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Effect of water soluble fertilizers on yield and content and uptake of nutrient in coriander (*Coriandrum sativum* L.)

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Abstract
A field experiment entitled "Effect of water soluble fertilizers on yield and content and uptake of nutrient in coriander (*Coriandrum sativum* L.)" was carried out under medium black clayey soil and slightly alkaline soil in reaction with pH 7.9 and EC 0.49 dSm^{-1} during *rabi* season of 2016-17 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. The experiment consisting of 10 treatment combinations, comprising (T_1) control, (T_2) RDF + water spray, (T_3) RDF + WSF (19:19:19), (T_4) RDF + WSF (13:40:13), (T_5) RDF + WSF (12:61:00), (T_6) RDF + WSF (00:52:34), (T_7) RDF + WSF (28:28:00), (T_8) RDF + WSF (00:00:50:17.5 S), (T_9) RDF + Urea and (T_{10}) RDF + KNO_3. Foliar spray of water soluble fertilizers (WSF), urea and KNO_3 was done @ 2 per cent at 30, 45 and 60 days after sowing. Recommended dose of fertilizers was applied at the time of sowing. These treatments were evaluated under randomized block design with 3 replications. The results of experiment indicated significant improvement in yield attributes *viz*., number of umbels per plant, number of umbellets per umbel, number of seed per umbel and seed, stover and biological yields was observed with the application of RDF 20:10 kg NP ha^{-1} + foliar application of WSF (19:19:19) @ 2 per cent over control and RDF + water spray. Significantly highest nitrogen content was obtained with the application of RDF + urea, phosphorus content with RDF + WSF (12:61:00) and potassium content with RDF + KNO_3 in seed and stover, respectively while uptake of nitrogen, phosphorus and potassium was significantly higher with the application of RDF 20:10 kg NP ha^{-1} + WSF (19:19:19) as compared to control. Significantly higher protein content in seed was recorded with the application of RDF 20:10 kg NP ha^{-1} + urea over control.

Keywords: Water soluble fertilizer, yield, quality, nutriant and coriander

Introduction
India is known for its seed spices since ancient times. The seed spices are a group which denotes all those annual whose dried fruits or seeds used as spices. The seed spices mostly used in pulverized state, primarily for seasoning or garnishing food and beverages. They are characterized by pungency, strong odour, sweet or bitter taste. Spices play an important role in human dietary because of their agreeable flavour and aroma to food and add greatly to the pleasure of eating (Ayaduraj, 1966) [4]. India is the world'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 (Meena *et al.* 2017) [9].

Coriander (*Coriandrum sativum* L.) Is one of the earliest spices and used by mankind (Luaza *et al.* 1996) [8]. Coriander belongs to family *Apiaceae* (*Umbelliferae*) and possess 2n=22 chromosomes with cross-pollination as mode of reproduction. The seed type is dicot and having epigeal germination. The term coriander came from the Greek word, koris, meaning bedbug because the leaves and green fruit of this plant have an odour similar to bedbugs. It is commonly known as "Dhania" or "Dhana". It is an important spice crop having a prime position in flavouring food. Besides the essential oil, the seed contains 16.1% fatty oil, 14.1% protein, 21.6% carbohydrate, 32.6% fibres, 11.2% moisture and 4.4% mineral matters and coriander leaves are very rich in vitamin A and vitamin C (Singh *et al.* 2017) [13]. The whole plant including stem, leaves and seeds have pleasant aromatic odour. The crop is grown both for tender leaves and seeds; tender leaves are extensively used for flavouring curries, soups,

chutneys, sauce and garnishing several food preparations. The seed has been immensely used as condiment in the preparation of curry powder, soups, pickling, sausages and for flavoring cakes, cookies and liquor, for preparing value added products such as coriander powder, dhana dal, besides used in several medicinal preparations. Coriander oil is a valuable ingredient in perfume industry as well as oleoresin extraction. The fruits and the oil are used as a flavouring agent to cover the test or correct the nauseating or gripping quality of other medicines. They are used medicinally for a number of purposes, particularly to relieve flatulence (Bhuiyan *et al*. 2009) [5]. The aromatic odour and taste of coriander fruits is due to presence of essential oil called 'coriandrol' (Pruthi, 1976) [12].

