The Agriculturists 15(1):101-109(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 Nitrogen, Phosphorus and Potassium Fertilizers on Yield and Yield Attributes of Marigold (*Tagetes patula* L.)

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Received: 22 February 2017 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 yield and yield attributes of Marigold (var. BARI Marigold-1) to different doses of N, P and K fertilizers and to find out the optimum and economic doses of NPK for maximizing flower yield. Eleven treatments as T_1, T_2, T_3, ..., T_{10} and T_{11} comprising with four levels of fertilizer nutrients each of N (0, 60, 90 and 120 kg ha^{-1}), P (0, 30, 40 and 50 kg ha^{-1}) and K (0, 60, 90 and 120 kg ha^{-1}) along with a blanket dose of 2 kg B and 4 kg Zn ha^{-1}. The experiment was conducted assigning the treatments in a randomized complete block design with three replications. Flower yield and yield attributes of marigold significantly increased with NPK fertilizer for all three years. The significantly highest flower yield (22.25, 27.38 and 25.15 ton ha^{-1}) was obtained from T_3 treatment applying the nutrients $N_{90}P_{40}K_{90}$ kg ha^{-1} along with blanket dose of 2 Kg B and 4 kg Zn ha^{-1} for the years 2012-13, 2013-14 and 2014-15, respectively which was statistically identical with T_4 treatment ($N_{120}P_{40}K_{90}$ kg ha^{-1}) for the year 2012-13, but significantly different from all other treatments for the years 2013-14 and 2014-15, respectively. Flower yields were increased in T_3 treatment ($N_{90}P_{40}K_{90}$ kg ha^{-1}) by 81.34, 62.53 and 49.53%; 146.00, 119.39 and 108.84% and 121.20, 92.13 and 84.11% over their control in respect to the years 2012-13, 2013-14 and 2014-15. The highest benefit-cost ratio 7.14 was obtained from T_3 ($N_{90}P_{40}K_{90}$ kg ha^{-1}) followed by T_4 (6.53) treatment. From the quadratic regression equation averaging three years data the optimum and economic doses 103.75 and 102.44 kg N; 36.67 and 36.31 kg P and 90.10 and 88.43 kg K, respectively were found which could be recommended for marigold production in Grey Terrace Soil of Joydebpur under AEZ 28.

Keywords: Marigold, NPK fertilizer, Optimum and economic dose.

1. Introduction

Flowers have gained very high economic values for their eternal beauty, love and tranquility. Flower is used for religious offering, decoration, pharmaceuticals, foods supplement and coloring agent for cosmetics (Priyanka *et al*., 2013). Marigold (*Tagetes patula* L) is one of the most important decorative plants and it has many medicinal values also. Marigold gained popularity amongst flower growers and dealers on account of its easy culture and wide adaptability. Its habit of free flowering, short duration to produce marketable flowers, wide

spectrum of attractive color, shape, size and good keeping quality attracted the attention of flower growers. Marigold has been adapted to different types of soil conditions and is growing successfully in different types of soil. However, a deep, fertile, sandy loam, and friable soil having good water holding capacity, well drained and near to neutral in reaction (pH 7.0-7.5) is most desirable for marigold cultivation (Bose &Yadav, 1998). Mild climate during growing period (14.5-28.6°C) greatly improved flowering while higher temperatures (26.2-34.4°C) adversely affected flower production (Yadav and Bose, 1998).

Marigold has long been cultivating in all areas of Bangladesh. Fertilizer is an essential key input for production and productivity of this crop. But its fertilizer requirement for cultivation is still not well documented regionally. Research has shown that fertilizer input contributes about 40–50% of total yield increase for most crops (Dass and Mitali, 2016). In fact 50% of the total increase in crop production comes from the use of fertilizers and rest from all other factors combined together. Good flower production requires optimal fertilizer management to attain a high ornamental value and to reduce production cost of a plant (Zhang *et al.*, 2012). Nitrogen, phosphorus and potassium play a vital role in the production of good quality flowers. Nitrogen and phosphorus are required in sufficient quantities to attain better growth of marigold and promote flowering (Pandey and Mishra, 2005). It was reported that nitrogen, phosphorus, and potassium greatly influence the growth, flower, and tuber production of tuberose (Khan *et al*., 2012).

