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Optimization of yield and quality of hull-less seeded pumpkin (*Cucurbita pepo* var. *styriaca*) through foliar application

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Abstract

The present investigation was conducted during the spring 2021 and 2022 at Vegetable Research Farm, Punjab Agricultural University, Ludhiana for optimization of yield and quality of hull-less seeded pumpkin (*Cucurbita pepo* var. *styriaca*) through foliar applications. The experiment was laid down in randomized complete block design with thirteen treatments *viz*., T1 (control-water spray), T2 ($ZnSO_4$ @ 0.5%), T3 ($MgSO_4$ @ 0.5%), T4 (KNO_3 @ 0.5%), T5 (B @ 0.5%), T6 ($ZnSO_4$ @ 1.0%), T7 ($MgSO_4$ @ 1.0%), T8 (KNO_3 @ 1.0%), T9 (B @ 1.0%), T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%), T11 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 1.0%), T12 (Salicylic acid @ 100ppm) and T13 (Salicylic acid @ 200 ppm), replicated thrice. All thirteen foliar treatments exhibited significant influence on horticultural yield and quality traits of hull-less seeded pumpkin cv. PAU Magaz Kadoo-1. Among horticultural traits, maximum vine length was observed in T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) while, salicylic acid @ 200 ppm (T13) gave highest leaf length, leaf width and petiole length. Minimum days to 50 % male and female flowering as well as harvest were observed with foliar application of $ZnSO_4$ @ 0.5% (T2). $ZnSO_4$ + $MgSO_4$ + KNO_3+ B; each @ 0.5% (T10) and $MgSO_4$ @ 0.5% (T3) significantly affected the fruit yield traits like polar and equatorial diameter of fruit, flesh thickness, fruit weight, number of fruits per plant, number of fruits per plot, fruit yield per plant, fruit yield per plot and seed yield traits *viz*., number of seeds per fruit, 100-seed weight and seed yield per plant. Quality traits like seed color, dry matter, oil content, protein content, ash content, fiber, total sugar and reducing sugar too were maximized by foliar application of T10 ($ZnSO_4$+ $MgSO_4$ + KNO_3 +B; each @ 0.5%) and T3 ($MgSO_4$ @ 0.5%). Consequent to the above and the cost involved, T3 ($MgSO_4$ @ 0.5%) can be adjudged as the best treatment for enhancing the growth and yield of PAU Magaz Kadoo-1. Thus, four foliar applications of $MgSO_4$ @ 0.5% at fortnightly interval with the onset of 50% flowering can significantly improve hull-less seeded pumpkin's horticultural, yield and quality attributes.

Keywords: PAU Magaz Kadoo-1, Hull-less, Pumpkin, Seed yield, Foliar application.

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Introduction

Pumpkin (2n=40) is an important vegetable crop belonging to the family Cucurbitaceae and used for various purposes from commercial and decorative to agricultural uses). India is the second largest producer of pumpkin, followed by China. The word pumpkin originated from Greek word '*pepon*' which means 'large melon'. It is also known as kashiphal, sitaphal and halwa kaddu in India. Pumpkin fruits carry more than 500 seeds, which are interspersed in a net like structure called mucilaginous fibre, present at its central inner cavity (Devi *et al*. 2018). The seeds are small, flat and nutty pepitas. These seeds generally contain a thick and leathery outer layer that must be dehulled before they are used as snacks or for oil extraction. This decortication process involves huge cost and barred pumpkin from becoming an industrial crop. However, the appearance of naked seeded (hull-less) mutant of pumpkin in 1880 in Austro-Hungarian monarchy transformed and revolutionized the entire pumpkin industry (Teppner 2004). Hull-less seeded pumpkin (*Cucurbita pepo* var. *styriaca*), also known as medicinal pumpkin, thus, lacks complete lignification of testa layer which makes it cost-effective option for baking and oil industries by evading expensive decorticating process. Easy extraction of oil facilitated rapid dispersal of hull-less seeded pumpkin in Europe, turning it into an oil crop (Gopan *et al.* 2020). In India, Punjab Agricultural University, Ludhiana, released the first variety of hull-less seeded pumpkin, "PAU Magaz Kadoo-1" in 2018 (Dhatt *et al.* 2020).

Seed yield is a function of the harvest index, seed index and seed size. Seed size is a valuable trait for the bakery industry, where bold seeds are preferred for snacking, while seed yield is important in case of oil production. The proto-chlorophyll content of the chlorenchyma layer gives the seeds an olive-green colour (Stuart and Loy 1983). In the bakery industry, seeds are used as a nutritional supplement and a functional agent. Besides oil (50% w/w), pumpkin seeds are also rich in protein (35%), unsaturated fatty acid (86%), carbohydrates (6–10%) and mineral elements (4%). Yield and nutritional composition of pumpkin seeds significantly depend upon the growing conditions such as climate and genetic characteristics of plant (Glew *et al.* 2006). *C. pepo* a temperate crop has been affected tremendously by temperature fluctuations in tropical areas. High temperature adversely affects the whole plant's growth, especially on above-grounded plant tissues (Hatfield and Prueger 2015). A decline in temperature during last stage of filling up of seed, converts oleic acid to linoleic acid, whereas increase in temperature maintains high levels of oleic acid (Murkovic *et al.* 1999). Intense sunlight deteriorates and oxidizes the intense green pigment of both seed and oil (Lankmayr *et al.* 2004). Thus, to maintain the seed yield and quality, a soothing climate especially a pleasant temperature, should be provided to this crop. However, in open field conditions, it's difficult to manipulate the temperature but agronomic practices can be utilized to overcome the stress caused by these fluctuations.