Coriander is native of Mediterranean Region and commercial grown in India, Morrocco, Russia, Hungary, Poland, Romania, Mexico, Turkey and USA. In India, coriander is mainly grown in the states of Rajasthan, Gujarat, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and Haryana. Total area under the crop in India is about 674 thousand hectares with an annual production of 883 thousand MT having the productivity of 1310.09 kg/ha (Anonymous, 2016-17a) [2]. In Gujarat, it occupies an area of 121199 hectares and production of 189518.03 tonnes with average productivity of 1563.69 kg/ha (Anonymous, 2016-17b) [3].

Foliar nutrition is designed to eliminate the above problems particularly with respect to macro nutrients. Now a day's application of N, P and K in different ratios through foliar sprays is being recognized as an important method of fertilization in modern agriculture. Application of nutrients through foliar spray at appropriate stages of growth becomes important for their utilization and better performance of the crop (Anandhakrishnaveni *et al*. 2004) [1]. Foliar application of nutrients is an important crop management strategy in maximizing crop yields. It can supplement soil fertilization. When nutrients are applied to soil, they absorbed by plant roots and translocated to aerial parts. In case of foliar application, the nutrients penetrate the cuticle of the leaf or the stomata and then enter the cells facilitating easy and rapid utilization of nutrients. Hence, crop response occurs in short time in foliar application compared to soil application. Foliar fertilization is the application of foliar sprays of one or more mineral nutrients to plants to supplement traditional soil applications of fertilizers. Foliar fertilization is used as a means of supplying supplemental doses of macro and micro-nutrients, plant hormones, stimulants and other beneficial substances. It is also determined that during crop growth supplementary foliar fertilization increase plants mineral status and improve crop yields (Kolota and Osinska, 2001) [7]. Foliar application could be considered one of the most common methods, which used to deliver the needed nutrients to plants in adequate concentrations and improve plant nutritional status as well as increase the crop yield and its quality (Smoleń, 2012) [14]. Foliar fertilization has the ability to improve the efficiency and rapidity of utilization of a nutrient urgently required by the plant for maximum growth and yield (Oosterhuis, 1999) [11].

Materials and Methods

An experiment was conducted at instructional farm, Junagadh Agricultural University, during *rabi* seasons of 2016-17. The experiment site is situated in South Saurashtra Agro-climatic region of Gujarat. The soil was medium clayey in texture and slightly alkaline in reaction with pH (7.9) and EC (0.49 dSm^{-1}), low in available N was carried out with Alkaline $KMnO_4$ method by Subbaiah and Asija, 1956 (242.60 kg ha^{-1}), medium in available P (34.70 kg ha^{-1}) and available K (269.00 kg ha^{-1}). The available P and K were carried out with Olsen's method and Flame Photometric method by Olsen *et al.*, 1954 and Jackson, 1974. The experiment were laid out in randomized block design with three replications and consisting of 10 treatment combinations, comprising (T_1) control, (T_2) RDF + water spray, (T_3) RDF + WSF (19:19:19), (T_4) RDF + WSF (13:40:13), (T_5) RDF + WSF (12:61:00), (T_6) RDF + WSF (00:52:34), (T_7) RDF + WSF (28:28:00), (T_8) RDF + WSF (00:00:50:17.5 S), (T_9) RDF + Urea and (T_{10}) RDF + KNO_3. Foliar spray of water soluble fertilizers (WSF), urea and KNO_3 was done @ 2 per cent at 30, 45 and 60 days after sowing. Recommended dose of fertilizers was applied at the time of sowing. The coriander variety 'Gujarat Coriander-2' was sown at 30 cm row to row and 10 cm plant to plant spacing. The crop was fertilized with recommended dose of fertilizers 20-10-0 kg N-P_2O_5-K_2O ha^{-1}. The crop was raised as per the recommended package of practices.

