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Davara Monali A
Junagadh Agricultural University, Junagadh, Gujarat, India

KB Polara
Junagadh Agricultural University, Junagadh, Gujarat, India

Trupti R Ribadiya
Junagadh Agricultural University, Junagadh, Gujarat, India

Bhumika M Vadaliya
Junagadh Agricultural University, Junagadh, Gujarat, India

LC Vekariya
Junagadh Agricultural University, Junagadh, Gujarat, India

Correspondence
Davara Monali A
Junagadh Agricultural University, Junagadh, Gujarat, India

Effect of potassium and zinc on growth, yield and quality of coriander (*Coriandrum sativum* L.)

Davara Monali A, KB Polara, Trupti R Ribadiya, Bhumika M Vadaliya and LC Vekariya

Abstract
A pot experiment was conducted at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh to assess the "Effect of potassium and zinc on yield and nutrient uptake by coriander" during the *rabi* season of 2016-17. The pot experiment comprising of five levels of potassium (0, 10, 20, 40 and 60 kg ha^{-1}) and four levels of zinc sulphate (0, 10, 20 and 30 kg ha^{-1}) in factorial completely randomized design replicated three times were tested in the experiment, in respect of yield attributes and yield and quality parameter. While the plant height and dry matter yield recorded at 30, 60 DAS and at harvest time. The experimental soil was medium black calcareous, clayey in nature which was slightly alkaline in reaction, $pH_{2.5}$ - 8.0, $EC_{2.5}$ - 0.58 dS m^{-1}, low in available nitrogen (242 kg ha^{-1}), medium in phosphorus (39.20 kg ha^{-1}), available potassium (208 kg ha^{-1}) and DTPA available zinc (0.55 mg kg^{-1}). The application of potassium @ 60 kg ha^{-1} and zinc sulphate @ 30 kg ha^{-1} significantly increased the plant height, dry matter yield, seed yield, No. of branches per plant, No. of umbels per plant, No. of umbellate per umbel, No. of seed per umbellate and 1000-seed test weight. While the application of potassium @ 60 kg ha^{-1} along with zinc sulphate 30 kg ha^{-1} gave significantly higher plant height, dry matter yield, seed yield and No. of seed per umbellate of coriander.

Keywords: Coriander, rabi, potassium level, zinc levels, growth attributes, yield, quality

Introduction
India is the worid's largest producers, consumers and exporter of seed spices. There are about 20 seed spices grown in India and among them cumin, fennel, coriander, fenugreek, dill seed, ajwain *etc*. are vital rabi seed spices for arid and semi arid regions of the country. Gujarat and Rajasthan together contribute more than 80 per cent of the total seed spices production in the country and thus, both the states together are known as "seed spices bowl" of India. Coriander (*Coriabdrum sativum* L.) is one of the most important spice crops having a prime position in flavouring food. It is used as medicine, oil and perfumery purpose. It is the first spice to be used by man as a common flavouring substance. It is one of the earliest spices and used by mankind Luaza *et al*. (1996) [4]. It is an annual herb; coriander plant gives two primary products that are used for flavouring purposes, the fresh green herb and the spice. Among the primary nutrients, potassium (K) is the second most important nutrient nutrient element next to nitrogen for growth and development of spices crops (Sadanandan, 1998) [8]. Potassium is known to play a vital role in photosynthesis and carbohydrate formulation in spices. It is also been shown that K play a key role in the activation of more than 60 enzyme system in plants. Potassium is necessary in young growing tissues for cell elongation and possibly for cell division. Potassium is very mobile in plants and therefore circulates freely and has vital role in maintenance of turgor pressure. It also helps in several physiological processes. It improves quality and yield of spices (Sadanandan, 1993) [7]. Among the micronutrients, zinc play vital role in plant growth and development. Zinc also catalyses the biosynthesis of indol acetic acid, acting as metal activator of the enzyme, there by ultimately increasing crop yield. Moreover, it controls the equilibrium between CO2, water and carbonic acid in plant metabolism and helps in synthesis of nucleic acids and stimulates seed formation.