Foliar application of nutrients plays an important role in imparting tolerance to plants against environmental stresses than soil application (Torun *et al.* 2001). Foliar application of different nutrients has played a significant role in increasing the size and boldness of seeds in field crops and seed yield of oilseeds crops (Dhaliwal *et al.* 2022). The application of micronutrients in wheat at the vegetative stage enhanced seed yield by ensuring better nutrition at the anthesis and seed filling stage (Ali *et al.* 2009). Foliar application of borax (1.0%) and urea (1.0%) at the time of flowering and capsule formation significantly improved the seed yield, stover yield, protein content, nutrient concentration, and uptake over control in Indian mustard (Dhaliwal *et al.* 2022). Sathiyamurthy *et al.* (2017) found foliar application of nutrients to be promising than the direct application of nutrients on tomato due to faster uptake of nutrient in the earlier case. Considering the above, the present study was thus planned to study the effect of foliar application of nutrients on growth, yield and quality attributes of hull-less seeded pumpkin (*Cucurbita pepo* var. *styriaca*).

Materials and Methods

The experiment was conducted for consecutively two years i.e., spring 2021 and spring 2022 at Vegetable Research Farm, Punjab Agricultural University, Ludhiana, Punjab, India situated at 30°54′ N, 70°45′ E and 247 m above sea level. Seeds were sown in the first week of February in 98-celled pro-tray and transplanted in first week of March at 2-4 leaf stage during both years. Effect of foliar application of zinc sulphate, magnesium sulphate, potassium nitrate, boron and salicylic acid at different concentration on yield and quality attributes in hull-less seeded pumpkin (*Cucurbita pepo* var. *styriaca*) cv. PAU-Magaz Kadoo-1 was studied in the current investigation. The experiment was laid out in randomized complete block design with thirteen treatments *viz*., T1 (Control - Water Spray), T2 ($ZnSO_4$ @ 0.5%), T3 ($MgSO_4$ @ 0.5%), T4 (KNO_3 @ 0.5%), T5 (B @ 0.5%), T6 ($ZnSO_4$ @ 1.0%), T7 ($MgSO_4$ @ 1.0%), T8 (KNO_3 @ 1.0%), T9 (B @ 1.0%), T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%), T11 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 1.0%), T12 (Salicylic acid @ 100 ppm) and T13 (Salicylic acid @ 200 ppm) replicated thrice. In total four foliar applications of nutrients were made with the onset of 50% flowering at 15 days intervals.

Five random plants were taken from each plot to evaluate the vegetative growth through vine length (cm), number of primary branches per plant, leaf length (cm), leaf width (cm), petiole length (cm), peduncle length (cm) and internodal length (cm). Effect on the flowering pattern was estimated by recording node number for first male and female flower, days to 50% male and female flowering and days to harvest. Polar and equatorial diameter of fruit (cm), flesh thickness (cm), number of fruits per plant, number of fruits per plot, fruit yield per plant, fruit yield per plot (kg) were analyzed to find out the best treatment responsible for the highest economical yield. Seed parameters *viz*. number of seeds per fruit, 100-seed weight (g) and seed yield per fruit (g) along with the quality traits *viz*. seed colour, dry matter (%), oil content (%), protein content (%), ash (%), fibre (%), total sugar (%), reducing sugars (%), non-reducing sugar (%) and starch (%) were also estimated and statistically analyzed to find out the best treatment. Seed colour was recorded on visual observations while, oil content (%) and protein content (%) were determined according to Folch *et al.* (1957) and Lowry *et al.* (1951), respectively. Ash (%) and fibre content (%) were analyzed according to the procedure given by A.O.A.C. (1990) and James (1995). Total sugars, reducing sugar and starch content were analyzed using Dubois *et al.* (1956), Nelson (1944) and Clegg (1956), respectively. Pooling of data was exercised based on Bartlett's test of homogeneity (Dixon and Massey 1969). Data were statistically analyzed using CPCS software (Snedecor and Cochran 1967) and the differences between means were compared using Duncan's multiple range test at 5% level of significance on the pooled data.

