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Efficacy of Mulch, N and K Application on Plant Growth and Yield Characters in Annual Chrysanthemum

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ABSTRACT

The present investigation was conducted to study the effect of mulch, N and K application and their interaction on plant growth characters, yield and yield attributes of annual chrysanthemum (Chrysanthemum coronarium L) using three types of mulches (i.e. Crop residue mulch, Silver plastic mulch and Black plastic mulch) and four levels of nitrogen and potassium i.e. 0 g N + 0 g K/m^2, 20 g N + 10 g K/m^2, 30 g N + 20 g K/m^2 and 40 g N + 30 g K/m^2 along with a uniform dose of phosphorus @ 20 g/m^2 & FYM @ 5 kg/m^2 except control. Black plastic mulch recorded maximum values w.r.t. plant height, plant spread, number of branches per plant, number of flowers per plant, flower diameter, number of seeds per flower head, seed yield per plant, seed yield per plot whereas in case of N and K application maximum values of these parameters were observed in case of the application of 40 g N+ 30 g K/m^2. The interaction effect of black plastic mulch × 40 g N+ 30 g K/m^2 recorded maximum values in terms of various growth, flowering and seed quality parameters of commercial importance.

Key words: *Plant growth, Yield, Chrysanthemum, Chrysanthemum coronarium L., Seed Quality, N and K Application*

INTRODUCTION

Annual chrysanthemum (*Chrysanthemum coronarium* L.) belongs to family Asteraceae and has originated in South Europe. Annual chrysanthemum has special importance during festival days as its flowers are in great demand and is also grown in beds for garden decoration and as pot plants. It has been established as one of the most important flower crops grown in India mainly in Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Uttar Pradesh, Punjab and Haryana. Annual chrysanthemum is also known as 'crown daisy' or 'garland chrysanthemum'. In India, the crop has been naturalized and locally called 'Bijli' in Nagpur[22], 'Babbona' in Haryana[23] 'Guldhak' in Punjab, 'Market' in Delhi and 'Gendi' in Uttar Pradesh[1]. Annual chrysanthemum is a hardy, vigorous and tall growing annual attaining a height of about 100 to 140 cm tall. The leaves are deeply cut and lanceolated, and flower size varies from 2.5 to 6.0 cm depending upon varieties, species and other factors.

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The flower colour is usually yellow or white with cream zone at the centre having single to fully double forms[7]. They are mainly classified as large and small flowers. Among the various factors influencing growth and flowering of annual chrysanthemum, balanced nutrition is also very important. The growth and development of plants generally depends on their judicious feeding right from very beginning till the harvest. Annual chrysanthemum is a heavy feeder of major nutrients and hence warrants for larger requirement of N, P and K. The emphasis at an early stage for better vegetative growth should be especially on nitrogen. Plant growth during initial seven weeks needs maintenance of higher levels of nitrogen and plants do not need additional phosphorus throughout the growing period and it should be applied as a basal dose only[20]. However, Joiner and Smith[16] emphasized the need of phosphorus during initiation of flower buds and subsequent development of flowering buds. Whereas, potassium is required by the plants right from initial plant growth till flowering. Thus, to standardize the optimum doses of nutrients (N & K) as well as use of mulching for better growth, flowering and yield of quality seeds in annual chrysanthemum the present investigation was conducted to determine the effects of mulching and nutrients (N and K) doses on growth, character, yield attributes and seed yield of chrysanthemum.

MATERIAL AND METHODS

The present investigation was carried out at Khaltoo experimental farm, Department of Seed Science and Technology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. during the year 2014 to 2016, located at an altitude of 1250 meters above mean sea level having a latitude of 35.5^{o} N and longitude of 77.8^{o} E. During the cropping season, mean temperature varied from 9.85 to 23.50 °C while relative humidity ranged from 45 to 63 per cent with minimum rainfall (0.00 mm) in the month of November, 2014 and maximum rainfall (213.00 mm) in March, 2015(Table 1).