Results and Discussion

Effect on yield attributes and yields

The critical examination of data (Table 1) showed that application of treatment (T_3) recommended dose of fertilizer 20:10 kg NP ha^{-1} + foliar application of WSF (19:19:19) at 30, 45 and 60 DAS recorded significantly higher number of umbels per plant (13.59), number of umbellets per umbel (5.44), number of seeds per umbel (27.60), seed yield (1888 kg/ha), stover yield (2110 kg/ha), biological yield (3998 kg/ha) over control and remained at par with treatments T_4 and T_7 that received foliar application of water soluble fertilizer 13:40:13 and 28:28:00 in case of of umbel lets per umbel and also with treatment (T_4) RDF + WSF 13:40:13, (T_6) RDF + 00:52:34 and (T_{10}) RDF + KNO_3 in case of number of seeds per umbel, and also with WSF 13:40:13 (T_4) in case of stover and biological yield. Foliar spray of WSF having all the three major nutrients also enhances the photosynthetic activity leading to production and accumulation of more carbohydrates and auxins which favour retention of more flowers ultimately leading to more number of reproductive parts per plant. The increased yield attributes with increased concentration of WSF might also be due to higher chlorophyll content with enhanced photosynthetic activity and higher uptake of nutrients and thereby increased plant dry matter production which might have improved the seed development and number of seeds per umbel and finally contributed for higher productivity.

Table 1: Effect of different water soluble fertilizers on yield attributes and yields of coriander

Treatments	Umbels/plant	Umbellets/umbel	Seeds/umbel	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
T_1-Control	7.86	3.97	22.50	1204	1506	2710
T_2-RDF + water spray	10.28	4.01	22.80	1423	1688	3111
T_3-RDF + WSF (19:19:19)	13.59	5.44	27.60	1888	2110	3998
T_4-RDF + WSF (13:40:13)	12.04	4.92	26.92	1643	1911	3554
T_5-RDF + WSF (12:61:00)	10.82	4.68	24.19	1618	1744	3362
T_6-RDF + WSF (00:52:34)	10.58	4.60	25.74	1615	1715	3330
T_7-RDF + WSF (28:28:00)	11.14	4.82	24.35	1641	1797	3438
T_8-RDF + WSF (00:00:50:17.5 S)	10.35	4.55	24.08	1538	1658	3196
T_9- RDF + Urea	11.09	4.69	24.02	1520	1798	3318
T_{10}- RDF + KNO_3	10.41	4.48	26.34	1554	1580	3134
S. Em ±	0.51	0.24	1.08	81	105	155
CD (P=0.05)	1.50	0.72	3.21	242	311	460
CV (%)	8.09	9.14	7.53	9.00	10.36	8.09

Effect on protein content

The data regarding protein content in seed furnished in Table 4.2 indicated that foliar application of urea @ 2% at 30, 45 and 60 DAS along with recommended dose of fertilizer 20:10 kg NP ha^{-1} (T_9) recorded significantly the highest protein content in seed (18.15%) and was remained statistically equivalent with the application of RDF + WSF 28:28:00 (T_7) and RDF + WSF 19:19:19 (T_3). Since, the higher nitrogen supply through foliar application at different crop growth stages resulted in enhancement of protein content of seeds, suggesting that hydrocarbons synthesized during photosynthetic process are diverted to form more of proteins.

Table 2: Effect of different water soluble fertilizers on content and uptake of nitrogen by coriander

Treatments	Protein content in seed (%)	Nitrogen content (%)		Nitrogen uptake (kg/ha)	
		Seed	Stover	Seed	Stover
T_1- Control	14.59	2.33	1.15	28.12	17.29
T_2-RDF + water spray	15.28	2.44	1.28	34.66	21.61
T_3-RDF + WSF (19:19:19)	17.42	2.79	1.77	52.58	37.36
T_4-RDF + WSF (13:40:13)	16.72	2.67	1.71	43.98	32.70
T_5-RDF + WSF (12:61:00)	16.34	2.61	1.67	42.44	29.04
T_6-RDF + WSF (00:52:34)	16.15	2.58	1.61	41.71	27.61
T_7-RDF + WSF (28:28:00)	17.53	2.80	1.79	46.03	32.07
T_8-RDF + WSF (00:00:50:17.5 S)	15.84	2.53	1.53	38.94	25.38
T_9-RDF + Urea	18.15	2.90	1.85	44.13	33.27
T_{10}-RDF + KNO_3	16.25	2.60	1.65	40.45	26.10
S. Em ±	0.25	0.04	0.03	2.48	1.81
CD (P=0.05)	0.74	0.12	0.09	7.36	5.37
CV (%)	2.64	2.64	3.18	10.39	11.09