Results and Discussion

Foliar application of nutrients significantly influenced all the traits under study. The analysis of variance (Table 1) exhibited significant differences among thirteen treatments for all the traits under study. Bartlett's test of homogeneity showed non-significant differences in variances of all the traits across treatments over the years (Table 1) and thus results have been discussed for the pooled data. T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) and T3 ($MgSO_4$ @ 0.5%) contributed maximum in enhancing the vegetative growth (Table 2) through vine length (68.51, 62.28) and number of primary branches per plant (2.78, 2.77), respectively. However, salicylic acid @ 200 ppm (T13) performed best in enhancing leaf length (19.59), leaf width (20.92) and petiole length (32.01) followed by T12-Salicylic acid @ 100 ppm (18.77, 19.57 and 28.93). The increment in horticultural traits may be due to the significant role played by these nutrients in cell wall synthesis, lignification of cell wall, development and differentiation of vascular tissues, protein synthesis, auxin synthesis, enzyme activation, regulation of cell division, cell differentiation, cell elongation, sugar transport, hormonal regulation, biochemical/physiological processes,

Table 1: Analysis of variance for horticultural,yield and quality traits of hull-less seeded pumpkin cv. PAU Magaz Kadoo-1

Traits	*2021*			*2022*			*Pooled*			χ^2
	Replication	*Treatment*	*Error*	*Replication*	*Treatment*	*Error*	*Replication*	*Treatment*	*Error*	
	d.f.=2	*d.f.=12*	*d.f.=24*	*d.f.=2*	*d.f.=12*	*d.f.=24*	*d.f.=4*	*d.f.=12*	*d.f.=48*	
Horticultural traits										
Vine length (cm)	7.86	31.75*	2.41	5.89	30.29*	1.94	6.88	61.95*	2.17	0.01
No. of primary branches/ plant	0.00	0.17*	0.01	0.00	0.19*	0.01	0.00	0.34*	0.01	11.62
Leaf length (cm)	0.11	11.84*	0.40	0.05	11.76*	0.09	0.08	23.55*	0.24	6.89
Leaf width (cm)	0.27	17.63*	0.38	0.05	17.26*	0.04	0.16	34.78*	0.21	9.59
Petiole length (cm)	0.14	46.10*	0.77	0.03	43.41*	0.43	0.09	89.24*	0.60	9.94
Peduncle length (cm)	0.02	0.70*	0.02	0.03	0.70*	0.01	0.02	1.40*	0.02	6.91
Internodal length (cm)	0.10	0.14*	0.00	0.00	0.06*	0.00	0.00	0.18*	0.00	10.31
Node to first male flower	0.77	0.24*	0.93	0.60	0.14*	0.67	0.34	0.34*	0.80	20.45
Node to first female flower	0.20	1.83*	0.09	0.09	1.69*	0.10	0.15	1.94*	0.10	19.87
Days to 50% male flower	0.23	5.59*	0.51	1.62	4.55*	0.89	0.92	7.95*	0.70	1.79
Days to 50% female flowering	0.49	10.31*	0.65	4.02	7.29*	2.66	2.26	12.22*	1.66	2.76
Days to harvest	0.10	9.97*	1.52	0.41	14.34*	4.19	0.26	19.63*	2.85	14.21
Yield traits										
Polar diameter of fruit (cm)	0.00	1.49*	0.04	0.00	1.75*	0.01	0.00	2.77*	0.03	13.92
Equatorial dia of fruit (cm)	0.04	1.21*	0.07	0.19	1.73*	0.07	0.11	2.74*	0.07	18.79
Flesh thickness (cm)	0.02	0.15*	0.00	0.00	0.07*	0.00	0.00	0.20*	0.00	12.61
Fruit weight (g)	16.38	14585.17*	223.76	38.08	15814.50*	27.62	27.23	27326.33*	125.68	6.88
Number of fruits per plant	0.00	0.20*	0.00	0.00	0.56*	0.00	0.00	0.67*	0.00	8.41
Number of fruits per plot	3.69	233.08*	4.69	11.08	644.08*	10.22	7.39	778.30*	7.45	8.50
Fruit yield per plant (kg)	0.00	0.22*	0.00	0.00	0.12*	0.00	0.00	0.31*	0.00	8.13
Fruit yield per plot (kg)	1.16	256.46*	2.41	1.10	397.04*	2.50	1.13	602.39*	2.45	3.23
Number of seeds per fruit	4.91	2128.28*	82.79	52.46	1571.53*	20.12	28.68	3635.82*	51.46	3.89
100-seed weight (g)	0.15	1.82*	0.06	0.05	5.67*	0.22	0.10	6.14*	0.14	2.18
Seed yield per plant (g)	1.46	239.01*	3.14	0.24	160.64*	1.09	0.85	368.38*	2.12	1.51
Quality traits	Replication	Treatment	Error							
	2	12	24							
Dry matter (%)	0.04	3.57*	0.14							
Oil content (%)	1.23	18.23*	0.38							
Protein (%)	0.57	1.57*	0.17							
Ash (%)	1.46	3.41*	0.54							
Fibre (%)	0.12	4.94*	0.13							
Total sugar (%)	0.07	0.94*	0.03							
Reducing sugar (%)	0.00	0.44*	0.04							
Non-reducing sugar (%)	0.03	0.67*	0.08							
Starch (%)	0.06	0.83*	0.05							

*5% level of significance, χ^2= Bartlett's test of homogeneity

Table 2: Effect of foliar application of nutrients on horticultural traits in hull-less seeded pumpkin cv. PAU Magaz Kadoo-1