Table 1: Mean monthly meteorological data of Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) for the year 2014-15

Month	Rainfall	Temperature (°C)			Relative Humidity (%)
		Maximum	Minimum	Mean	
October, 2014	15.70	25.70	10.30	18.00	60.00
November, 2014	0.00	23.60	5.70	14.65	49.00
December, 2014	75.60	19.70	2.40	11.05	58.00
January, 2015	49.40	17.10	2.60	9.85	63.00
February, 2015	67.00	19.60	5.70	12.65	59.00
March, 2015	213.60	21.40	7.80	14.60	58.00
April, 2015	71.80	25.40	11.90	18.65	58.00
May, 2015	16.10	31.30	15.70	23.50	45.00

The healthy, disease free, bold and uniform seeds of annual chrysanthemum (*Chrysanthemum coronarium* L.) were obtained from the Department of Floriculture and Landscape Architecture, Dr. Y.S. Parmar University of Horticulture and Forestry Nauni, Solan (H.P.). These obtained seeds were sown in nursery beds. Each seed was covered with sieved well rotten Farm Yard Manure and watered properly. The experiment was laid out in randomized block design comprising of sixteen treatment combinations of mulches (M_1: no mulch; M_2: crop residue mulch; M_3: silver plastic mulch; M_4: black plastic mulch) and four levels of nitrogen and potassium(N_0K_0: Control *i.e.* no fertilizers; N_1K_1: 20g N + 10g K/m^2; N_2K_2: 30g N + 20g K/m^2;N_3K_3: 40g N + 30g K/m^2). A constant dose of phosphorus @ 20 g/m^2 and FYM @ 5 kg/m^2 (except control) was applied uniformly.

The sources of nitrogen, phosphorus and potassium were Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP), respectively. The half dose of nitrogen and full doses of phosphorous and potassium were applied at the time of field preparation. The remaining half dose of nitrogen was applied after 30 days of transplanting. Calculations of different fertilizers doses are presented in Table 2.

Table 2: Calculation of fertilizers doses:

Nitrogen doses (Source Urea; 46 % N; Quantity of urea in g)			**Potassium doses (Source MOP; 60 % K; Quantity of MOP in g)**	
	1st dose	**2nd dose**		
N_0 (0 g)	0 g/m^2	0 g/m^2	K_0 (0 g)	0 g/m^2
N_1 (20 g)	21.74 g/m^2	21.74 g/m^2	K_1 (10 g)	16.67 g/m^2
N_2 (30 g)	32.61 g/m^2	32.61 g/m^2	K_2 (20 g)	33.33 g/m^2
N_3 (40 g)	43.48 g/m^2	43.48 g/m^2	K_3 (30 g)	50.00 g/m^2

Healthy, disease free and stocky seedlings of uniform size and vigour at 5-6 leaf stage were selected and transplanted on the beds of 1 m × 1 m size accommodating 9 plants with a spacing of 30 × 30 cm. The plants were gently watered or irrigated daily during summer months and twice a week during winter months in the entire cropping period. Frequency of irrigation was altered depending on the prevailing weather conditions. Weeds were removed manually as and when they appeared to keep the field free from weeds. Prominent weeds found during cultivation were *Oxalis sp.*, *Cyperus rotundus*, *Trifolium repens*, *Cynodon dactylon*, *Parthenium* sp. *etc.* Hoeing was started right after few days from establishment of seedlings and practiced when hard crust formed over the soil surface. After 30 days of transplanting, the plants were pinched so as to encourage lateral growth.

