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Studies to determine the optimum rates of nitrogen and potassium fertilization of Early Sweet grapevine under open field and plastic cover conditions

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Abstract

The current study, conducted during 2019 and 2020 with a preliminary season in 2018, aimed to ascertain the ideal nitrogen and potassium fertilization rates for the Early Sweet grape cultivar. This investigation was carried out under both open field and plastic cover conditions. Six treatments were applied in this experiment, three in an open field and three under a transparent plastic cover with different rates of 60, 45 and 30 units fed^{-1} for nitrogen and 100, 75 and 50 units fed^{-1} for potassium. Results showed that the vines receiving rates of N 45 units + K 75 units fed^{-1} under plastic cover recorded a higher percentage of bud break followed by N 60 units + K 100 units fed^{-1} treatment under plastic cover. In addition to an earlier sprout than those in the open field, they gave the highest values in terms of yield and all physical and chemical parameters for reproductive growth, except for the vegetative growth where the best treatment was obtained from N 60 units + K 100 units fed^{-1} under plastic cover followed by N 60 units + K 100 units fed^{-1} in the open field. This result suggests that the plastic cover has a beneficial effect on decreasing fertilization rates due to the change in vine canopy microclimate through enhancing vegetative and reproductive growth as well as creating a balance between them.

Key words: Early Sweet seedless grape, plastic cover, nitrogen, potassium, fertilization, quality; microclimate

Introduction

Early Sweet is a seedless table grape cultivar characterized by a big berry, green to yellow color with a high commercial value, which matures during May in Egypt, producing a high yield suitable for export. Earlier harvesting of this cultivar may permit the promotion of the vineyard, especially by exportation to European markets. A few researches dealing with fertilizers have been published on the Early Sweet grape cultivar, even though it is considered one of the important grape cultivars in Egypt. To date, few reports are available concerning the incidence of nitrogen and potassium fertilization on plant growth and the composition of grape juice of this variety.

Nitrogen (N) is one of the most required mineral elements for plant growth, and potassium (K) plays a vital role in nitrogen metabolism, both elements being widely applied as fertilizers in agricultural production (Xu *et al.,* 2020). It has been found that high nitrogen levels reduce the availability of potassium and increased nitrogen levels increase the need for magnesium (Bell and Robinson, 1999). Regarding potassium's effect, high potassium levels in grape berries may have a negative impact on their quality, mainly because they reduce the free tartaric acid, which increases the pH of grape juice (Mpelasoka *et al.* 2003).

Solar radiation and temperature at the cluster zone have a great influence on the yield quality and quantity; therefore, clear polyethylene plastic cover techniques are used to advance the harvest season of some crops by trapping the solar energy under the cover, causing the rise of air and soil temperatures (Bowen, 1998; and Jenni *et al.*, 1998). Previous studies found that the plastic cover of vineyards causes crucial differences in their microclimate. It increases relative humidity and air temperature, reduces light intensity, and involves the type of solar radiation to reduce ultraviolet radiation (Chavarria and Santos, 2009). Moreover, plastic covers have radiometric properties, which affect the canopy microclimate through their ability to trap infrared and longwave radiation around the cluster zone under the covered vines (Novello *et al.*, 2000).

The objectives of this study was to adjudge the exact amount of nitrogen and potassium needed by the vines at different and specific stages of growth and the development of berries for the 'Early Sweet' grapevines under the open field and plastic cover conditions to produce an economical yield and good berry quality.

Material and methods

A field experiment was undertaken in a vineyard located at 30° 22' 30" N and 30° 30' 1" E El-Sadat City, where this area is characterized by a hot to moderate climate, in 2018 as a preliminary season followed by 2019 and 2020 seasons. Seven-year-old seedless table grape "Early sweet" grafted on Freedom rootstock and spaced at 2 x 3 m, grown in sandy soil, were used in this investigation. Vines were cane pruned and trellised by a Spanish parron system with a bud load of 80 buds/vine (10 canes x 8 buds) and 10 spurs x 2 buds/spur. Pruning was carried out on the 1st week of January and irrigated via a drip irrigation system.