Treatments		*Vine length (cm)*	*No. of primary branches per plant*	*Leaf length (cm)*	*Leaf width (cm)*	*Petiole length (cm)*	*Peduncle length (cm)*	*Internodal length (cm)*	*Node no. for first male flower*	*Node no. for first female flower*	*Days to 50% male flowering*	*Days to 50% female flowering*	*Days to harvest*
Code	*Details*												
T1	Control	57.13^{g}	2.14^{c}	13.15^{h}	13.48^{h}	17.71^{h}	3.40^{fg}	1.18^{def}	1.27^{cd}	7.53^{a}	28.33^{a}	35.17^{a}	79.50^{b}
T2	$ZnSO_4$ @ 0.5%	63.48^{c}	2.74^{ab}	17.24^{cd}	16.56^{d}	22.30^{g}	4.44^{ab}	0.98^{g}	1.37^{c}	5.98^{e}	24.33^{e}	29.33^{e}	74.84^{f}
T3	$MgSO_4$ @ 0.5%	62.28^{cd}	2.78^{a}	17.26^{cd}	18.46^{c}	23.29^{ef}	4.35^{abc}	0.86^{h}	1.00^{f}	6.95^{bcd}	25.83^{d}	31.50^{d}	76.00^{ef}
T4	KNO_3 @ 0.5%	62.94^{c}	2.70^{ab}	15.16^{f}	18.25^{c}	24.17^{de}	3.34^{g}	1.22^{cde}	1.59^{ab}	6.60^{d}	24.83^{e}	32.17^{cd}	77.34^{cde}
T5	B @ 0.5%	58.75^{fg}	2.27^{c}	16.90^{d}	19.39^{b}	25.81^{c}	3.60^{d}	1.12^{f}	1.00^{f}	5.94^{e}	26.17^{cd}	32.33^{cd}	78.50^{bcd}
T6	$ZnSO_4$ @ 1.0%	65.24^{b}	2.17^{c}	13.74^{g}	14.14^{g}	22.57^{fg}	4.48^{a}	1.47^{a}	1.51^{b}	6.20^{e}	26.17^{cd}	32.00^{d}	77.17^{cde}
T7	$MgSO_4$ @ 1.0 %	60.03^{ef}	2.26^{c}	17.46^{cd}	15.93^{e}	25.02^{cd}	3.52^{def}	1.16^{ef}	1.24^{de}	6.97^{bc}	26.17^{cd}	32.83^{bcd}	79.00^{bc}
T8	KNO_3 @ 1.0 %	60.64^{de}	2.73^{ab}	16.10^{e}	14.32^{g}	24.34^{d}	4.27^{c}	1.23^{cd}	1.14^{e}	6.70^{cd}	26.33^{cd}	32.83^{bcd}	79.84^{ab}
T9	B @ 1.0%	57.78^{g}	2.59^{b}	13.79^{g}	15.18^{f}	22.31^{g}	4.33^{abc}	1.40^{b}	1.18^{de}	5.92^{e}	26.00^{d}	32.83^{bcd}	78.50^{bcd}
T10	$ZnSO_4$+$MgSO_4$+KNO_3+ B @ 0.5%	68.51^{a}	2.77^{a}	15.36^{f}	16.34^{de}	17.84^{h}	3.32^{g}	1.13^{f}	1.65^{a}	7.27^{ab}	27.00^{bc}	32.33^{cd}	77.00^{de}
T11	$ZnSO_4$+$MgSO_4$+KNO_3+ B @ 1.0%	58.64^{fg}	2.60^{b}	17.61^{c}	19.35^{b}	24.27^{d}	3.42^{efg}	1.15^{f}	1.23^{de}	5.96^{e}	27.83^{ab}	34.17^{ab}	81.67^{a}
T12	Salicylic acid @ 100ppm	62.28^{cd}	2.58^{b}	18.77^{b}	19.57^{b}	28.93^{b}	3.56^{de}	1.27^{c}	1.00^{f}	6.06^{e}	27.50^{ab}	34.00^{ab}	79.00^{bc}
T13	Salicylic acid @ 200ppm	62.97^{c}	2.48^{b}	19.59^{a}	20.92^{a}	32.01^{a}	4.30^{bc}	1.44^{ab}	1.63^{a}	7.39^{a}	27.50^{ab}	33.50^{bc}	79.67^{b}
	*CD%	1.71	0.14	0.57	0.53	0.9	0.15	0.06	0.10	0.36	0.97	1.49	1.96

*Critical difference; Duncan's multiple range test with same letter(s) are not significantly different at p=0.05

organic acid metabolism, chloroplast development and photosynthesis in plants. For example, zinc is critically required for cell-elongation and translocation of metabolites while magnesium plays a major role in activation of many enzymes and carbohydrate synthesis, being an essential component of chlorophyll (Hatwar *et al.* 2003, Rahman *et al.* 2020). The inter-nodal length was found to be minimum (0.86) in T3 ($MgSO_4$ @ 0.5%), as in Table 2. Longer internodal length prolongs the height/vine of plant, whereas shorter internodal length produces dwarf /bushy plants. Days to 50% female flowering is an important indicator of the crop maturity. Lesser the number of days crop takes to first harvest indicates crop earliness. Minimum days to 50% male (24.33 days) and female flowering (29.33 days) and harvest (74.84 days) was observed in T2 ($ZnSO_4$ @ 0.5%) given in Table 2. Rahman *et al.* (2020) revealed major role of Zn in auxin synthesis, flower fertilization, pollen production and promotion of flowering.

