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Research Article

RESPONSE OF EXOTIC VEGETABLES TO PLANT SPACING, FERTILIZATION, AND INSECT PEST MANAGEMENT UNDER SUBTROPICAL REGION OF WESTERN HIMALAYAS OF HIMACHAL PRADESH

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ABSTRACT

Objective: The study was conducted with the objective to study the effect of different plant spacing and fertilizer treatments on the yield and growth parameters of exotic vegetables.

Methods: The study was carried out at the experimental farm of Regional Horticultural Research and Training Station Jachh (32° 16' N latitude and 75°51' E longitude, 440 m above mean sea level) during the year 2021–22. The experiment was laid out in a factorial randomized complete block design with three replications. The treatments were comprised of three levels of fertilizers (120, 100, 75% RDF) and two levels of spacing.

Results: The observations revealed significant variations in the fresh yield of Kale, Parsley, and Celery in response to different fertilizer doses and plant spacing. Specifically, the fresh yield of Kale, Parsley, and Celery showed significant improvements with higher levels of fertilization (F1) and narrow plant spacing (S2). In addition, the number of leaves per plant increased with higher fertilizer doses but did not vary significantly across different spacing levels in all three crops. While the leaf length and width of Kale were not significant, the leaf length of Parsley and Celery varied significantly with increasing fertilizer doses. Furthermore, among the three crops studied, Kale was observed to be infested by aphids, particularly *Brevicoryne brassicae*, during the crop period. The application of imidacloprid (0.5 ml/L) and chlorantraniliprole (0.4 ml/L) demonstrated effective management of this pest, providing better results for pest control.

Conclusion: Fresh yield of kale, parsley, and celery increased under high level of fertilization and narrow spacing as well. Moreover, imidacloprid and chlorantraniliprole can be utilized for the management of cabbage aphids in Kale crop.

Keywords: Aphids, Celery, Kale, Parsley, Plant density, Yield.

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INTRODUCTION

Exotic vegetables are species which are imported and not common in traditional crop production of a country. Growing of exotic vegetable is a more profitable venture as the exotic vegetables market is growing at the rate of 15–20% per annum and is increasing day by day since India is importing more than 85% exotic vegetables (Rao and Sasanka, 2015). Exotic vegetables can be consumed raw as salad or cooked and mostly used in hotel industries for making continental cuisines. The exotic vegetables are not only tasty but are powered with antioxidants and offer numerous health benefits. These are rich sources of important minerals (K, Fe, and Ca), Vitamins (A, C, E, K, and riboflavin), and fiber sources with lower calories. These can prevent nutritional deficiencies and reduce the risk of obesity and chronic disease including diabetes, cardiovascular diseases, and cancer. Exotic vegetables are grown in a few places in India including Maharashtra, Uttarakhand, Bangalore, Jammu Kashmir, and Himachal Pradesh (Rao and Sasanka, 2015). Some of the exotic vegetables grown in HP are broccoli, lettuce, leek, chinese cabbage, snow pea, asparagus, parsley, kale, etc.

Kale (*Brassica oleracea* L. var. *acephala*) is a green leafy vegetable in Brassicaceae family. Kale plant is a cool season annual crop and its size and nutritional variation depend on the variety and growing conditions (Lefsrud *et al*., 2007). Kale leaves are generally consumed as fresh and unprocessed as salad or cooked and used as garnish and they are usually sold in fresh, canned and frozen forms (Fahey, 2003).

Parsley (*Petroselinum crispum*) is also one of the most popular garden herbs belonging to Umbelliferae family. Parsley is widely cultivated on a commercial scale for its strong aromatic edible leaves commonly used for garnishing and seasoning (Kmiecik and Lisiewska, 1999) and essential oils (Mylavarapu and Zinati, 2009). The Vitamin C-rich leaves are used fresh, dried/frozen, incorporated in salads, and used as an ingredient spice to add flavor to soups, stews, and sauces. Parsley is a good source of carotene (pro-vitamin A), Vitamins B1, B2, and C as well as iron and other minerals (Osman and El-Wahab, 2009). The herb is reported to possess many medicinal uses that include antispasmodic carminative and diuretic; since it contains essential oil of 0.3% in leaf and 2–7% in the fruit (Midrad, 2011; Hussain *et al*., 2020). Celery (*Apiumgraveolens* L.) is another widely cultivated herb that belongs to Umbelliferae family and is used extensively for garnishing and seasoning foods and essential oil (Ahmed, 2017) The stalks or petioles are eaten as salad, in soup, sauce, puree, fried and spiced curry. Celery is mainly consumed for its aroma and flavor which is due to Apiin a glycoside present in leaves and celeriac storage roots and used in medicinal, household, cosmetic and fragrance (Hussain *et al*., 2020; Rashed and Nahed, 2002).

