levels of N, P and K.

4. Conclusions

From three years study, results indicated that judicious nutrient management in chrysanthemum can ensure high profit. Application of 150-75-135 kg NPK ha^{-1} along with blanket dose of 2 kg B and 4 kg Zn ha^{-1} showed the best performance for chrysanthemum production. From quadratic regression equation averaging three years data 155 kg N, 79.3 kg P and 118.75 kg K ha^{-1} and 151.8 kg N, 77.68 kg P and 115.7 kg K ha^{-1}, respectively were found as the optimum and economic doses which could be recommended for chrysanthemum production in Grey Terrace Soil of Joydebpur under AEZ 28.

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