The effect of foliar application of nutrients on fruit and seed yield of hull-less seeded pumpkin are presented in Table 3. Number of fruits per plant and the number of fruits per plot directly contributed towards the yield. Polar and equatorial diameter of fruit is an important parameter for deciding the fruit's shape. Larger fruit tends to have large size seed cavity and loose placental tissue, which is preferred by industry due to easy extraction of seed. The data displayed in Table 3 revealed that foliar feeding of a mixture of $ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5% (T10) recorded significantly highest polar (11.66 cm) and equatorial fruit diameter (11.88 cm), flesh thickness (2.05 cm) and fruit weight (700.81 g) followed by T5-B @ 0.5% (11.17, 11.74, 1.99 and 646.67) and T4-KNO_3 @ 0.5% (11.44, 11.39, 1.88 and 595.49). The highest number of fruits per plant (2.54, 2.49) and number of fruits per plot (86.34, 84.67) were obtained in $MgSO_4$ @ 0.5% (T3) and $ZnSO_4$+ $MgSO_4$+ KNO_3+B; each @ 0.5% (T10). Fruit yield per plant (1.59) and fruit yield per plot (59.37 kg) were maximally observed in $ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5% (T10) followed by T3-$MgSO_4$ @ 0.5% (1.40, 53.08).

The improvement in polar and equatorial diameter of fruit as a result of foliar feeding of nutrients might be due to the better chlorophyll content, cell division, cell elongation and increased metabolic activities as Hatwar *et al.* (2003) reported. Foliar application of T10 ($ZnSO_4$+ $MgSO_4$+ KNO_3+B; each @ 0.5%) increased the fruit weight due to better source to sink relation, accumulation of more carbohydrates, better vegetative growth. Similar findings have been reported by Hatwar *et al.* (2003). More number of fruits per plant in T3 and T10 could be due to involvement of magnesium in chlorophyll synthesis, expansion of cell wall, formation of new cell wall, enhanced metabolic activities, translocation of carbohydrates, role of boron in reduction of pollen sterility, better pollen germination and growth of pollen tube which ultimately resulted in greater number of fruits as opined by Hatwar *et al.* (2003) in chilli and Rahman *et al.* (2020) in okra.

Table 3: Effect of foliar application of nutrients on yield and its attributing traits in hull-less seeded pumpkin cv. PAU Magaz Kadoo-1

Treatments		*Polar diameter of fruit (cm)*	*Equatorial diameter of fruit (cm)*	*Flesh thickness (cm)*	*Fruit weight (g)*	*Number of fruits per plant*	*Number of fruits per plot*	*Fruit yield/ plant (kg)*	*Fruit yield/ plot (kg)*	*Number of seeds/ fruit*	*100 seed weight (g)*	*Seed yield/ plant (g)*
Code	*Detail*											
T1	Control	9.39^{h}	9.41^{f}	1.44^{h}	483.38^{i}	1.50^{g}	51.00^{g}	0.82^{h}	25.09^{i}	115.36^{f}	8.64^{g}	14.04^{g}
T2	$ZnSO_4$ @ 0.5%	10.79^{d}	10.52^{de}	1.83^{cd}	577.99^{e}	2.04^{d}	69.34^{d}	1.21^{d}	40.62^{e}	155.94^{c}	10.54^{c}	29.55^{b}
T3	$MgSO_4$ @ 0.5%	10.40^{e}	10.79^{d}	1.67^{f}	614.56^{c}	2.54^{a}	86.34^{a}	1.40^{b}	53.08^{b}	183.00^{ab}	11.28^{b}	39.25^{a}
T4	KNO_3 @ 0.5%	11.44^{b}	11.39^{c}	1.88^{c}	595.49^{d}	2.22^{c}	75.17^{c}	1.20^{d}	44.79^{c}	181.83^{ab}	8.97^{fg}	27.68^{c}
T5	B @ 0.5%	11.17^{c}	11.74^{ab}	1.99^{b}	646.67^{b}	1.89^{e}	64.00^{e}	1.32^{c}	41.86^{de}	175.33^{b}	8.81^{g}	23.41^{d}
T6	$ZnSO_4$ @ 1.0%	9.98^{f}	10.80^{d}	1.98^{b}	523.62^{g}	2.39^{b}	81.33^{b}	1.08^{f}	42.83^{d}	178.00^{b}	8.80^{g}	29.80^{b}
T7	$MgSO_4$ @ 1.0 %	10.04^{f}	10.36^{e}	1.66^{f}	489.17^{i}	1.84^{e}	62.33^{e}	0.91^{g}	30.79^{h}	140.50^{d}	9.29^{f}	19.17^{e}
T8	KNO_3 @ 1.0 %	9.71^{g}	10.46^{e}	1.57^{g}	476.31^{i}	1.66^{f}	56.50^{f}	0.84^{h}	26.90^{i}	128.00^{e}	10.26^{cd}	19.63^{e}
T9	B @ 1.0%	9.97^{f}	10.52^{de}	1.78^{de}	505.42^{h}	1.69^{f}	57.50^{f}	0.93^{g}	29.48^{h}	128.86^{e}	10.08^{de}	17.16^{f}
T10	$ZnSO_4$+$MgSO_4$+KNO_3+ B@ 0.5%	11.66^{a}	11.88^{a}	2.05^{a}	700.81^{a}	2.49^{a}	84.67^{a}	1.59^{a}	59.37^{a}	188.56^{a}	11.72^{a}	39.64^{a}
T11	$ZnSO_4$+$MgSO_4$+KNO_3+ B@ 1.0%	10.44^{e}	11.51^{bc}	1.73^{e}	553.42^{f}	1.84^{e}	62.50e	1.09^{f}	35.59^{g}	139.44^{d}	9.80^{e}	23.09^{d}
T12	Salicylic acid @ 100ppm	10.87^{d}	10.57^{de}	1.88^{c}	577.25^{e}	1.93^{e}	65.50e	1.15^{e}	38.40^{f}	140.58^{d}	11.02^{b}	24.27^{d}
T13	Salicylic acid @ 200ppm	10.46^{e}	10.46^{e}	1.98^{b}	579.00^{e}	1.70^{f}	57.84^{f}	1.15^{e}	34.08^{g}	146.78^{d}	9.98^{de}	20.77^{e}
	*CD%	0.19	0.31	0.05	13.01	0.09	3.17	0.04	1.82	8.32	0.43	1.69