The plant height was measured with a meter rod from the ground level to the top of apical shoot at the time of peak flowering for every plant. The average height of plants was worked out and expressed in centimetres. Plant spread was measured as the average of distances between apices of a plant in East-West and North-South directions with a meter rod at the time of peak flowering. The average spread of plants was worked out and expressed in centimetres. The number of branches produced in each plant during the entire season were counted and recorded accordingly. The total number of flowers produced in each plant during the entire season was counted and average number of flowers per plant was worked out accordingly. Size of ten flowers on each plant was recorded at the time of peak flowering as the average of distance between apices of petals in East to West direction and distance between apices of petals in North to South direction at the fully opened stage. The average flower diameter was worked out accordingly and expressed in centimeter. Total numbers of seeds were counted from ten flowers selected at random and average value was worked out to calculate number of seeds per flower head in each treatment combination. The seeds harvested from each plant were dried in shade, properly cleaned and weighed with an electronic balance and average was worked out. Seed yield per plot was calculated by weighing the total seeds produced by all the plants of a plot. The statistical analysis was done as per design of the experiment as suggested by Gomez and Gomez[10].

RESULTS AND DISCUSSION

Maximum plant height (132.12 cm) was recorded with the use of black plastic mulch (M_4) and found to be significantly higher over all other treatments .Whereas, minimum plant height (126.32 cm) was observed with no mulch (M_1). Mulching provides a favorable environment for growth which results in the

production of more vigorous and healthier plants. Consequently, the plants might exhibit more tolerance to pest injuries. Mulching is known to increase the soil temperature, moisture content and stimulate root growth which leads to greater plant growth. Therefore, mulched plants usually grow and mature more uniformally than unmulched plants[4,28]. Similarly, Chawla[5]. had reported maximum plant height (70.91 cm) with the use of black plastic mulch in african marigold. Similar results have been reported by Kumar *et al.*[18], in rose and Shinde *et al.*[32], in chilli. The tallest plants (136.37 cm) were produced with the application of 40 g N + 30 g K/m^2 (N_3K_3) and found to be statistically superior to all other doses. However, minimum plant height (118.75cm) was observed with no application of nitrogen and potassium (N_0K_0) *i.e.* control. The combined doses of nitrogen and potassium had also influenced plant height significantly. Taller plants were produced with higher doses of combined applications of nitrogen and potassium. The results are in agreement with the findings of Chezhiyan *et al.*[6], who reported highest increase in plant height of chrysanthemum during 1984 and 1985 with the application of NPK @ 20: 20: 20 g/m^2 and minimum with no application of NPK. Jayaprabha and Shakila[14] also observed that application of nitrogen and potassium in higher doses *i.e.* @ 150: 150 mg/kg of soil significantly increased the plant height of celosia in comparison to control. Javid *et al.*[13], also recorded maximum plant height of zinnia cv. 'Dahlia Flowered' with the application of NPK @ 30: 20: 20 g/m^2 and minimum in control (*i.e.* without fertilizers). Sharma and Singh[30] observed tallest plants (79.15 cm) in gladiolus with the application of NPK @ 40: 20: 20 g/m^2, whereas, minimum plant height (63.37 cm) was obtained in the control (*i.e.* no fertilizer application). The results also got support from Barad *et al.*[3], who recorded the highest plant height in gerbera (32.90 cm) with the application of highest levels of fertilizers (*i.e.*NPK @ 20: 10: 20 g/m^2). Interaction effects of mulches, N and K application (M × NK) had also exhibited a significant effect on plant height. The interactive effects of mulches, N and K application resulted in maximum plant height (139.20 cm) in the interaction, M_4 × N_3K_3 *i.e.* combined application of mulching with black plastic sheet and fertilization with 40 g N/m^2 + 30 g K/m^2. However plant height was recorded to be minimum (115.66 cm) in the interaction, M_1 × N_0K_0 *i.e.* when no application of nitrogen, potassium and mulch was practiced (Table 3). Mulching with black plastic sheet might led to better absorption of nutrients, check growth of weeds and also temperature moderation and as a result of which the plant growth in terms of plant height is increased significantly especially with the application of higher doses of nutrients (N & K). Easmin *et al.*[9], reported maximum plant height (48.77 cm) in Chinese cabbage with the application of 250 kg N/ha and black polythene mulch. Similarly, Islam *et al.*[12], also observed taller plants in onion when the plants were fertilized with 120 kg N/ha + 112.5 kg K/ha and mulched with straw mulch.

