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Effect of Mulch, N and K Application on Seed Quality of Annual Chrysanthemum (*Chrysanthemum coronarium* L.)

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ABSTRACT

The present investigation was conducted to study the effect of mulch, N and K application and their interaction on seed quality 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 gave maximum values w.r.t. 1000 seed weight, germination percentage, seedling length, seedling dry weight, seed vigour index-I, seed vigour index-II and minimum electrical conductivity of seeds and in case of N and K application the maximum value of these parameters were recorded in case of the application of 40 g N+ 30 g K/m^2. The interaction, $M_4 \times N_3K_3$ i.e. black plastic mulch and application of 40 g N/m^2 + 30 g K/m^2 recorded maximum values in terms of various seed quality parameters of commercial importance.

Key words: *Chrysanthemum, Chrysanthemum coronarium L., Seed Quality, Mulch, N and K Application*

INTRODUCTION

Annual chrysanthemum (*Chrysanthemum coronarium* L.) belongs to family Asteraceae and has been originated in South Europe. It has been established as one of the most important flower crops grown in India especially for loose flower production and landscapes. It is gaining popularity among the growers owing to the facts that it is a short duration crop with a wider adaptability and easy to cultivate besides less photosensitive, thus capable of producing quality blooms round the year.

Annual chrysanthemum is commercially grown in Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Uttar Pradesh, Punjab and Haryana. Annual chrysanthemum is also known as 'crown daisy' or 'garland chrysanthemum'.

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In India, the crop has been naturalized and locally called 'Bijli' in Nagpur[12], 'Babbona' in Haryana[13] 'Guldhak' in Punjab, 'Market' in Delhi and 'Gendi' in Uttar Pradesh[4]. Annual chrysanthemum is commercially propagated by seeds and its seeds are in great demand. The seed germination, seedling quality, growth and flowering of plants are greatly influenced by various environmental factors like temperature, soil, relative humidity, light, nutrition and mulching. The quality of annual chrysanthemum seeds is very high especially when the plants are supplied with the requisite nutrition and grown at cooler temperature than the higher temperature conditions. In addition, close planting particularly with the use of black plastic mulching also contributes notably for higher seed yields.

Thus, because of scarce knowledge and literature available in this field a dire need was observed 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.

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 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 stocked 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. 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.

1000 seeds were counted with the help of seed counter and weighed using electronic balance. The germination test was carried out as per ISTA procedure[3]. Germination percentage was worked out using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings germinated}}{\text{Total number of seeds kept for germination}} \times 100$$

Total seedling length was worked out by taking the total length of randomly selected ten seedlings from the tip of the apex leaf to the tip of primary root with the help of a scale and expressed as mean value in centimetre (cm). These seedlings were then used to work out seedling dry weight. Seedlings were put in butter paper pocket and kept in oven at 50^0C for 48 hours. Dry weight was recorded and the mean value was expressed in milligrams (mg). Seed vigour index-I was calculated as per the formula suggested by Abdul-Baki and Anderson[1] as given below:

Seed vigour index-I = Germination percentage (%) × Seedling length (cm)

Seed vigour index-II was also calculated as per the formula given by Abdul-Baki and Anderson[1] as follows:

Seed vigour index-II = Germination percentage (%) × Seedling dry weight (mg)

Four replicates of 0.5g seeds of each treatment were weighed and soaked in 25 ml distilled water and incubated for 24 hours at 25 °C in the dark. First electrical conductivity of distilled water was measured and then electrical conductivity of the soak solution (leachate) was measured using electrical conductivity meter and actual value was worked out as:

Actual electrical conductivity = Electrical conductivity of leachate – electrical conductivity of distilled water

The statistical analysis was done as per design of the experiment as suggested by Gomez and Gomez[7].

RESULTS AND DISCUSSION

Maximum 1000 seed weight (1.54 g) was recorded with the use of black plastic mulch (M_4) and found to be statistically at par with M_3 *i.e.* 1.52 g (Table 3). Whereas, minimum 1000 seed weight (1.50 g) was recorded with no mulch (M_1). The application of 40 g N + 30 g K/m^2 (N_3K_3) resulted in maximum 1000 seed weight (1.57 g) and found to be statistically at par with N_2K_2 (1.54 g). However, minimum