Nitrogen is considered to be the most crucial because it is a constituent of protein and nucleic acid which is helpful in plant growth as well as to promote rapid growth (Haque, 2001). 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 (Belorker *et al*., 1992). 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). According to Beata (2011), the marigold does not require intensive mineral fertilization, and high doses of nitrogen result in the decrease of yield of flower head. Application of macro and micronutrients also increase the flower quality and total flower production. In the light of above information a fertilizer recommendation with optimum doses of N, P and K for marigold production and cultural practices is necessary for this area. Hence, the present study was undertaken to evaluate the response of marigold to NPK fertilizers and to find out their optimum and economic doses for maximizing yield of marigold in Grey Terrace soil of Joydebpur, Gazipur.

2. Materials and Methods

The experiments were conducted at the Horticultural Research Farm, BARI, Gazipur during Rabi season of 2012-13 to 2014-15 to evaluate the response of marigold yield and yield attributes to N, P and K fertilizer and to find out the optimum and economic doses of NPK for maximizing yield of marigold. The initial soil characteristics of the experimental field were shown in Table 1. The soil test values showed that the experimental soil was deficient in nutrients especially of N, P and K. The experiment was conducted following randomized complete block design with three replications. Treatments as T_1, T_2, T_3, ..., T_{10} and T_{11} comprising with four levels of fertilizer nutrients each of N (0, 60, 90 and 120 kg ha^{-1}), P (0, 30, 40 and 50 kg ha^{-1}) and K (0, 60, 90 and 120 kg ha^{-1}) along with a blanket dose of 2 kg B and 4 kg Zn ha^{-1}.

The unit plot size was 2 m x2 m. The row to row and plant to plant spacing were 50 cm and 40 cm, respectively. Every plot except control had received a blanket dose of 2 kg B and 4 kg Zn ha^{-1}. Urea, TSP, MoP, boric acid and zinc sulphate were used as a source of N, P, K, B and Zn, respectively. All P, K, B, Zn and 1/3rd N were applied at the time of final land preparation and the remaining 2/3^{rds} N were applied in two equal splits each at 30 and 45 days after transplanting. Thirty days old seedlings of marigold (var. BARI Marigold-1) were planted on 2nd December, 2012; 17th December, 2013 and 07th November, 2014 for the years, respectively. All intercultural operations such as three weeding were made and irrigation was done at 7 days interval up to harvesting.

The flower was harvested four times from 13th February to 8th March, 2013, 13th February to 12th March, 2014 and 24th January to 2nd March, 2015, respectively. The data on plant height, number of flower per plant and yield contributing characters were recorded from ten randomly selected plants from each treatment. Data on yield and yield contributing characters were analyzed statistically and the mean differences were tested by Duncan's Multiple Range Test (Steel and Torrie, 1960). Soil pH was measured by a glass calomel electrode (Jackson, 1958). Total N was determined by modified Kjeldhl method and Ca, Mg were by KCL extractable method (Hunter, 1984).

3. Results and Discussion

3.1 NPK on yield and yield attributes

Effect of different levels of NPK on the yield and yield attributes of marigold were presented in Table 2. Different treatment combination showed a significant influence on yield and yield contributing characters of marigold. The highest plant height, number of flowers $plant^{-1}$, flower diameter, individual flower weight and yield per hectare were recorded in T_3 ($N_{90}P_{40}K_{90}$ kg ha^{-1}) treatment which received 90 kg N 40 kg P and 90 kg K ha^{-1} and the lowest values were in respective control (T_{11}) for all three years (Tables 2 and 3). The maximum plant heights (70.53, 72.80 and 56.67 cm) were recorded in T_3 treatment that was statistically similar to that in T4 ($N_{120}P_{40}K_{90}$ kg ha^{-1}) for 2012-13 and 2013-14, respectively but it was similar to T4 and T_2 ($N_{60}P_{40}K_{90}$ kg ha^{-1}) for 2014-15.