Table 3: Effect of mulch, N and K application and their interaction on plant height (cm) of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	115.66	121.33	134.26	134.03	126.32
M_2(Crop residue mulch)	116.33	123.00	132.43	135.50	127.02
M_3(Silver plastic mulch)	121.00	125.00	132.26	136.76	128.75
M_4(Black plastic mulch)	122.00	132.50	134.80	139.20	132.12
Mean	118.75	125.45	133.44	136.37	
$CD_{0.05}$	**M:**0.81; **NK:**0.81; **M × NK:**1.62				

Among different types of mulches, maximum plant spread (25.62 cm) was recorded with the use of black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 4). Whereas, minimum plant spread (20.75 cm) was found with no mulch (M_1). The plants attained wider spread with the application of black polythene mulch and may be due to the fact that black colour polythene has more capacity to regulate soil temperature as compared to other mulch materials. In addition to this, no weed infestation was seen under black polythene mulch treatment. Chawla[5] reported maximum plant spread (53.05 cm) in african marigold when plants were mulched with black polythene mulch. Similar results were also reported by Kumar *et al.*[18], in rose when mulching was done with black polythene sheet. The widest plant spread (34.35 cm) was observed with the application of 40 g N + 30g K /m^2 (N_3K_3) and found to be statistically superior to all other doses. However, minimum plant spread (17.09) was reported with no application of nitrogen and potassium (N_0K_0) *i.e.* control. Plant spread was also influenced significantly with the combined applications of nitrogen and potassium especially at higher doses. Maximum plant spread was reported with higher doses of combined application of nitrogen and potassium which could be as a result of the fact that application of nitrogen and potassium at higher doses might have put up more plant biomass especially the formation of lateral shoots. Sharma *et al.*[29], reported increased plant spread in chrysanthemum with the application of NPK @ 30: 30: 30 g/m^2. Sharma *et al.*[31], have observed highest plant spread (49.12 cm) in barleria with the application of 30 g/m^2 each of nitrogen and potassium. Minimum plant spread (31.78 cm) was observed with no application of nitrogen and potassium. Interaction effects of mulching, N and K application (M × NK) had also exhibited significant effects on plant spread. The interactive effects of mulches, N and K applications have resulted in maximum plant spread (3.40 cm) in the interaction, $M_4 \times N_3K_3$ *i.e.* mulching with black plastic mulch and fertilization with 40 g N/m^2 + 30 g K/m^2. The plant spread was recorded to be minimum (16.20 cm) in the interaction, $M_1 \times N_0K_0$ *i.e.* when no application of nitrogen, potassium and mulch was given. Plant spread was also increased significantly with combined applications of nitrogen and potassium especially at higher doses along with the use of black plastic mulch. The wider plant spread with the use of black polythene sheet in combination with higher doses of nitrogen and potassium could be attributed to the reason that black plastic sheet might have created congenial environment at the root-zone, besides improving the various physico-chemical and biological properties of soil, The application of higher doses of nitrogen and potassium might have assured the optimum supply of N and K for the plants needed for requisite growth and production of more biomass. Hence, more plant spread. Easmin *et al.*[9], had also reported maximum plant spread (69.84 cm) in Chinese cabbage with the combined applications of 250 kg N/ha and black polythene mulch.

Table 4: Effect of mulch, N and K application and their interaction on plant spread (cm) of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	16.20	18.73	19.63	28.43	20.75
M_2(Crop residue mulch)	16.63	19.20	22.10	34.00	22.98
M_3(Silver plastic mulch)	17.33	20.30	24.50	36.56	24.67
M_4(Black plastic mulch)	18.20	20.43	25.46	38.40	25.62
Mean	17.09	19.66	22.92	34.35	
$CD_{0.05}$	**M:**0.57; **NK:**0.57; **M × NK:**1.54				