1000 seed weight (1.45) 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) exhibited non-significant effect on 1000 seed weight. However numerically maximum 1000 seed weight (1.59 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 1000 seed weight was observed to be minimum (1.44 g) in $M_1 \times N_0K_0$ *i.e.* when no application of nitrogen, potassium and mulch was practiced. The practice of mulching has exhibited significant effect on 1000 seed weight and black plastic mulch has been found to be the best. Kalaghatagi *et al.*[10], had also reported maximum 1000 seed weight (217.90 g) in maize with black polyethylene mulch.1000 seed weight increased with the application of higher levels of nitrogen and potassium as they played important part in increasing the cell division and increase in photosynthesis and transferring assimilatory materials and thus increased the weight of individual seed. Singh[17] also reported maximum 1000 seed weight in pansy with 25 g N/m^2 (1.175 g) and minimum (1.067 g) with no application of nitrogen. Rahmani *et al.*[15], also found maximum 1000 seed weight (12.66 g) in calendula with the application of 90 kg N/ha and minimum (11.17 g) with 30 kg N/ha. Similarly, Samoon and Kirad[18] observed maximum 1000 seed weight (8.50 g) in calendula var. 'Touch of Red Mix' with 150 kg N/ha and minimum (6.75 g) with 0 kg N/ha. Mansouri and Shokoohfar[11] also reported maximum 1000 seed weight (231.94 g) of cow pea with the application of higher dose of potassium *i.e.*140 kg/ha and minimum (207.02 g) with 0 kg/ha.

Table 3: Effect of mulch, N and K application and their interaction on 1000 seed weight (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)	1.44	1.49	1.52	1.56	1.50
M_2(Crop residue mulch)	1.45	1.50	1.53	1.57	1.51
M_3(Silver plastic mulch)	1.46	1.52	1.55	1.58	1.52
M_4(Black plastic mulch)	1.48	1.54	1.55	1.59	1.54
Mean	1.45	1.51	1.54	1.57	
$CD_{0.05}$	**M:**0.03; **NK:**0.03; **M × NK:**NS				

Germination percentage (81.75%) was recorded maximum with the use of black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 4). Whereas, minimum germination percentage (79.06 %) observed with no mulching (M_1). The application of 40 g N + 30g K /m^2 (N_3K_3) resulted in maximum germination percentage (85.68 %) of seeds and found to be statistically at par with N_2K_2 (85.68 %). However, minimum germination percentage (76.06 %) was observed when no application of nitrogen and potassium was given (N_0K_0). The interactive effect of mulches as well as N and K application exhibited maximum germination percentage (87.00 %) in 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 germination percentage was recorded to be minimum (75.75 %) with the interaction effect of $M_1 \times N_0K_0$ *i.e.* when no application of nitrogen, potassium and mulch was practiced. The use of black plastic mulch

in alone as well as in combination with the application of higher doses of nutrients (N & K) might has exhibited positive response on various growth, flowering and seed quality attributes. Consequently, the quality of the seeds produced was superior. Hence, the germination percentage of the seeds produced with the augmentation of this treatment combination was found to be higher in comparison to other treatment combinations. Sanderson and Fillmore[16]. while investigating the influence of different mulch types on yield and quality of hips in various wild rose species (*Rosa sp.*) have reported production of better quality hips with the application of black plastic mulch. However, on the contrary, Verma[20] observed maximum seed germination (94.22 %) in bell pepper with silver-black mulch. The results also got the support of Singh (1978) who reported maximum germination percentage in pansy with higher dose of nitrogen *i.e.*25 g N/m^2 (74.2 %) and minimum (63.7 %) with lower dose of nitrogen *i.e.*10 g N/m^2. Warraich *et al.*[21], have also reported maximum germination percentage (100 %) in wheat with 180 kg N/ha and minimum (80 %) with 0 kg N/ha. Balachandra *et al.*[5], reported maximum germination percentage in ageratum with the application of highest levels of NPK @ 100: 75: 60 kg/ha over the lower doses. Narayanan[14] also observed maximum germination percentage (91.5 %) in plots fertilized with 60: 30: 30 kg NPK/ha and minimum seed germination (71.0 %) in control (without fertilizer application) in phlox. Ali *et al.*[2], reported highest germination (69.29 %) in onion with the application of 80 kg potassium/ha and lowest (61.94 %) in control.

Table 4: Effect of mulch, N and K application doses and their interaction on germination percentage (%) 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)	75.75 (8.76)	77.00 (8.83)	80.00 (9. 00)	83.50 (9.19)	79.06 (8.94)
M_2(Crop residue mulch)	76.25 (8.78)	77.25 (8.84)	81.50 (9.08)	86.00 (9.32)	80.25 (9.01)
M_3(Silver plastic mulch)	75.75 (8.76)	77.50 (8.86)	81.50 (9.08)	86.25 (9.34)	80.25 (9.02)
M_4(Black plastic mulch)	76.50 (8.80)	80.50 (9.02)	83.00 (9.16)	87.00 (9.38)	81.75 (9.09)
Mean	76.06 (8.77)	78.06 (8.89)	85.68 (9.08)	85.68 (9.31)	
$CD_{0.05}$	**M:**0.03; **NK:**03; **M × NK:**0.07				

Figures in parenthesis are arc sine transformed values.