Effect on content and uptake of nutrient

The data furnished in Table 4.2 and Table 4.3 indicated that significantly highest nitrogen content in seed (2.90%) and stover (1.85%) were obtained with the application of RDF + urea which remained statistically equivalent with the treatment (T_7) RDF + WSF 28:28:00 and (T_3) RDF + WSF 19:19:19, significantly highest phosphorus content in seed (0.350%) and stover (0.261%) recorded with RDF + WSF (12:61:00) which remained at par with treatments (T_6) RDF + WSF 00:52:34, (T_4) RDF + WSF 13:40:13 and (T_7) RDF + WSF 28:28:00 and significantly highest potassium content in seed (0.733%) and stover (1.284%) recorded with RDF + KNO_3 which is remained at par with treatment (T_8) RDF + WSF (00:00:50:17.5 S), (T_6) RDF + WSF 00:52:34 and (T_3) RDF + WSF (19:19:19) in case of potassium content in seed and with treatments (T_8) RDF + WSF (00:00:50:17.5 S), (T_6) RDF + WSF (00:52:34), (T_3) RDF + WSF (19:19:19) and (T_4) RDF + WSF (13:40:13) in case of potassium content in stover, while uptake of nitrogen by seed (52.58 kg/ha) and stover (37.36 kg/ha), phosphorus uptake by seed (6.212 kg/ha) and stover (4.988 kg/ha) and potassium uptake by seed (13.560 kg/ha) and stover (26.589 kg/ha) were significantly higher with the application of RDF 20:10 kg NP ha^{-1} + WSF (19:19:19) as compared to control but remained at par with treatment (T_7) RDF + WSF 28:28:00 in case of nitrogen uptake by seed and with RDF + WSF 13:40:13 (T_4), RDF + urea (T_9) and RDF + WSF 28:28:00 (T_7) in case of nitrogen uptake by stover and also remained statistically at par with RDF + WSF 12:61:00 (T_5), RDF + WSF 13:40:13 (T_4), RDF + WSF 00:52:34 (T_6) and RDF + WSF 28:28:00 (T_7) in case of phosphorus uptake by seed and stover. Increased uptake of nitrogen, phosphorus and potassium is the cumulative effect of increased nutrient concentration and also due to improved nutritional environment might have favourably influenced carbohydrate metabolism which in turn increased the uptake.

Table 3: Effect of different water soluble fertilizers on content and uptake of phosphorus and potassium by coriander

Treatments	Phosphorus content (%)		Phosphorus uptake (kg/ha)		Potassium content (%)		Potassium uptake (kg/ha)	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
T_1- Control	0.280	0.185	3.381	2.771	0.607	1.080	7.288	16.220
T_2- RDF + water spray	0.291	0.204	4.147	3.438	0.643	1.193	9.104	20.151
T_3- RDF + WSF (19:19:19)	0.328	0.236	6.212	4.988	0.719	1.259	13.560	26.589
T_4- RDF + WSF (13:40:13)	0.338	0.251	5.564	4.803	0.697	1.251	11.451	23.928
T_5- RDF + WSF (12:61:00)	0.350	0.261	5.657	4.534	0.687	1.229	11.115	21.379
T_6- RDF + WSF (00:52:34)	0.341	0.257	5.529	4.397	0.722	1.267	11.645	21.720
T_7- RDF + WSF (28:28:00)	0.334	0.248	5.484	4.437	0.694	1.230	11.383	22.094
T_8- RDF + WSF (00:00:50:17.5 S)	0.303	0.226	4.671	3.755	0.728	1.280	11.187	21.183
T_9- RDF + Urea	0.318	0.232	4.847	4.166	0.696	1.231	10.581	22.155
T_{10}- RDF + KNO_3	0.307	0.230	4.775	3.633	0.733	1.284	11.430	20.283
S. Em ±	0.006	0.005	0.249	0.273	0.012	0.017	0.583	1.207
CD (P=0.05)	0.017	0.015	0.740	0.812	0.035	0.050	1.732	3.585
CV (%)	3.09	3.66	8.59	11.57	2.92	2.36	9.29	9.69

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