In a complete randomized block design, ninety uniform vines were chosen for this assessment, divided into six treatments, three replicates and five vines/replicate. The experiment was carried out on the same vines for both seasons and received common horticultural practices recommended by the Ministry of Agriculture. Ammonium nitrate (33.5 % N) and potassium sulphate (50 % K_2O) were used as sources of nitrogen and potassium, respectively. Each rate was divided and added as soil addition thrice along the growing season as follows: 50% N and 25% K after bud burst and before flowering, 25% N + 50% K after berry set and 25% N + 25% K after harvest and the fertilization treatments involved:

N 60 units + K 100 units fed^{-1} (open field)

N 45 units + K 75 units fed^{-1} (open field)

N 30 units + K 50 units fed^{-1} (open field)

N 60 units + K 100 units fed^{-1} (plastic cover)

N 45 units + K 75 units fed^{-1} (plastic cover)

N 30 units + K 50 units fed^{-1} (plastic cover)

(One Feddan is equal to 0.41 ha)

Representative soil samples were taken from the experimental area for soil analysis and mechanical, physical and chemical characteristics of the soil was evaluated according to Wilde *et al.* (1985) and the data is shown in Table 1.

Table 1. Mechanical, physical and chemical characteristics of the soil

Parameter	Content
Sand (%)	90.1
Silt (%)	3.42
Clay (%)	6.35
Texture	Sandy
FC (%)	13.68
WP%	5.97
Bulk density g/ m^3	1.56
Organic matter (%)	0.41
pH	7.73
EC Mmhos/cm	1.83
Ca^{++} meq/L	12
Mg^{++} meq/L	5.2
Ca Co_3 (%)	3.12
N (%)	0.91
P (%)	0.11
K (%)	0.54

The following measurements were taken to evaluate the effect of the different treatments:

Climatic data beneath the vine canopy: Data of microclimate (canopy temperature (°C), sunlight intensity (1000 Lux), relative humidity (%)) was recorded inside the vine canopy for each treatment starting from the beginning of the growing season till harvest.

These Data were taken on three levels lower, middle and upper shoots using "Scheduler Plant Stress Monitor" using the apparatus microprocessor to calculate the average microclimate of the vine canopy and the relationship between the factors of microclimate and different treatments was assessed.

Bud behavior: Dormant buds per vine were observed along the bursting period. The number of burst buds and cluster/vine were recorded then the percentage were calculated during both study seasons. Also, the number of fruitful buds was counted and the percentages were calculated in relation to the total number of burst buds according to the following equations:

Budburst (%)= Number of burst buds / Total number of buds x 100

Bud fertility (%) = Number of clusters/vine / Total number of buds x 100

Fruitfulness (%) = Number of fruitful buds / Number of burst buds x 100

Yield: A sample of 15 clusters for each treatment was collected randomly when total soluble solids reached about 15-18%. Yield and its attributes (average cluster weight, the number of cluster/vine, berry weight and berry size) were recorded.

Chemical characteristics of berries: Total soluble solids % was measured using a refractometer, titratable acidity % was evaluated as one gram of tartaric acid for 100 mL of juice then TSS/acid ratio was calculated according to AOAC (1985).

Chemical characteristics of leaves and shoots: Mature basal leaves from the sixth and seventh nodes were collected to measure the total chlorophyll content of leaves at harvest time using "the nondestructive Minolta chlorophyll meter model SPAD 502". The percentage of N and K content in leaf petioles and total carbohydrates in canes at winter pruning, according to Smith *et al.* (1956), were tested.

Physical characteristics of leaves and shoots: Samples of 20 leaves were collected from each treatment for leaf area determination at harvest time "using leaf area meter, Model CI 203, USA," then the total leaf area/vine was calculated. Shoot length and pruning weight was measured.

The economic feasibility study: Economic analysis was performed based on financial criteria including the price of yield/fed (LE), cost of covering/fed (LE), cost of fertilizers (N / fed and K / fed (LE)), the total cost/fed (LE) and the net profit/fed (L/E).

Statistical analysis: The statistical analysis was performed according to Snedecor and Cochran (1980). Averages were compared using the new LSD values at 5% level using a randomized complete block.

Results and discussion

Microclimatic data beneath the vine canopy

Canopy temperature (°C): The data presented in Table 2 shows that the canopy temperature was affected significantly by covering the vines. Canopy temperature values are higher under the transparent plastic cover than the uncovered treatment. Similarly, Chavarria *et al.* (2007) observed an increase of 1°C in the average temperature of plastic-covered vines compared to vines exposed to open air, besides the results obtained from Leitão *et al.* (2017), who indicated that the plastic cover prevented the passage of about 40% of the global and net radiation and generated an increase of air temperature.