These results were in agreement with the findings of Beata (2011) who reported that marigold does not require intensive mineral fertilization, and high doses of nitrogen result in the decrease of yield of flowers. Nitrogen promotes rapid growth as a constituent of protein and nucleic acid (Haque, 2001).

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 yield and yield attributes of marigold

Treatments	Plant height (cm)			Flower plant^{-1} (no.)			Flower diameter (cm)		
(Kg/ha)	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
T_1= $N_0P_{40}K_{90}$	55.75h	48.95hi	37.35fg	18.62f	11.75g	15.19fg	7.19d	6.90fg	7.05de
T_2= $N_{60}P_{40}K_{90}$	66.55bc	66.90bc	51.72ab	24.10bc	17.75b	20.93a-c	7.96ab	8.55a-c	8.26ab
T_3= $N_{90}P_{40}K_{90}$	70.53a	72.80a	56.67a	25.87a	19.50a	22.69a	8.55a	9.10a	8.83a
T_4= $N_{120}P_{40}K_{90}$	68.60ab	69.85ab	54.22ab	24.40ab	18.65ab	21.53ab	7.98ab	8.78ab	8.38ab
T_5= $N_{90}P_0K_{90}$	56.95gh	50.25g-i	38.6fg	19.35fg	12.25fg	15.80fg	7.42b-d	7.08e-g	7.25c-e
T_6= $N_{90}P_{30}K_{90}$	59.95e-g	54.55fg	42.25d-f	21.25de	13.68de	17.47def	7.62b-d	7.65d-f	7.64b-d
T_7= $N_{90}P_{50}K_{90}$	61.15ef	57.35ef	44.25c-e	22.55cd	14.65d	18.60c-e	7.82bc	7.85c-e	7.83b-d
T_8= $N_{90}P_{40}K_0$	57.85f-h	52.95f-h	40.40ef	19.85ef	12.95ef	16.85ef	7.59b-d	7.25ef	7.42b-e
T_9= $N_{90}P_{40}K_{60}$	62.35de	60.55de	46.45cd	22.95bc	15.75c	19.35b-e	7.85bc	8.11b-d	7.98a-d
T_{10}= $N_{90}P_{40}K_{120}$	64.75cd	63.75cd	49.25bc	23.35bc	16.55c	19.95b-d	7.94ab	8.28b-d	8.11a-c
T_{11}= Native fertility	52.35i	45.80i	34.07g	17.05g	10.50h	13.78g	6.56e	6.35g	6.46e
CV (%)	8.85	9.45	7.75	9.79	9.55	8.33	8.93	8.26	9.05

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 marigold

Treatments	Individual flower weight (g)			Yield (Ton ha^{-1})			Average yield
(Kg ha^{-1})	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15	(Ton ha^{-1})
T_1= $N_0P_{40}K_{90}$	13.68g	17.25g	15.47fg	12.27h	11.13h	11.37g	11.48g
T_2= $N_{60}P_{40}K_{90}$	19.31bc	25.75b	22.53a-c	19.45bc	22.85bc	20.82c	20.93c
T_3= $N_{90}P_{40}K_{90}$	21.49a	28.08a	24.78a	22.25a	27.38a	25.15a	24.82a
T_4= $N_{120}P_{40}K_{90}$	20.43ab	26.45b	23.44ab	21.05a	24.66b	23.19b	22.86b
T_5= $N_{90}P_0K_{90}$	14.35fg	18.75f	16.55e-g	13.69g	12.48gh	13.09f	12.98f
T_6= $N_{90}P_{30}K_{90}$	16.15e	21.85d	18.95c-f	15.63f	14.95fg	15.29e	15.18e
T_7= $N_{90}P_{50}K_{90}$	16.42de	22.35d	19.38c-e	16.16ef	16.37ef	15.93e	16.04e
T_8= $N_{90}P_{40}K_0$	15.75ef	20.25e	17.96d-f	14.88fg	13.11gh	13.66f	13.77f
T_9= $N_{90}P_{40}K_{60}$	17.92cd	23.95c	20.93b-d	17.51de	18.86de	17.85d	17.96d
T_{10}= $N_{90}P_{40}K_{120}$	18.09cd	24.45c	21.27a-d	18.55cd	20.23cd	19.06d	19.17d
T_{11}= Native fertility	12.05h	15.58h	13.82g	10.85i	8.17i	9.18h	9.29h
CV (%)	9.90	10.15	9.45	9.97	11.25	4.98	4.34