*Critical difference; Duncan's multiple range test with same letter(s) are not significantly different at p=0.05

Table 4: Effect of foliar application of nutrients on quality traits of hull-less seeded pumpkin cv. PAU Magaz Kadoo-1

Treatments		*Seed colour*	*Dry matter (%)*	*Oil content (%)*	*Protein (%)*	*Ash (%)*	*Fibre (%)*	*Total sugar (%)*	*Reducing sugar (%)*	*Non-reducing sugar (%)*	*Starch (%)*
Code	*Details*										
T1	Control	Light green	92.35^{f}	27.93^{h}	2.36^{f}	3.00^{f}	4.20^{f}	2.86^{f}	0.36^{f}	2.50^{de}	3.12^{e}
T2	$ZnSO_4$ @ 0.5%	Dark green	93.68^{bc}	31.83^{ef}	2.58^{ef}	4.33^{de}	4.40^{ef}	4.50^{a}	1.25^{ab}	3.25^{ab}	4.65^{ab}
T3	$MgSO_4$ @ 0.5%	Dark green	95.51^{a}	34.33^{ab}	4.63^{a}	6.00^{ab}	7.53^{a}	3.70^{bc}	1.49^{a}	2.21^{ef}	3.84^{cd}
T4	KNO_3 @ 0.5%	Green	93.43^{cd}	33.07^{cd}	3.24^{de}	5.67^{abc}	6.30^{b}	3.72^{bc}	0.67^{def}	3.05^{ab}	3.66^{d}
T5	B @ 0.5%	Green	93.05^{cde}	32.13^{de}	3.13^{de}	5.33^{bcd}	5.67^{c}	3.68^{bcd}	0.57^{def}	3.11^{abc}	3.80^{cd}
T6	$ZnSO_4$ @ 1.0%	Green	94.16^{b}	28.67^{gh}	3.71^{cd}	4.00^{ef}	4.67^{ef}	3.66^{bcd}	0.61^{def}	3.05^{abc}	3.77^{cd}
T7	$MgSO_4$ @ 1.0 %	Green	92.69^{ef}	28.17^{h}	3.77^{bcd}	4.67^{cde}	4.58^{ef}	4.53a	1.10^{bc}	3.42^{a}	4.83^{a}
T8	KNO_3 @ 1.0 %	Light Green	93.43^{cd}	30.80^{f}	3.66^{cd}	4.33^{de}	7.63^{a}	3.84^{b}	0.67^{def}	3.17^{ab}	4.04^{c}
T9	B @ 1.0%	Green	92.75^{ef}	31.00^{f}	4.18^{abc}	5.00^{bcde}	5.60^{c}	3.48^{cde}	0.84^{cde}	2.63^{cde}	3.67^{cd}
T10	$ZnSO_4$+$MgSO_4$+KNO_3+ B@ 0.5%	Dark green	95.69^{a}	35.20^{a}	4.65^{a}	6.67^{a}	7.80^{a}	4.45^{a}	1.54^{a}	2.92^{bcd}	4.44^{b}
T11	$ZnSO_4$+$MgSO_4$+KNO_3+ B@ 1.0%	Green	92.89^{def}	34.00^{bc}	3.27^{de}	3.00^{f}	4.93^{de}	3.40^{de}	1.23^{ab}	2.17^{ef}	3.60^{d}
T12	Salicylic acid @ 100ppm	Dark green	92.55^{ef}	33.60^{bc}	4.43^{ab}	5.00^{bcde}	4.71^{ef}	3.37^{e}	0.56^{ef}	2.81^{bcd}	3.65^{d}
T13	Salicylic acid @ 200ppm	Green	92.51^{ef}	29.27^{g}	3.61^{cd}	5.00^{bcde}	5.40^{cd}	2.76^{f}	0.89^{cd}	1.88^{f}	3.06^{e}
	*CD%		0.64	1.04	0.70	1.24	0.61	0.28	0.32	0.49	0.37