Materials and methods
The experiment was conducted at Department of Agricultural Chemistry and Soil science, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* season of

2016-17. The soil of the experimental was clayey in texture and alkaline in reaction (pH of 8.0 and EC of 0.58 dS m^{-1}). The soil was low in available nitrogen (242 kg ha^{-1}), medium in available phosphorus (39.20 kg ha^{-1}), medium in available potassium (208 kg ha-1) and medium in available zinc (0.50ppm). The experiment comprised of total twenty treatment combinations in which five levels of potassium K_0, K_1, K_2, K_3 and K_4 (0, 10, 20,40 and 60 K_2O kg ha^{-1}) and four levels of zinc sulphate Z_0, Z_1, Z_2 and Z_3 (0, 10, 20 and 30 $ZnSO_4$ kg ha^{-1}) were laid out in complete randomization design having factorial concept with three replications. The fertilizer application was done with fixed doses of nitrogen at 20 kg ha^{-1} and phosphorus at 10 kg ha^{-1}. Potassium and zinc sulphate application was done according to the treatments. The nutrients of N, P, K and Zn were applied by using sources of Urea, DAP, MOP and zinc sulphate (WG 35%Zn), respectively. The experimental data recorded for growth parameters, yield attributes and yield parameters were statistically analyzed for level of significance.

Result and Discussion

Growth, yield attributes and yields

Effect of potassium

The plant height was increased significantly with increasing K levels up to 60 kg K_2O ha^{-1} (K_4) at all period of crop growth. The significantly higher plant height was reported under K_4 treatments as 20.53 and 35.91 cm over control at 60 DAS and at harvest, respectively and this treatment was statistically at par with application of K_2O @ 40 kg ha^{-1}. During 60 DAS recorded significantly higher dry matter yield (2.511 g $plant^{-1}$) with application of K_2O @ 60 kg ha^{-1} and this treatment was statistically at par with K_3 treatment at 60 DAS and at harvest stage. Dry weight of plant found significant result at harvest (6.161 g $plant^{-1}$) with application of potash 40 kg ha^{-1} which remains statistically at par with application of K_2O @ 60 kg ha^{-1}. These findings were also collaborated with Solanki *et al.* (2017) [11] coriander. The increase plant height owing to potassium application might be attributed to crucial role in meristematic growth through its effect on the synthesis of hormones. Among various plant hormones, cytokinine play important role in growth of plant to improve cell enlargement and cell elongation which results in more vegetative growth and ultimately increased the plant height. It has also a role in stomatal respiration, photosynthetic transfer, crop development etc., which increase vegetative growth and resulted in increased Dry matter yield. The application of potassium was significantly affected the seed yield of coriander. The seed yield was increased due to application of potassium up to K_4 treatment. The significantly, higher (4.819 g $plant^{-1}$) seed yield was recorded with K_4 treatment, followed by (4.754 g $plant^{-1}$) with K_3 treatment. Mishra *et al.* (2016) [6] also reported such favourable effect of K on seed yield of coriander. The maximum branches (5.332) per plant, Appreciably higher number of umbels per plant of (9.232) and the maximum numbers of umbellate per umbel (5.053) was recorded under K_4 treatment at harvest which remains statistically at par with K_3 treatment. No. of seed per umbellate was recorded higher (6.063) under the K_4 treatment (K_2O @ 60 kg ha^{-1}). The application of potassium at different levels had significant effect on test weight (14.67 g) and it was recorded higher under the K_4 treatment, which was 7.25 % higher over the control (13.67 g). This treatment was at par with K_3, K_2, and K_1 treatment. The similar trends of results in coriander were also reported by Bhoya (2008) [2] and Solanki *et al*. (2017) [11].