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

Table 4. Single effect of N, P and K on yield of marigold

Nutrient level (kg ha^{-1})	Flower yield (ton ha^{-1})				% yield increase over control			
	2012-13	2013-14	2014-15	Average	2012-13	2013-14	2014-15	Average
N level								
0	12.27	11.13	11.37	11.59	-	-	-	-
60	19.45	22.85	20.82	21.04	58.52	105.30	83.11	82.31
90	22.25	27.38	25.15	24.93	81.34	146.00	121.20	116.18
120	21.05	24.66	23.19	22.97	71.56	121.56	103.96	99.03
P level								
0	13.69	12.48	13.09	13.09	-	-	-	-
30	15.63	14.95	15.29	15.29	14.17	19.79	16.81	16.92
40	22.25	27.38	25.15	24.93	62.53	119.39	92.13	91.35
50	16.16	16.37	15.93	16.15	18.04	31.16	21.70	23.63
K level								
0	14.88	13.11	13.66	13.88	-	-	-	-
60	17.51	18.86	17.85	18.07	17.67	43.85	30.67	30.73
90	22.25	27.38	25.15	24.93	49.53	108.84	84.11	80.83
120	18.55	20.23	19.06	19.28	24.66	54.30	39.53	39.50

Table 5. Economic analysis of marigold production under different fertilizer treatments

Treatments	Fixed cost (Tk. ha^{-1})	Variable cost, Fertilizer only (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Yield (ton ha^{-1})	Price of Marigold (Tk. ton^{-1})	Gross return (Tk. ha^{-1})	BCR
T_1	1,57,500	12,380	1,69,880	11.48	50,000	574000	3.38
T_2	1,57,500	14,980	1,72,480	20.93	50,000	1046500	6.07
T_3	1,57,500	16,280	1,73,780	24.82	50,000	1241000	7.14
T_4	1,57,500	17,580	1,75,080	22.86	50,000	1143000	6.53
T_5	1,57,500	11,880	1,69,380	12.98	50,000	649000	3.83
T_6	1,57,500	15,180	1,72,680	15.18	50,000	759000	4.40
T_7	1,57,500	17,380	1,74,880	16.04	50,000	802000	4.59
T_8	1,57,500	12,140	1,69,640	13.77	50,000	688500	4.06
T_9	1,57,500	14,900	1,72,400	17.96	50,000	898000	5.21
T_{10}	1,57,500	17,660	1,75,160	19.17	50,000	958500	5.47
T_{11}	1,57,500	-	1,57,500	9.29	50,000	464500	2.95

Labor + Seedling + Pesticide/insecticide + Irrigation (37500+100000+ 5000+15000=157500/-) Labour = 150 × 250/- =37500/-, Seedlings= 50000 × @ 2/- =1, 00,000/- , Price = Marigold Tk. 50 kg^{-1}, 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}

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 number of flowers plant^{-1} (25.87, 19.50 and 22.69), diameter of flower (8.55, 9.10 and 8.83 cm) and

individual flower weight (21.49, 28.08 and 24.78 g) were also found the highest in the T_3 treatment for three years, respectively followed by T_4 ($N_{120}P_{40}K_{90}$ kg ha^{-1}). As the number of branches $plant^{-1}$ were higher in the treatments with NPK, it favored 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. But control treatment took more days for flowering 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.