*Critical difference; Duncan's multiple range test with same letter(s) are not significantly different at p=0.05

Number of seeds per fruit is the deciding factor in exploiting potential yield recovery in oilseeds crops. Hull-less seeded pumpkin cv. PAU Magaz Kadoo-1 is cultivated for its edible seeds used as snacks and for oil. Among the thirteen treatments, a maximum number of seeds per fruit (188.56) was observed in T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each@ 0.5%) followed by T3 ($MgSO_4$ @ 0.5%) having 183.00 seeds. Seed weight indicates the development of seed and is affected by various production factors (Rahman *et al.* 2020). Maximum 100-seed weight i.e. 11.72 g was obtained in T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) followed by 11.28 g in T3 ($MgSO_4$ @ 0.5%). This could be due to the fact that foliar application of these nutrients at the anthesis stage increased the fertility of pollen and seed filling and enhanced activity of dehydrogenase and proteinase, resulting in higher cell division, expansion and elongation of seed (Sathiyamurthy *et al.* 2017).

Seed yield per plant depends on the better fruit set, number of fruits per plant, fruit yield, number of seeds per fruit and 100 seed weight. Seed yield per plant (39.64 g) was maximum observed in T10 ($ZnSO_4$+ $MgSO_4$+ KNO_3+B; each @ 0.5%) and T3-$MgSO_4$ @ 0.5% (39.25 g) followed by T6-$ZnSO_4$ @ 0.5% (29.80) as depicted in Table 3. Seed yield per plant (g) was increased by T10 ($ZnSO_4$+ $MgSO_4$+ KNO_3+B; each @ 0.5%), T3 ($MgSO_4$ @ 0.5%) and T6 ($ZnSO_4$ @ 0.5%) due to the favorable effect of these nutrients on plant growth, enhanced metabolism, better source to sink relation, better hormonal balance causing higher pollen production and proper fertilization and seed set as reported by Abu Nuqta and Al-Shater (2011). The quality of hull-less seeded pumpkin depends on different parameters such as color, oil, protein, ash, fiber, and carbohydrates, as shown in Table 4. Seeds of hull-less seeded pumpkin are used to produce oil for food and pharmaceutical purposes (. Among quality traits, hull-less seeded pumpkin has a green colour seeds due to presence of an immediate precursor of chlorophyll (Stuart and Loy 1983). The treatments *viz*., T2 ($ZnSO_4$ @ 0.5%), T3 ($MgSO_4$ @ 0.5%), T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) and T12 (Salicylic acid @100 ppm) exhibited dark green colour seeds. Maximum dry matter (95.69%), oil content (35.20%), protein (4.65%), ash (6.67%) and fibre (7.80%) were observed in T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) and T3-$MgSO_4$ @ 0.5% (95.51, 34.33, 4.63, 6.00, and 7.53%). Total sugar was maximum observed in T7 (MgSO4 @ 1.0%), T2 ($ZnSO_4$ @ 0.5%) and T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) as 4.53, 4.50 and 4.45%, respectively. Maximum reducing sugar was observed in T10-$ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5% (1.54%) and T3 -$MgSO_4$ @ 0.5% (1.49%). The increase in seed quality parameters may be due to the participation of micronutrients in catalytic activity and the breakdown of complex substance into simpler form as observed by Rahman *et al.* (2020). Increased in dry matter in T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) could be due to better source to sink relation resulting in higher accumulation of photosynthates. The highest oil content in T10 could be attributed to sulphur provided by applying various nutrients, improvement in physiological processes and biological pathways leading to oil synthesis. Increase in protein content with the combined application of nutrients might be due to the fact that foliar feeding of nutrients is more effectively utilized for photosynthesis and assimilates are quickly mobilized for seed formation and protein synthesis (Rahman *et al.* 2020). Study showed the influence of planting time and mulching on yield and quality of muskmelon (Anusha *et al.* 2021) and integrated pest management module against whitefly in bitter gourd (Nayak *et al.* 2020) were studies in different cucurbits Increase in more carbohydrates like total sugar content, reducing sugar might be due to role of these nutrients in efficient translocation of photosynthates, accumulation of quality constituents and transformation from leaves to fruit and seeds (Farhat *et al.* 2016).

Conclusion

The present investigation showcased the significant influence of foliar application of nutrients on hull-less seeded pumpkin's growth, yield and quality attributes. The probable increment in horticultural yield and quality traits could be due to the role played by these nutrients in physiological processes, photosynthesis, cell wall synthesis, cell-division, hormonal regulation, better source to sink relation, accumulation of more carbohydrates, better protein synthesis, translocation of more photosynthates to fruits and seeds. It could be concluded that foliar application of T10 ($ZnSO_4$ + $MgSO_4$ + KNO_3 + B; each @ 0.5%) and T3 ($MgSO_4$ @ 0.5%) significantly affected the fruit yield (polar and equatorial diameter of fruit, flesh thickness, fruit weight, number of fruits per plant, number of fruits per plot, fruit yield per plant, fruit yield per plot and seed yield traits *viz*., number of seeds per fruit, 100-seed weight and seed yield per plant) and quality traits (seed colour, dry matter, oil content, protein content, ash content, fibre, total sugar and reducing sugar). Consequent upon above and the cost involved, T3 ($MgSO_4$ @ 0.5%) can be adjudged as the best treatment for enhancing growth and yield of PAU Magaz Kadoo-1. Thus, four foliar applications of $MgSO_4$ @ 0.5% at fortnightly interval with the onset of 50% flowering can significantly improve hull-less seeded pumpkin's growth, yield and quality attributes.