Fertilization is one of the most important factors limiting the productivity of plants that influences growth, quality, and reproductive development of plant. It is not enough for plants to rely solely on nutrients from the soil. Therefore, plants need to be given additional nutrients from outside, namely, in the form of fertilizers (Prihmantoro,

Table 1: Treatment combinations

S. No.	Kale	Parsley	Celery
Levels of fertilizers			
F_1	120% RDF+FYM @ 20 t/ha	120% RDF+FYM @ 20 t/ha	120% RDF+FYM @ 20 t/ha
F_2	100% RDF+FYM @ 25 t/ha	100% RDF+FYM @ 25 t/ha	100% RDF+FYM @ 25 t/ha
F_3	75% RDF+FYM @ 30 t/ha+V.C @ 5 t/ha	75% RDF+FYM @ 30 t/ha+V.C @ 5 t/ha	75% RDF+FYM @ 30 t/ha+V.C @ 5 t/ha
Spacing			
S_1	60×40 cm	45×45 cm	60×30 cm
S_2	45×45 cm	30×30 cm	45×30 cm

2001). Efforts to increase the efficiency of fertilizer use can be pursued through the principles of right dosage, right method, on time application, and balanced according to plant needs (Novizan, 2002). Furthermore, fertilizers are materials and nutrients that are given or added to plants with the intention of increasing the nutrients for the soil (Munawar, 2011). Lack of farmer knowledge regarding the type and amount of fertilizer dosage needed by plants is also a problem which will result in low production of large-scale unified crops (Lingga, 2004).

Various insect pests damage Kale crops all over the world, namely, whitefly (*Bemisiatabaci*), diamondback moth (*Plutella xylostella*), black cutworm (*Agrotisipsilon*), and aphids (*Brevicorynebrassicae* and *Myzuspersicae*). Among these, the cabbage aphid *Brevicorynebrassicae* occurs quite significantly under a chemical fertilization regime as compare to organic fertilizers (Cividanes *et al*., 2020). It causes damage by sap-sucking which eventually leads to wilting and wrinkling of leaves along with the transmission of viral diseases (Luciana *et al*., 2023). The application of insecticides is considered an effective strategy for the management of this pest. However, the frequent application of these pesticides may lead to insecticide resistance and failure of chemical control strategy (Ahmad and Akhtar, 2013). Plant spacing and supply of judicial fertilizers play a vital role to produce vegetables. Hence, the present experiment was undertaken to assess the response of exotic vegetables with respect to planting density and different levels of fertilization.

METHODS

The study was carried out at the experimental farm of Regional Horticultural Research and Training Station Jachh (32º 16' N latitude and 75º51' E longitude, 440 m above mean sea level) during the year 2021–22. The average annual rainfall of the place is about 1500 mm. The surface soil (0–0.15 m) of the experimental field was neutral in nature (7.2), low in available N (219.5 kg/ha), high in available P (70.2 kg/ha), and medium in available K (215.5 kg/ha). Kale *cv* Pusa K-64, Parsley *cv* Mosscurled, and Celery *cv* FHE were transplanted during *Rabi* season in a plot size of 4 m^2. The treatments were comprised of three levels of fertilizers and two levels of spacing. The details of treatments are mentioned as below:

The experiment was laid out in a factorial randomized complete block design with three replications. The fertilizer doses for Kale, namely, 120% RDF (180:91:47, 150:76:39 and 112.5:57:29), Parsley (72:48:36, 60:40:30 and 45:30:22.5), and Celery (120:60:36, 100:50:36 and 75:37.5:22.5). Whole quantity of FYM, phosphorus, potassium, and half nitrogen was applied at the time of transplanting and remaining nitrogen was applied as spilt doses after one month of transplanting. All the intercultural operations and irrigation were done as and when required. The fresh marketable yield of Kale, Parsley, and Celery was recorded at harvest and expressed in q/ha.