Maximum number of branches per plant (26.41) was recorded with the use of black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 5). Whereas, minimum branches per plant (21.06) were found with no mulch (M_1). The maximum number of branches per plant (31.77) was produced with the application of 40 g N + 30 g K /m^2 (N_3K_3) and found to be statistically higher to all other doses. However, minimum number of branches per plant (17.93) was observed with the no application of nitrogen and potassium (N_0K_0). Interaction effects of mulch, N and K application (M × NK) had also exhibited significant effects on number of branches per plant (Appendix-II). The maximum number of branches per plant (36.33) was produced in the interaction, $M_4 \times N_3K_3$ *i.e.* with the combined effect of black plastic mulch and application of 40 g N/m^2 + 30 g K/m^2. The number of branches per plant was recorded to be minimum (15.13) in the interaction, $M_1 \times N_0K_0$ *i.e.* when no application of nitrogen, potassium and mulch was practiced. The mulching had exhibited significant effects on the number of branches per plant. The highest number of branches per plant was observed in black plastic mulch. Srivastava *et al.*[34], reported that the black polythene mulch exhibited maximum number of branches per plant (21.94) in chilli. Kumar *et al.*[18], also recorded more number of branches per plant (5.19) in rose with the use of black polythene mulch. Ashrafuzzaman *et al.*[2], also observed maximum number of primary branches in chilli under black plastic mulch. Number of branches per plant increased with application of higher levels of nitrogen and potassium which could be as a consequence of production of more biomass of plants with the application of higher doses of nutrients. Dorajeerao *et al.*[8], reported more branches per plant (41.81) with the application of 150 kg N/ha along with 100 kg K/ha in garland chrysanthemum. Similarly, Sharma *et al.*[31], reported maximum number of branches per plant in barleria with the application of N:P:K @ 30:30:30 g/m^2. Thaneshweri[35] had also reported more branches per plant in hydrangea when nitrogen and potassium was applied at higher doses.

Table 5: Effect of mulch, N and K application and their interaction on number of branches per plant of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	15.13	19.33	22.35	27.43	21.06
M_2(Crop residue mulch)	17.00	21.39	24.86	29.33	23.14
M_3(Silver plastic mulch)	19.39	21.51	25.50	34.00	25.10
M_4(Black plastic mulch)	20.20	23.00	26.16	36.33	26.41
Mean	17.93	21.30	24.72	31.77	
$CD_{0.05}$	**M:**0.60; **NK:**0.60; **M × NK:**1.20				

Maximum flowers per plant (257.93) were produced with the black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Tabe 6). Whereas, minimum number of flowers per plant (248.92) were recorded with no mulching (M_1). The application of 40 g N + 30g K /m^2 (N_3K_3) resulted in the production of maximum flowers (264.38) per plant and found to be statistically superior to all other doses. However, minimum number of flowers per plant (237.25) was observed with no application of nitrogen and potassium (N_0K_0) *i.e.* control. Interaction effects of mulching, N and K applications (M × NK) have exhibited significant effects on production of number of flowers per plant. The maximum number of flowers per plant (266.13) was produced in

$M_4 \times N_3K_3$ *i.e.* combined effect of black plastic mulch and application with 40 g N/m^2 + 30 g K/m^2 and found to be statistically at par with the interaction, $M_3 \times N_3K_3$ (264.66). The number of flowers per plant was recorded to be minimum (232.01) with interactive effects of $M_1 \times N_0K_0$ *i.e.* when no application of nitrogen, potassium and mulch was practiced. Number of flowers per plant increased significantly with the use of black plastic mulch due to the fact that black colour polythene have more capacity to regulate soil temperature than other mulch materials making more favorable micro climate for the growth and flowering of plant. Murugan and Gopinath had[24] reported that plants mulched with black polyethylene mulch had produced more number of flowers per plant. Chawla[5] also observed more number of flowers per plant (53.45) in african marigold in black plastic mulch. Similar results were also reported by Kumar *et al.*[18], in rose when the plants were mulched with black plastic sheet. The results are also in agreement with the earlier findings of Locher *et al.*[19], in sweet pepper. The combined applications of black plastic mulch along with nitrogen and potassium especially at higher doses had a positive effect in terms of growth and development of plants, thus resulting in better flowering by producing more flowers per plant in comparison to the application of nitrogen and potassium at lower doses. Chezhiyan *et al.*[6], reported highest number of flowers per plant in chrysanthemum during 1984 and 1985 with the application of NPK @ 20: 20: 20 g/m^2 and minimum when NPK was applied at lower doses or no application was given. Barad *et al.*[3], also found highest number of flowers per plant (24.55) in gerbera (32.90 cm) with the production of highest levels of fertilizers of NPK @ 20:10:20 g/m^2 and minimum (11.73) with NPK @ 0: 0: 0 g/m^2.