Maximum seedling length (9.42 cm) was recorded with the use of black plastic mulch (M_4) and found to be statistically at par with M_3 *i.e.* 9.39 cm (Table 5). Whereas, minimum seedling length (9.08 cm) was observed with no mulch (M_1). The longest seedlings (10.30 cm) were produced with the applications of 40 g N + 30g K /m^2 (N_3K_3) and found to be statistically superior to all other doses. However, minimum seedling length (8.54cm) was observed with no application of nitrogen and potassium (N_0K_0) *i.e.* control. Maximum seedling length (10.24 cm) was reported in the interaction, M_4 × N_3K_3 *i.e.* combined application of mulching with black plastic sheet and supplying of 40 g N/m^2 + 30 g K/m^2 and was found to be statistically at par with M_2 × N_0K_0 (8.49 cm). However, seedling length was recorded to be minimum (8.48 cm) in M_1 × N_0K_0 *i.e.* when no application of nitrogen,

potassium and mulch was given. The mulching of plants with black polythene sheet in combination with the application of higher levels of nitrogen and potassium have resulted in the production of better quality seeds and as a consequence, the seedling length was significantly higher. The reason could be that when the nutrients (N & K) applied at optimum rate and application of black plastic mulch might have created congenial micro climate for the better growth, flowering as well as production of quality seeds. This particular treatment combination might have induced the formation of proteins, carbohydrates and other metabolites in seeds, besides the enzymes in adequate quantity which might have acted on the metabolites in the seeds. Thus, resulted in the better seed quality and consequently, produced taller seedlings. The results got support from earlier findings of Narayanan[14] who reported maximum root length (6.0 cm) and shoot length (5.7 cm) in plots fertilized with 60: 30: 30 kg NPK/ha and minimum root length (2.8 cm) and shoot length (2.6 cm) in control (without fertilizer application). Chawla[6]. has also reported better results in african marigold with the application of black plastic mulch in combination with the recommended dose of fertilizers. Similar results have been reported by Solaiman *et al*.[19], in china aster.

Table 5: Effect of mulch, N and K application and their interaction on seedling length (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)	8.48	8.73	9.31	9.81	9.08
M_2(Crop residue mulch)	8.49	8.74	9.39	10.45	9.26
M_3(Silver plastic mulch)	8.51	8.93	9.44	10.70	9.39
M_4(Black plastic mulch)	8.68	9.23	9.54	10.24	9.42
Mean	8.54	8.91	9.42	10.30	
$CD_{0.05}$	**M:**0.07; **NK:**0.07; **M × NK:**0.14				

Maximum seedling dry weight (7.31 mg) was recorded with the use of black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 6). Whereas, minimum seedling dry weight (7.02 mg) was recorded with no mulch (M_1). The application of 40 g N + 30g K /m^2 (N_3K_3) resulted in maximum seedling dry weight (7.56 mg) and found to be statistically superior to all other doses. However, minimum seedling dry weight (6.63 mg) was observed with no application of nitrogen and potassium (N_0K_0) *i.e.* control. Maximum seedling dry weight (7.75 mg) was recorded in the interaction M_4 × N_3K_3 *i.e.* combined application of mulching with black plastic mulch and 40 g N/m^2 + 30 g K/m^2. However, seedling dry weight was observed to be minimum (6.32 mg) with M_1 × N_0K_0 *i.e.* when no application of nitrogen, potassium and mulch was given. The mulching of plants with black polythene sheet in combination with the application of higher levels of nitrogen and potassium have resulted in the production of better quality seeds and as a consequence, the seedlings produced were of better quality. The reasons could be that when the nutrients (N & K) were applied at optimum doses and the plants being mulched with black plastic sheet might have created congenial conditions for the better growth, flowering as well as production of quality seeds. Consequently, the seeds produced with this particular treatment combination were of very good quality parameters (both in terms physical and physiological quality attributes). Thus, resulted in the production of better quality seedlings and consequently, the seedlings dry weight

was significantly higher. The results got support from findings of Narayanan[14]. who reported maximum dry matter production (0.034 g/10 seedling) in plots fertilized with NPK @ 60: 30: 30 kg/ha and minimum dry matter production (0.017 g/10 seedling) in control (without fertilizer application) in phlox. Chawla[6] has also reported better results in african marigold with the application of black plastic mulch in combination with the recommended dose of fertilizers. Similar results have been reported by Hossain *et al*.[8], in carrot with the combined application of black polythene mulch and higher doses of nutrients (N & K). Similar finding have also been reported by Yathindra *et al*.[22], in china aster.