The management of aphid (*Brevicorynebrassicae*) in the kale crop was also investigated in the field by application of seven insecticides, namely, Monocrotophos, Imidacloprid, Chlorantraniliprole, Profenphos, Cypermethrin, and Chlorpyriphos at standard dosage. The precount was recorded before spray by counting number of aphids per leaf. Corrected mortality or percent reduction over control (PROC) was calculated as per the formula (Henderson and Tilton, 1955).

Table 2: Effect of plant spacing and fertilizer levels on yield and growth parameters of Kale

S. No.	Fresh Yield (q/ha)	No. of leaves/ plant	Leaf length (cm)	Leaf width (cm)
Spacing				
S_1	147.08	10.56	25.23	9.83
S_2	187.77	10.21	25.76	9.64
SE (m)	3.070	0.194	0.541	0.391
$CD_{0.05}$	9.672738	NS	NS	NS
Levels of fertilizers				
F_1	186.53	10.96	26.16	9.94
F_2	168.38	10.21	25.26	9.70
F_3	147.37	10.00	25.06	9.56
SE (m)	3.760	0.238	0.663	0.479
$CD_{0.05}$	11.85	0.75	NS	NS
Interaction effect (S*F)				
SE (m)	5.3	0.3	0.9	0.7
$CD_{0.05}$	16.8	NS	NS	NS

$$\text{PROC} = \left(1 - \frac{ninCtrlbeforeTreatment \times ninTaftertreatment}{ninCtrlaftertreatment \times ninTbeforetreatment}\right) \times 100$$

Where n = Insect Population; T = Treated Sample; Ctrl = Control

RESULTS AND DISCUSSION

The observations recorded revealed that fresh yield of Kale, Parsley, and Celery varied significantly with an increase in fertilizer doses and plant spacing (Tables 2 and 3). Fresh yield of kale (186.53 q/ha), parsley (109.19 q/ha), and celery (218.35 q/ha) was found significantly superior under high level of fertilization (F_1) and higher spacing (S_2) as well (Tables 2 and 3). The main reason for maximum yield per hectare in closer plant spacing may be due to higher plant population per unit area. Increased dose of NPK fertilizers and closer spacing produced a higher yield of Indian spinach (Alam *et al*., 2008). However, the number of leaves per plant increased with an increase in fertilizer dose but not significant under different spacing levels in all three crops. The leaf length and width of Kale were found to be non-significant whereas in case of Parsley and Celery leaf length significantly varied with an increase in fertilizer dose. In Parsley and Celery, leaf lengths under F_2 and F_3 were significantly at par with each other.

Under interaction effect, the yield was found to be significant in Kale, Parsley, and Celery whereas it was not significant in case of other growth parameters. The results clearly show that with increase in fertilizer dose and plant density increases the fresh yield of Kale, Parsley, and Celery. However, yield-related parameters were not significant under different plant spacing so more yield can be achieved with higher plant density. The closer spacing of Broccoli (30 cm × 30 cm) attained significantly maximum plant height at transplanting (21.90 cm), at 45 DAT (39.35 cm), and at harvest (57.67 cm), minimum number of days taken for head initiation (61.48) and head harvest (81.37), maximum yield per plot (5.73 kg) and yield per hectare (219.36 q) (Tejaswini *et al*., 2018). The overall yield/ha of onion was the highest (17.69 t/ha) at the closest spacing and the lowest (9.51 t/ha) was at the widest spacing (Ngullie *et al*., 2017).

Table 3: Effect of plant spacing and fertilizer levels on yield and growth parameters of Parsley and Celery

S. No.	Parsley			Celery		
	Fresh Yield (q/ha)	No. of leaves/plant	Leaf length (cm)	Fresh Yield (q/ha)	No. of leaves/plant	Leaf length (cm)
Spacing						
S_1	58.10	9.04	20.32	151.26	9.71	23.86
S_2	110.52	9.28	18.31	182.56	9.65	22.93
SE (m)	2.549	0.221	0.675	1.459	0.231	0.368
$CD_{0.05}$	8.03	NS	NS	4.59	NS	NS
Levels of fertilizers						
F_1	109.19	9.85	20.79	218.35	10.53	24.68
F_2	84.47	8.75	20.00	163.35	9.06	22.35
F_3	59.27	8.88	17.15	119.04	9.44	23.14
SE (m)	3.121	0.270	0.827	1.787	0.283	0.451
$CD_{0.05}$	9.84	0.85	2.60	5.63	0.89	1.42
Interaction effect (S*F)						
SE (m)	4.4	0.4	1.2	2.5	0.4	0.6
$CD_{0.05}$	13.9	NS	NS	8.0	1.3	NS