Table 6: Effect of mulch, N and K application and their interaction on number of flowers per plant of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	232.00	246.00	255.00	262.70	248.92
M_2(Crop residue mulch)	234.66	251.00	257.76	264.03	251.86
M_3(Silver plastic mulch)	236.00	254.00	259.23	264.66	253.47
M_4(Black plastic mulch)	246.33	256.63	262.63	266.13	257.93
Mean	237.25	251.90	258.65	264.38	
$CD_{0.05}$	**M:**0.98**; NK:**0.98; **M×NK:**1.96				

Maximum flower diameter (5.59 cm) was recorded with the use of black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 7) whereas, minimum flower diameter (5.42 cm) was recorded with no mulch (M_1) and found to be statistically at par with M_2 (5.18 cm). The application of 40 g N + 30 g K/m^2 (N_3K_3) resulted in the production of largest size flowers (5.81 cm) and found to be statistically superior to all other doses. However, minimum flower diameter (5.19 cm) was observed with no application of nitrogen and potassium (N_0K_0) *i.e.* control. The interaction effects of mulches, N and K applications (M × NK) have exhibited non-significant effects on flower diameter. Maximum flower diameter (6.03 cm) was recorded in the interaction, $M_4 \times N_3K_3$ *i.e.* with the combined effects of black plastic mulch and fertilization with 40 g N/m^2 + 30 g K/m^2. The flower diameter was recorded minimum (5.18 cm) with no application of nitrogen, potassium and mulch ($M_1 \times N_0K_0$). Flower diameter increased with the use of mulching and found to be maximum in black polythene mulch due to the fact that black colour polythene sheet has more capacity to regulate soil temperature than other mulch materials. In addition to this, no weed infestation was seen under black polythene

mulch treatment, besides creating a more favourable micro-climate for the growth and flowering of plants in comparison to other mulches. Similar results were reported by Kumar *et al.*[18], in rose when the plants were mulched with black polythene mulch. Maximum flower diameter was obtained with higher doses of nitrogen and potassium in comparison to lower doses especially with the use of black plastic mulch. This might be due to increased photosynthetic activity and better vegetative growth obtained under higher dose of nitrogen and potassium, which led to production of better size and quality of flowers as compared to other doses. Hamlin and Mills[11] reported in pansy (*Viola* × *wittrockiana*) that more potassium was absorbed after the flowers were opened because potassium ion stimulates petal cell expansion.

Table 7: Effect of mulch, N and K application and their interaction on flower diameter of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30g/Km^2)	Mean
M_1(No mulch)	5.18	5.27	5.58	5.64	5.42
M_2(Crop residue mulch)	5.37	5.47	5.33	5.78	5.49
M_3(Silver plastic mulch)	4.83	4.53	5.13	5.77	5.07
M_4(Black plastic mulch)	5.39	5.54	5.51	6.03	5.59
Mean	5.19	5.20	5.39	5.81	
$CD_{0.05}$	**M:**0.27; **NK:**0.27; **M × NK:** NS				