Effect of Zinc sulphate

A personal of data indicates that diligence of zinc sulphate recorded the significantly higher plant height was recorded under $ZnSO_4$ application @ 20 kg ha^{-1} treatments with value of 34.10 cm over control, at harvest. zinc has an effect on building up the natural auxin (IAA) and consequently activating the cell division and enlargement. Verma (1997) [12] found that the significant increase in plant height of coriander The maximum dry matter yield (6.061 g $plant^{-1}$) obtained with zinc @ 20 kg ha^{-1}, which remains statistically at par with zinc @ 30 kg ha^{-1}at harvest. Zinc is important in the synthesis of growth hormones. Such improvement under increased availability of zinc in rhizosphere might have resulted in greater uptake by the plant consequently leading to a favourable effect on various processes of plant resulted into greater meristematic activities and apical growth, thereby improving plant dry matter accumulation per plant at all the stages. Madhuri (2015) [5] reported that the application of zinc gave significant result at 60, 90 DAS and at harvest. The significantly higher (4.729 g $plant^{-1}$) seed yield was recorded with Zn_3 treatment and also at par with Zn_2 treatment. Different levels of zinc sulphate was recorded significant result in number of branches per plant at harvest which was recorded higher (5.381) with zinc sulphate application 20 kg ha^{-1} and it was statistically at par with zinc sulphate application of 30 kg ha^{-1}. The maximum number of umbels (8.909) per plant, the maximum numbers of umbellate per umbel (5.053), the maximum number of seed (6.234) per umbellate was recorded under application of zinc @ 30 kg ha^{-1} over a control. Singh (2015) [10] reported significant effect of zinc on yield attributing characters of coriander. The significantly, the higher (14.66 g) test weight was recorded with Zn_3. Aishwath *et al*. (2011) [1] found that the application of zinc was significantly increased the weight of 1000 seed of coriander.

Interaction effect of K and Zn

The interaction effect of potassium and zinc sulphate were significant in respect of plant height at harvest significantly the highest plant height (35.78) cm was registered under K_4xZn_2 treatment combinations, which were remain at par with treatment combinations of K_4xZn_3, K_3xZn_3 and K_3xZn_2, respectively and lowest plant height (25.17 cm) was recorded under K_0xZn_0 treatment combinations (Table-2). The interacting effect between potassium and zinc sulphate levels in the present investigation was recorded significant result. The higher dry matter yield of 6.94 g $plant^{-1}$ was registered under K_4xZn_2 treatment combinations, which was remained statistically at par with treatment combinations of K_4xZn_3, K_3xZn_3 and K_3xZn_2 (6.71, 6.73 and 6.67 g $plant^{-1}$), respectively and lowest dry matter (3.96 g $plant^{-1}$) was recorded under K_0xZn_0 treatment combinations (Table-2). The interaction effect between potassium and zinc sulphate were found significant on seed yield of coriander and depicted in Table-3. The highest seed yield of (5.28 g $plant^{-1}$) was found under K_4 x Zn_3 treatment combinations and lowest seed yield of 3.86 g $plant^{-1}$ was recorded under K_0 x Zn_0 treatment combinations. Sadanandan *et al.* (2005) [9] revealed that the interaction effect of K and Zn gave a positive response in spices crops. The interacting effect between potassium and zinc in the present investigation was recorded significant result. The higher number of seed (6.71) per umbellate was registered under K_4xZn_3 treatment combinations which remain statistically at par with treatment combinations of K4xZn2, K_3xZn_3 and K_3xZn_2 (6.67, 6.70 and 6.67),

respectively and lowest value (3.96) was recorded under K_0xZn_0 treatment combinations, (Table-3). Chauhan *et al.* (2013) [3] who reported that the significantly increased the number of seed per umbellate in coriander with interaction effect of potassium and zinc sulphate.

Table 1: Effect of K and Zn on plant height and dry matter yield of coriander at different period of crop growth and seed yield, yield attributes and quality parameter at harvest