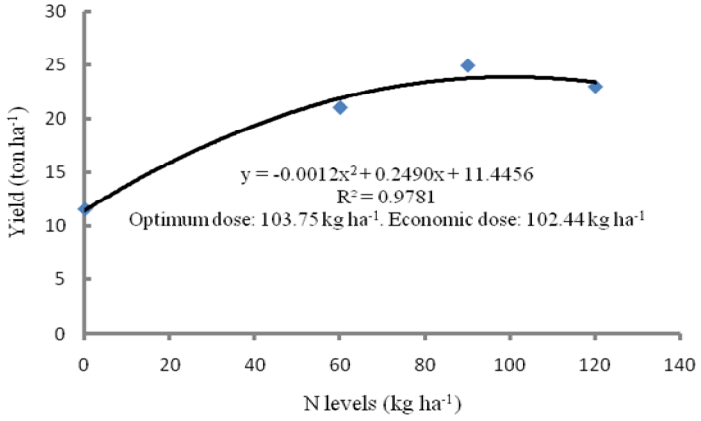
Flower yield was also significantly influenced by different levels of N, P and K fertilizers (Table 3) and it was increased to a maximum of 22.25, 27.38 and 25.15 ton ha^{-1}, respectively for 1st, 2nd and 3rd year. Highest flower yield 22.25, 27.38 and 25.15 ton ha^{-1}, were obtained, respectively for the years from T_3 treatment which was similar to T_4 for the year 2012-13.. Average flower yield was also affected by the different nutrient levels and the maximum (24.82 ton ha^{-1}) was obtained from T_3 treatment that was significantly different from rest of the treatments. These results are in agreement with the findings of Lodhi and Tiwari (1993). Application of 90, 40 and 90 kg NPK ha^{-1} produced the highest flower yield of marigold (Table 3). Addition of nitrogen increased flower yield of 58.52, 81.34 and 71.56%; 105.30, 146.00 and 121.56% and 83.11, 121.20 and 103.96% by 60, 90 and 120 kg N ha^{-1}, respectively for the years 2012-13, 2013-14 and 2014-14 over control (Table 4). Additional of nitrogen also increased average flower yield of 82.31, 116.18 and 99.03% over control.

Nitrogen, phosphorus, and potassium greatly influence the growth, flower, and tuber production of tuberose (Khan *et al.,* 2012). Nitrogen and phosphorus are required in sufficient quantities to attain better growth and promote flowering (Pandey and Mishra, 2005). Table 4 reveals that the effect of nitrogen was more pronounced as compared to that of P and K. Flower yield of marigold was also increased progressively with added P and K fertilizer up to 40 and 90 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 was 91.35% and 80.83% in case of P and K, respectively. Arulmozhiyan and Pappaiah (1989) stated that the increased flower production might be due to increased content of available nitrogen which promotes better vegetative growth and enhance production. Anuradha *et al.* (1988b) also reported significant increase in flower production due to nitrogen application. Since the absorption of nitrogen was more to promote more growth and production more phosphorus was needed accordingly and the plant might have taken more phosphorus. Anuradha *et al*. (1988a) also reported higher content of nitrogen and phosphorus due to increased application of nitrogen and phosphorus and their combination. The higher uptake of these mineral nutrients and their translocation to different parts might have helped in the production of higher total dry matter and flower yield.