Maximum number of seeds per flower head (234.41) was recorded with the black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 8). Whereas, minimum number of seeds per flower head (227.84) was produced with no mulching (M_1). The application of nitrogen and potassium doses also exhibited significant effect on number of seeds per flower head. Maximum number of seeds per flower head (240.35) was produced with the application of 40 g N + 30g K /m^2 (N_3K_3) and found to be statistically higher to all other doses. However, minimum seeds per flower head (222.73) were recorded with no application of nitrogen and potassium (N_0K_0) *i.e.* control. The interaction effect of mulches, N and K application (M × NK) also exhibited significant effect on number of seeds per flower head. Maximum number of seeds per flower head (244.66) was produced with the interaction $M_4 \times N_3K_3$ *i.e.* combined effect of mulching with black plastic sheet and fertilization with 40 g N/m^2 + 30 g K/m^2. The number of seeds per flower head was recorded to be minimum (217.66) in $M_1 \times N_0K_0$ *i.e*. when no application of nitrogen, potassium and mulch was given. Number of seeds per flower head increased significantly when the plants were mulched with black plastic sheet. The increased number of seeds per flower head might be because of increased levels of nitrogen and potassium as they had role in increasing carbohydrates production and their quick translocation to the developing capsules. Singh[33] reported maximum number of seeds per pod (62.0) in pansy with 25 g N/m^2 and minimum (52.1) with no application of nitrogen. John *et al.*[15], also observed maximum number of seeds per capsule in pansy with 30 g N/m^2. Rahmani *et al.*[26], found more number of seeds per head (29.25) in calendula with 90 kg N/ha and minimum (24.0) with 30 kg N/ha. Samoon and Kirad[27] recorded maximum number of seeds per flower head (46.14) in calendula var. 'Touch of Red Mix' with 150 kg N/ha and minimum (33.72) with 0 kg N/ha. Mansouri and Shokoohfar[21] also reported maximum number of seeds per pod (7.27) in cow pea with the application of highest dose of potassium *i.e.*140 kg/ha and minimum (5.92) with 0 kg/ha (control).

Table 8: Effect of mulch, N and K application and their interaction on number of seeds per flower head of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	217.66	226.46	231.50	235.73	227.84
M_2(Crop residue mulch)	223.00	229.00	234.13	239.00	231.28
M_3(Silver plastic mulch)	225.00	230.97	235.86	242.00	233.45
M_4(Black plastic mulch)	225.26	230.77	236.96	244.66	234.41
Mean	222.73	229.30	234.61	240.35	
$CD_{0.05}$	**M:**0.65; **NK:**0.65; **M × NK:**1.30				

Maximum seed yield per plant (9.19 g) was recorded with the application of black plastic mulch (M_4) and was found significantly higher over all other mulching treatments (Table 9). Whereas, minimum seed yield per plant (8.73 g) was observed with no mulch (M_1). The maximum seed yield per plant (9.73 g) was reported with the application of 40 g N + 30g K /m^2 (N_3K_3) and found to be statistically superior to all other doses. However, minimum seed yield per plant (8.45 g) was found in the control (*i.e.* with no application of nitrogen and potassium). The interaction effects of mulches, N and K applications (M × NK) also exhibited significant effect on seed yield per plant. Maximum seed yield per plant (10.17 g) was recorded in the interaction, $M_4 \times N_3K_3$ *i.e.* combined effect of mulching with black plastic mulch and application of 40 g N/m^2 + 30 g K/m^2. The seed yield per plant was found to be minimum (8.29 g) in $M_1 \times N_0K_0$ *i.e.* when no application of nitrogen, potassium and mulch was given. The combined applications of nitrogen and potassium especially at higher doses had a positive effect on seed yield. Seed yield increased with an increase in levels of nitrogen and potassium fertilization. This could be due to the fact that higher application of nutrients (N and K) have contributed notably for the production of more number of flowers per plant as well as highest seed yield per flower head, besides producing more bold and quality seeds. The results got support from the work of Narayanan[25] who reported maximum seed yield per plant (1.72 g) in plots fertilized with higher doses of NPK (@ 60: 30: 30 kg/ha) and minimum (1.22 g) in control (without fertilizer application). The conjoint use of mulching as well as application of higher doses of nutrients (N and K) have resulted in the production of more flowers per plant as well as highest seed yield per flower head, hence contributed for more seed yield per plant.