Treatments	Plant height (cm)			Dry matter yield (g plant^{-1})			Seed yield (g plant^{-1})	Yield attributes				Quality parameter
	Days after sowing (DAS)			Days after sowing (DAS)				No. of branches per plant	No. of umbels per plant	No. of umbellate per umbel	No. of seeds per umbellate	1000 seed Test weight (g)
	30	60	At harvest	30	60	At harvest						
Potassium levels (kg K_2O ha^{-1})												
K_0 – 0	5.300	15.02	30.53	0.969	2.301	4.342	3.886	4.852	7.929	4.540	5.090	13.67
K_1 – 10	5.375	16.74	32.10	0.972	2.392	5.343	4.302	4.989	8.058	4.613	5.343	14.22
K_2 – 20	5.388	17.61	32.33	0.976	2.432	5.755	4.639	5.219	8.347	4.733	5.672	14.29
K_3 – 40	5.439	19.98	33.93	0.977	2.483	6.161	4.754	5.317	9.117	4.962	6.002	14.65
K_4 – 60	5.431	20.53	35.91	0.973	2.511	6.064	4.819	5.332	9.232	5.053	6.063	14.67
S. Em.±	0.030	0.113	0.218	0.006	0.015	0.069	0.034	0.074	0.137	0.051	0.058	0.23
C.D. at 5%	NS	0.347	0.641	NS	0.046	0.200	0.096	0.213	0.392	0.145	0.166	0.65
Zinc levels (kg $ZnSO_4$ ha^{-1})												
Zn_0 – 0	5.342	17.83	31.22	0.969	2.410	4.925	4.122	4.909	7.993	4.368	4.858	13.77
Zn_1 – 10	5.364	17.87	32.78	0.972	2.409	5.106	4.384	4.987	8.398	4.736	5.238	14.19
Zn_2 – 20	5.328	17.92	34.10	0.975	2.436	6.061	4.685	5.381	8.847	4.979	6.207	14.58
Zn_3 – 30	5.408	18.20	33.49	0.976	2.442	6.041	4.729	5.290	8.909	5.039	6.234	14.66
S. Em.±	0.029	0.100	0.201	0.005	0.013	0.062	0.030	0.067	0.123	0.045	0.052	0.20
C.D. at 5%	NS	NS	0.579	NS	NS	0.186	0.086	0.190	0.351	0.130	0.149	0.58
C.V.%	1.11	1.25	2.36	1.28	1.23	4.31	2.59	5.02	5.57	3.68	3.57	5.54
Interaction	-	-	1.28	-	-	0.39	0.19	NS	NS	NS	0.33	NS

Table 2: Interaction effect of K and Zn on plant height and dry matter yield of coriander at harvest

Treatments (kg ha^{-1})	Plant height at harvest(cm)					Dry matter yield at harvest (g plant^{-1})				
	K_0 -00	K_1- 10	K_2 -20	K_3 - 40	K_4 - 60	K_0 -00	K_1- 10	K_2 -20	K_3 - 40	K_4 - 60
Zn_0 – 00	25.17	31.20	32.22	31.88	34.08	3.96	4.82	5.21	5.20	5.44
Zn_1 –10	31.25	31.29	32.31	33.28	34.32	3.90	4.92	5.26	5.77	5.67
Zn_2 –20	33.33	33.35	33.39	35.09	35.78	4.71	5.85	6.14	6.67	6.94
Zn_3 –30	32.36	32.56	31.41	35.48	35.62	4.79	5.79	6.18	6.73	6.71
S.Em. ±	0.45					0.14				
C.D. at 5 %	1.28					0.39				

Table 3: Interaction effect of K and Zn on seed yield and No. of seed per umbellet of coriander at harvest

Treatments (kg ha^{-1})	seed yield (g plant^{-1})					No. of seed per umbellet				
	K_0 -00	K_1- 10	K_2 -20	K_3 - 40	K_4 - 60	K_0 -00	K_1- 10	K_2 -20	K_3 - 40	K_4 - 60
Zn_0 – 00	3.86	3.87	4.27	4.29	4.32	3.96	4.82	5.10	5.20	5.21
Zn_1 –10	3.87	4.42	4.45	4.58	4.59	4.90	4.92	5.26	5.44	5.67
Zn_2 –20	3.91	4.45	4.91	5.07	5.08	5.71	5.85	6.14	6.67	6.67
Zn_3 –30	3.91	4.46	4.93	5.08	5.28	5.79	5.79	6.18	6.70	6.71
S.Em. ±	0.07					0.12				
C.D. at 5 %	0.19					0.33				

Conclusion

Based on the results it can be concluded that the application of potassium @ 60 kg K_2O ha^{-1} enhanced growth, yield, yield attributes and quality parameter of coriander. The application of zinc sulphate @ 30 kg ha^{-1} significantly superior in respect of growth, yield and yield attributes and quality parameter of coriander. The combined application of potassium @ 60 kg ha^{-1} and zinc sulphate @ 30 kg ha^{-1} was registered highest seed yield of coriander. It was conceived to take benefit of potassium and zinc's positive effect on vegetative and reproductive phase of coriander.

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