Table 6: Effect of mulch, N and K application and their interaction on seedling dry weight (mg) 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)	6.32	7.14	7.20	7.42	7.02
M_2(Crop residue mulch)	6.40	7.15	7.27	7.45	7.06
M_3(Silver plastic mulch)	6.82	7.20	6.39	7.62	7.01
M_4(Black plastic mulch)	7.00	7.17	7.35	7.75	7.31
Mean	6.63	7.16	7.05	7.56	
$CD_{0.05}$	**M:**0.19; **NK:**0.19;**M × NK:**0.39				

Maximum seed vigour index-I (772.67) was recorded with black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 8). Whereas, minimum seed vigour index-I (719.86) was observed with no mulch (M_1). The maximum seed vigour index-I (882.88) 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 vigour index-I (649.82) was observed with no application of nitrogen and potassium (N_0K_0) *i.e.* control. Maximum seed vigour index-I (897.00) was recorded with the interaction of $M_4 \times N_3K_3$ *i.e.* mulching of plants with black plastic sheet and application of 40 g N/m^2 + 30 g K/m^2. The seed vigour index-I was observed to be minimum (642.73) when no application of nitrogen, potassium and mulch was given. The mulching of plants with black polythene sheet in combination with the application of higher levels of nitrogen and potassium have resulted in the production of better quality seeds and as a consequence, the seedlings produced were of better quality. This could be due to the reason that when the nutrients (N & K) have been applied at optimum doses and the plants being mulched with black plastic sheet might have created congenial conditions for the better growth, flowering as well as production of quality seeds. Consequently, the seeds produced with this particular treatment combination were of very good quality parameters (both physical and physiological quality attributes). Thus, resulted in better germination percentage besides, the production of better quality seedlings. The production of seeds with the augmentation of this particular treatment combination has exhibited highest germination percentage as well as maximum seedling length upon sowing. Hence, resulted in maximum seed vigour index-I. Narayanan[14] reported maximum seed vigour (1067) in phlox with the application of NPK @ 60: 30: 30 kg/ha and minimum seed vigour (391) in control (without fertilizer application). Chawla[6] has also reported better results in african marigold with the application of black plastic mulch in combination with the recommended dose of fertilizers. Similar results have been reported by Hossain *et al*.[8],

in carrot with the combined application of black polythene mulch and higher doses of nutrients (N & K). Similarly, Islam *et al*.[9], while investigating the effect of various mulches and different levels of nitrogen and potassium on plant growth and seed yield of onion have reported better results with the combined use of mulching and higher doses of nitrogen and potassium.

Table 8: Effect of mulch, N and K application and their interaction on seed vigour index (length) 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)	642.73	672.20	745.38	819.14	719.86
M_2(Crop residue mulch)	647.36	675.55	765.50	898.62	746.76
M_3(Silver plastic mulch)	645.00	692.62	769.77	922.75	757.53
M_4(Black plastic mulch)	664.21	743.22	792.23	891.00	772.67
Mean	649.82	695.90	768.22	882.88	
$CD_{0.05}$	**NK:**8.45**; M:**8.45; **NK × M:**16.90				