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सारांश

वर्तमान पर्णीय रसायन अनुप्रयोगों का छिलके रहित बीज वाले कद्दू के उपज और गुणवत्ता के अनुकूलन हेतु वसंतकाल (वर्ष 2021 और 2022) में सब्जी अनुसंधान प्रक्षेत्र, पंजाब कृषि विश्वविद्यालय, लुधियाना (पंजाब) में मूल्यांकित किया गया। याद्दच्छिक पूर्ण ब्लाक डिजाइन में 13 उपचारों जैसे- टी1 (जल स्प्रे), टी2(जेड.एन.एस.ओ.4 / 0.5 प्रतिशत), टी3 (एम.जी.एस.ओ.4 / 0.5 प्रतिशत), टी4 (के.एन.ओ.3 / 0.5 प्रतिशत), टी5 (बी. / 0.5 प्रतिशत), टी6 (जेड.एन.एस.ओ.4 / 1.0 प्रतिशत), टी7 (एम.जी.एस.ओ.4 / 1.0 प्रतिशत), टी8 (के.एन.ओ.3 / 1.0 प्रतिशत), टी9 (बी. / 1.0 प्रतिशत), टी10 (जेड.एन.एस.ओ.4 $ एम.जी.एस.ओ.4 $ के.एन.ओ.3 $ बी. प्रत्येक / 0.5 प्रतिशत), टी11 (जेड.एन.एस.ओ.4 $ एम.जी. एस.ओ.4 $ के.एन.ओ.3 $ बी. प्रत्येक / 1.0 प्रतिशत), टी12 (सैलिसिलिक एसीड / 100 पी.पी.एम.) और टी13 (सैलिसिलिक एसीड / 200 पी.पी. एम.) के साथ तीन बार पुनरावृत्ति की गयी। सभी 13 पर्णीय उपचारों ने छिलका रहित-बीज वाले कद्दू की औद्यानिक गुणों, उपज और गुणवत्ता लक्षणों पर महत्वपूर्ण प्रभाव पाया गया। पंजाब कृषि विश्वविद्यालय, लुधियाना (पंजाब) द्वारा विकसित किस्म 'मगज कद्दू-1' के औद्यानिक लक्षणों के बीच टी10 (जेड.एन.एस.ओ.4 $ एम.जी.एस.ओ.4 $ के.एन.ओ.3 $ बी. प्रत्येक / 0.5 प्रतिशत) के पर्णीय प्रयोग से अधिकतम लता की लम्बाई पायी गयी जबकि सैलिसिलिक एसीड / 200 पी.पी.एम. (टी13) से अधिक पत्ती की लम्बाई, पत्ती की चौड़ाई और डंठल की लम्बाई पायी गयी। जेड.एन.एस.ओ.4 / 0.5 प्रतिशत (टी2) के पर्णीय अनुप्रयोग के साथ कम से कम 50 प्रतिशत नर और मादा फूलों के साथ-साथ कटाई देखी गयी। जेड.एन.एस.ओ.4 $ एम.जी. एस.ओ.4 $ के.एन.ओ.3 $ बी.; प्रत्येक / 0.5 प्रतिशत (टी10) और एम.जी.एस.ओ.4 / 0.5 प्रतिशत (टी3) ने फलों की पैदावार के लक्षणों जैसे-फल का धुरवीय और भूमध्यरेखीय व्यास, गूदा की मोटाई, फलों का वजन, प्रति पौध फलों की संख्या, 100 बीज वजन और प्रति पौध बीज उपज, बीज का रंग, शुष्क पदार्थ, तेल सामग्री, प्रोटीन सामग्री, रास सामग्री, खाद्य रेशा, कुल शर्करा और कम शर्करा वाली जैसे गुणवत्ता लक्षण भी टी10 (जेड.एन.एस.ओ.4 $ एम.जी.एस.ओ.4 $ के.एन.ओ.3 $ बी. प्रत्येक / 0.5 प्रतिशत) और टी3 (एम.जी.एस.ओ.4 / 0.5 प्रतिशत), के पर्णीय अनुप्रयोग द्वारा अधिकतम पाया गया। लागत के परिणाम स्वरूप, टी3 (एम.जी.एस.ओ.4 / 0.5 प्रतिशत) को पंजाब कृषि विश्वविद्यालय द्वारा विकसित किस्म 'मगज कद्दू-1' की वृद्धि और उपज बढ़ाने के लिए सबसे अच्छा उपचार माना जा सकता है। अतः 50 प्रतिशत पुष्पन के साथ पखवाड़े के अंतराल पर एम.जी.एस.ओ.4 / 0.5 प्रतिशत के चार पर्णीय अनुप्रयोगों से छिलके रहित बीज वाले कद्दू की वृद्धि, उपज और गुणवत्ता विशेषताओं में काफी सुधार हो सकता है।