Table 9: Effect of mulch, N and K application and their interaction on Seed yield per plant (g) of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	8.29	8.40	8.84	9.38	8.73
M_2(Crop residue mulch)	8.50	8.62	8.91	9.70	8.93
M_3(Silver plastic mulch)	8.40	8.75	9.06	9.89	9.02
M_4(Black plastic mulch)	8.63	8.77	9.19	10.17	9.19
Mean	8.45	8.64	9.00	9.78	
$CD_{0.05}$	**M:**0.07; **NK:**0.07; **M × NK:**0.15				

Maximum seed yield per plot (82.73 g) was recorded with the use of black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 10). Whereas, minimum seed yield per plot (78.59) was found in the control (M_1). The application of 40 g N + 30 g K /m^2 (N_3K_3) resulted in maximum seed yield per plot (88.09 g) and found to be statistically superior to all other doses. However, minimum seed yield per plot (76.11 g) was recorded when with no application of nitrogen and potassium (N_0K_0) was given *i.e.* control. The interaction effects of mulches, N and K applications (M × NK) had also influenced seed yield per plot significantly. The interaction, M_4 × N_3K_3 resulted in maximum seed yield per plot (91.56 g) and it was found to be significantly higher over other treatments. However, seed yield per plot was found to be minimum (74.68 g) with the interactive effects of M_1 × N_0K_0 *i.e.* when no application of nitrogen, potassium and mulch was practiced. The application of black plastic mulch in combination with higher doses of nitrogen and potassium have resulted in the production of more flowers per plant, maximum seeds per flower head as well as higher seed yield per plant. Seed yield increased with combined application of nitrogen and potassium along with black plastic mulch which could be as a consequence of the fact that mulching improves better nutrition absorption and weed control as a result of which more growth of plant occurred and seed yield per plant might have increased. Hence, this treatment combination had produced highest seed yield per plot. Kalaghatagh *et al.*[17], reported maximum seed yield (53.50 q/ha) in maize when plants were mulched with black plastic sheet and fertilized with recommended doses of NPK as compared to control (36.20 q/ha). Similarly, Narayanan[25] reported maximum seed yield per plot (11.8 g) in phlox with the application of NPK @ 60: 30: 30 kg/ha and minimum seed yield (7.7 g) in control (without fertilizer application). Samoon and Kirad[27]. also observed maximum seed yield (115.10 kg/ha) in calendula var. 'Touch of Red Mix' with 150 kg N/ha and minimum (53.76 kg/ha) with 0 kg N/ha. Mansouri and Shokoohfar[21] reported maximum seed yield (1479.91 kg/ha) in cow pea with the application of higher dose of potassium *i.e.*140 kg/ha and minimum (1204.75 kg/ha) with 0 kg/ha.

Table 10: Effect of mulch, N and K application and their interaction on seed yield per plot (g) of annual chrysanthemum

N & K application / Mulches	N_0K_0 (Control)	N_1K_1 (20gN+10gK/m^2)	N_2K_2 (30gN+20gK/m^2)	N_3K_3 (40gN+30gK/m^2)	Mean
M_1(No mulch)	74.68	75.67	79.56	84.46	78.59
M_2(Crop residue mulch)	76.50	77.64	80.23	87.30	80.41
M_3(Silver plastic mulch)	75.60	78.76	81.56	89.03	81.24
M_4 (Black plastic mulch)	77.66	78.96	82.73	91.56	82.73
Mean	76.11	77.76	81.02	88.09	
$CD_{0.05}$	**M:**0.69; **NK:**0.69; **M × NK:**1.38				

CONCLUSION

Use of organic amendments with chemical fertilization is of vital importance and of great need in modern era. So as to get better growth, flowering characters and yield, the annual chrysanthemum should be fertilized with

$40gN/m^2$ + 30 g K/m^2 and mulched with black plastic sheet.

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