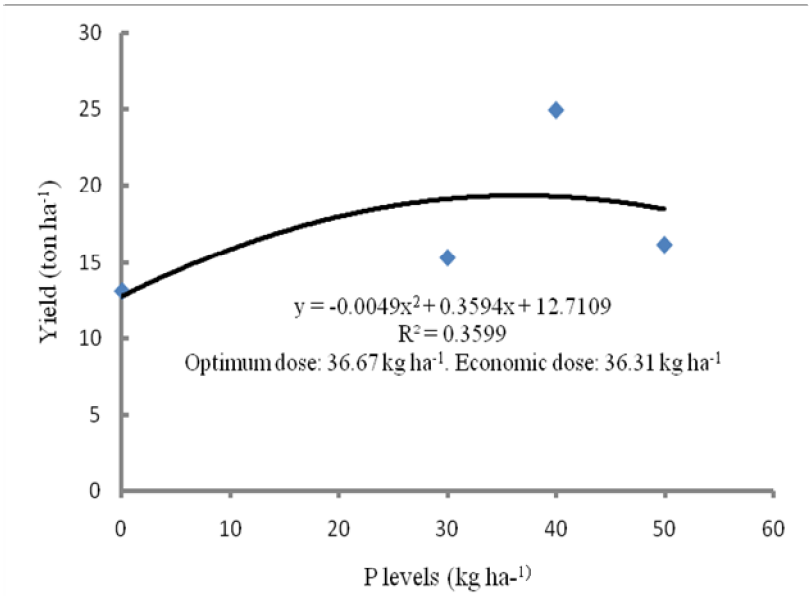
3.2. Regression analysis

Single effect of N, P and K on yield of marigold shown in Table 4 reveals that the maximum average yield (24.93 ton ha^{-1}) was obtained with the application of NPK @ 90, 40 and 90 kg ha^{-1} which were 116.18, 91.35 and 80.83% higher in average over control. Regression analysis of average yield of marigold shows 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 Fig. 1 that yield of marigold increased with increasing level of fertilizer

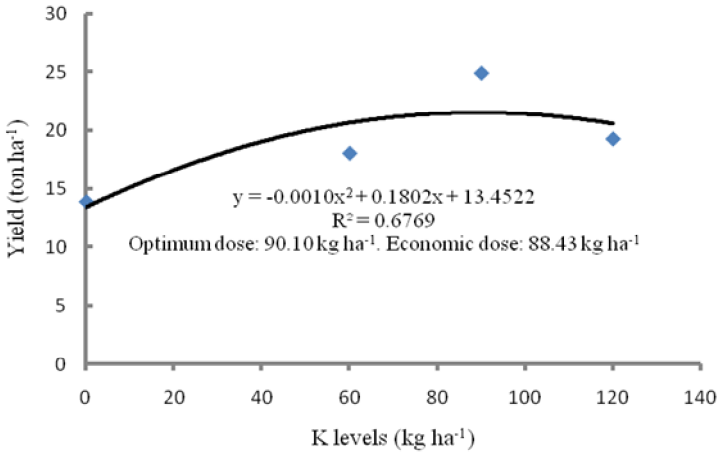
nutrients to a certain level and then decreased with further increase of nutrient level. The yield increment was prominent in case of N fertilizer application and the highest yield (22.25, 27.38 and 25.15 ton ha^{-1}, respectively for the years) was obtained from 90 kg N, 40 kg P and 90 kg K ha^{-1}. The optimum and economic dose was found as 103.75 and 102.44 kg ha^{-1} for N (Fig. 1.a) , 36.67 and 36.31 kg ha^{-1} for P (Fig. 1.b) and 90.10 and 88.43 kg ha^{-1} for K (Fig. 1.c), respectively which could be suggested as a recommended doses for marigold production.



a. Optimum and economic dose of N for marigold production



b. Optimum and economic dose of P for marigold production



c. Optimum and economic dose of K for marigold production

Figure 1. Functional relationship between mean yield of marigold and different levels of NPK.

3.3. Economic comparison

Average data pertaining to economic comparison is presented in Table 5. Maximum gross return (Tk. 1241000.00 ha^{-1}) was achieved with the treatment T_3 ($N_{90}P_{40}K_{90}$ kg ha^{-1}). The highest benefit cost ratio (7.14) was also found in the treatment T_3 followed by T_4 and T_2 and the lowest 2.95 was found in control. The result revealed that the treatment T_3 (90, 40 and 90 kg NPK ha^{-1} was the most economically viable dose for marigold production.

4. Conclusions

From three years study, results have indicated that judicious nutrient management in marigold can ensure high profit. Application of 90-40-90 kg NPK ha^{-1} along with blanket dose of 2 kg B and 4 kg Zn ha^{-1} showed the best performance for marigold production. From quadratic regression equation averaging three years data 103.75 kg N, 36.67 kg P and 90.10 kg K ha^{-1} and 102.44 kg N, 36.31 kg P and 88.43 kg K ha^{-1} were found as the optimum and economic doses, respectively which could be recommended for marigold production in Grey Terrace Soil of Joydebpur under AEZ 28.

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