Maximum seed vigour index-II (599.33) was recorded with the black plastic mulch (M_4) and found to be significantly higher over all other mulching treatments (Table 9). Whereas, minimum seed vigour index-II (556.38) was recorded with no mulch (M_1). The application of 40 g N + 30 g K/m^2 (N_3K_3) resulted in maximum seed vigour index-II (648.15) and found to be statistically superior to all other doses. However, minimum seed vigour index-II (504.95) was reported when no applications of nitrogen and potassium (N_0K_0) were given *i.e.* control. The interaction effects of mulches, N and K applications (M × NK) have also exhibited a significant effect on seed vigour index-II. Maximum seed vigour index-II (674.25) was recorded in the interaction, M_4 × N_3K_3 *i.e.* combined application of mulching with black plastic mulch and application of 40 g N/m^2 + 30 g K/m^2. The seed vigour index-II was recorded to be minimum (479.22) in M_1 × N_0K_0 *i.e.* when no application of nitrogen, potassium and mulch was practiced. The mulching of plants with black polythene sheet in combination with the application of higher levels of nitrogen and potassium have resulted in the production of better quality seeds and as a consequence, the seedlings produced were of better quality. This could be due to the reasons that when the nutrients (N & K) have been applied at optimum doses and the plants being mulched with black plastic sheet might have created congenial conditions for the better growth, flowering as well as production of quality seeds. Consequently, the seeds produced with this particular treatment combination were of very good quality parameters (both physical and physiological quality attributes). Thus, resulted in better germination percentage besides, the production of better quality seedlings. The production of seeds with the augmentation of this particular treatment combination has exhibited highest germination percentage as well as maximum seedling dry weight upon sowing. Hence, resulted in maximum seed vigour index-II. Narayanan[14] reported maximum seed vigour (1067) in phlox with the application of NPK @ 60: 30: 30 kg/ha and minimum seed vigour (391) in control (without fertilizer application). Chawla[6] has also reported better results in african marigold with the application of black plastic mulch in combination with the recommended dose of fertilizers. Similar results have been reported by Hossain *et al*.[8], in carrot with the combined application of black polythene mulch and higher doses of nutrients (N & K). Similarly, Islam *et al*.[9], while investigating the effect of various mulches and different levels of

nitrogen and potassium on plant growth and seed yield of onion have reported better results with the combined use of mulching and higher doses of nitrogen and potassium.

Table 9: Effect of mulch, N and K application and their interaction on seed vigour index (mass) 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)	479.22	550.42	575.92	619.95	556.38
M_2(Crop residue mulch)	487.95	552.37	592.90	640.75	568.49
M_3(Silver plastic mulch)	517.23	558.10	520.38	657.65	563.34
M_4(Black plastic mulch)	535.42	577.57	610.10	674.25	599.33
Mean	504.95	559.61	574.82	648.15	
$CD_{0.05}$	**M:**15.61; **NK:**15.61; **M × NK:**31.22				

Maximum electrical conductivity of seeds (54.70 µS/cm) was recorded with the no mulch *i.e.* M_1(Table 10). Whereas, minimum electrical conductivity of seeds (48.24 µS/cm) was reported with black plastic mulch (M_4). Minimum electrical conductivity of seeds (35.30 µS/cm) was recorded in the seeds which were produced with the application of 40 g N + 30g K /m^2 (N_3K_3) and found to be significantly lower in comparison to all other treatments. However, maximum electrical conductivity of seeds (74.50 µS/cm) was reported for the seeds produced in the control *i.e.* when no application of nutrients (N & K) was given and found to be significantly higher over all other doses. The interaction effects of mulches, N and K application (M × NK) have also exhibited significant effects on electrical conductivity of seeds. The electrical conductivity of seeds was recorded to be minimum (33.00 µS/cm) in the interaction, M_4 × N_3K_3 *i.e.* with the combined effect of mulching with black plastic sheet and application of 40 g N/m^2 + 30 g K/m^2 . Whereas, maximum electrical conductivity of seeds (76.33µS/cm) was reported in the interaction, M_1 × N_0K_0 *i.e.* no application of nitrogen, potassium and mulch. Minimum electrical conductivity of seeds has been reported for the seeds which were produced with the highest doses of nitrogen and potassium along with the mulching of plants with plastic sheet. This could be due to the reasons that the seeds produced under this treatment combination were of very high quality in comparison to the seed produced with the augmentation of other treatment combinations. Consequently, the seeds produced with the above mentioned treatment combination might have leaked significantly less amount of solutes in leachate while testing the EC of seeds in comparison to the seeds produced under other treatments. Thus, the most vigorous seeds. However, electrical conductivity of seeds was reported to be maximum in control as the seeds might have leaked more solutes when placed in water and hence less vigorous seed. Warraich *et al.*[21], reported maximum electrical conductivity of seeds in wheat with 0 kg N/ha and minimum with higher dose of nitrogen *i.e.*120 kg N/ha.

Table 10: Effect of mulch, N and K application and their interaction on electrical conductivity (µS/cm) of seed 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)	76.33	61.06	44.06	37.36	54.70
M_2(Crop residue mulch)	74.66	56.00	42.33	35.83	52.20
M_3(Silver plastic mulch)	74.00	55.00	41.33	35.00	51.33
M_4(Black plastic mulch)	73.00	48.06	38.90	33.00	48.24
Mean	74.50	55.03	41.65	35.30	
$CD_{0.05}$	**M:**0.88; **NK:**0.88; **M × NK:**1.77				

CONCLUSION

Use of organic amendments with chemical fertilization is of vital importance and of great need in modern era. It is concluded that for better seed quality, 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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