Table 4: Effect of different pesticide applications on population of *Brevicorynebrassicae* infesting Kale crop

Treatment	Formulation (Trade Name)	Dosage	Precount (Aphids/Leaf)	Percent reduction over control (Mean±SD)		
				3 days	7 Days	15 days
Monocrotophos	Monodhan 36 SL	1.0 ml/Lt	26.67	77.70±5.67	79.87±3.48	70.41±4.02
Imidacloprid	Mantra 17.8 SL	0.5 ml/Lt	29.33	86.60±6.78	91.87±1.83	88.01±3.46
Chlorantraniliprole	Coragen 18.5 SC	0.4 ml/Lt	28.33	83.92±5.36	90.46±3.58	90.74±3.05
Profenphos 40+Cypermethrin 4	Rocket 44 EC	1.0 ml/Lt	29.67	80.43±5.61	80.93±3.61	79.38±3.01
Cypermethrin	Cyperhit 25 EC	1.0 ml/Lt	26.33	62.74±3.84	69.32±4.10	65.55±2.78
Chlorpyriphos	Care 50 EC	1.5 ml/Lt	27.67	78.74±3.31	79.33±3.51	72.52±1.40
$CD_{0.05}$			NS	9.36	5.88	4.61

Further, infestation of insect-pests was also observed during the crop growth period. The infestation of aphid (*Brevicorynebrassicae*) was observed mainly in the Kale crop whereas; the infestation was negligible in Parsley and Celery. To manage the aphid population in Kale crop, seven insecticides, namely, Monocrotophos, Imidacloprid, Chlorantraniliprole, Profenphos, Cypermethrin, and Chlorpyriphos were tested in the field at standard dosage (Table 4). The results revealed that after 3 days of spray, application of Imidacloprid caused maximum reduction (86.60%) in aphid population which was significantly at par with all other treatments except cypermethrin (62.74%). Similarly, Imidacloprid and Chlorantraniliprole showed significantly better control, that is, 91.87 and 90.46% reduction over control than other insecticides after 7 days of spray, whereas cypermethrin showed the minimum population reduction, that is, 69.32%. The effect of Chlorantraniliprole and Imidacloprid was also long lasting with significantly maximum reduction, that is, 90.74 and 88.01% reduction over control after 15 days of spray.

Imidacloprid has been observed to be potent against cabbage aphids in Egypt with 81.6% reduction; however, it was also lethal to its parasitoids (Dakhli *et al*., 2023). Similarly, sprays with imidacloprid on canola crop in Iran led to more than 90.0% mortality of *B. brassicae* after 3, 7, and 15 days (Keyhanian *et al*., 2021). However, the results of the present findings were in contrast with those observed under laboratory conditions on Oilseed Rape, *Brassica Napus*in who found that Cypermethrin was more effective than Imidacloprid (Hira *et al*., 2022). Similarly, under laboratory conditions that imidacloprid and cypermethrin caused 90.0 and 73.33% aphid mortality after 72 h of treatment whereas, Chlorantraniliprole application caused only 63.33% mortality by leaf spray method (Thapa and Shrestha, 2022). The difference in the response of cabbage aphid against these chemicals may be attributed to differences in the field and laboratory conditions as well as the difference in standard dosage applied.

CONCLUSION

Fresh yield of kale, parsley, and celery increased under high level of fertilization and narrow spacing as well. However, yield-related parameters were not significant under different plant spacing so more yield can be achieved with higher plant density. Moreover, imidacloprid and chlorantraniliprole can be utilized for management of cabbage aphids in Kale crop.

AUTHORS CONTRIBUTION

Conceptualization: Renu and Dharminder; Methodology: Renu, Dharminder, VGS; Writing: Renu, VGS; Review and Editing: Renu, Anil, Anurag, Rajesh, and Vipan.

CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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