Sunlight intensity (1000 Lux): The data in Table 2 shows the sunlight intensity as affected by various treatments. Both covered and uncovered treatments were significantly different. Data revealed that sunlight intensity values were lower under the plastic cover by about 20-30% than the uncovered treatment, as it decreased the amount of light reaching the clusters for both seasons, which is considered as a favorite condition for clusters.

These results can be explained according to the fact that clusters exposed to high radiation and heat are damaged by the sun; many berries dehydrate completely, making it inappropriate, thereby reducing yield. This is a common phenomenon in regions with high light intensities and temperatures during the growing period (Greer and Weedon, 2012). However, plastic sheet coverings inevitably filter the incoming solar radiation and alter its radiometric traits, modifying the microenvironment and influencing vine ecophysiological function and grape quality (Matthew *et al.,* 2016).

Relative humidity (%): Notable correlations between canopy coverage and relative humidity levels was observed (Table 2). Under the covered canopies, relative humidity (RH%) is notably higher compared to the uncovered ones. This phenomenon aligns with the findings of Qin *et al*. (2015), who observed that humidity tends to accumulate in dense canopies. Consequently, vines that were not covered had lower RH% levels due to the transpirational cooling effect of leaves, mitigating humidity buildup commonly seen in densely covered canopies receiving elevated N and K fertilization rates. In the context of the open field, the wind's ventilating impact reduces canopy humidity, and even slight discrepancies in humidity can significantly affect crop quality. Leitão *et al.* (2017) demonstrated that the plastic cover maintains higher relative humidity levels within the canopy.

Bud burst (%): There was a significant increase in bud burst percentage, accompanied by the tested nitrogen and potassium fertilization rates under the plastic cover and open field (Tables 3). Data obtained for the vines treated with rates of N 45 units + K 75 units fed^{-1} followed by N 60 units + K 100 units fed^{-1} under plastic cover gave the highest values in both seasons. Values obtained from N 60 units + K 100 units fed^{-1} (open field) and N 30 units + K 50 units fed^{-1} (plastic cover) treatments had no significant differences. The advance of bud break was confirmed as the responsible factor for most of the berry ripening earliness under covering. In a previous study, it was found that in open fields, cv. 'Matilde' vines showed a 50% bud break and vines under covering sprouted 20 days earlier than those in the open field (Novello *et al.,* 2000). At the same time, plastic covering hastened bud-burst as higher air temperatures under plastic covers have been accounted for earlier bud-burst compared with vines grown in the open field (Çoban, 2007). Additionally, it is obvious that vines receiving N 45 units + K 75 units fed^{-1} followed by N 60 units + K 100 units fed^{-1} resulted in the highest percentage of bud burst in both seasons of this study under the open field conditions. Abd Elrazek *et al.* (2011) stated that high nitrogen supply reduced bud burst. Whereas the lowest percentage of bud burst was obtained from vines receiving 30-unit N + 50-unit K fed^{-1} (Ola *et al.,* 2016)

Bud fertility (%): Results in Table 3 clearly show that the adequate amount of nitrogen and potassium supply under plastic cover was N 45 units + K 75 units fed^{-1}, as high N-supply reduced bud fertility in Crimson Seedless grapes (Abd Elrazek *et al.,* 2011). Furthermore, N 60 units + K 100 units fed^{-1} in the open field was better than the lower rates.

Fruitfulness (%): Concerning the effect of nitrogen and potassium fertilization treatments (Table 3) it is clear that the highest percentage of fruitful buds was obtained from covered vines, receiving N 45 units + K 75 units fed^{-1} followed by N 60 units + K 100 units fed^{-1}, while vines receiving N 30 units + K 50 units fed^{-1} gave the lowest values in both seasons.

A significant interaction was noticed between different tested rates of nitrogen and potassium fertilization treatments, microclimate and covering. Meanwhile, in line with the results of Abd El-Razek *et al.* (2011) N 45 units + K 75 units fed^{-1} gave the maximum percentage in the uncovered ones. In addition, temperature increases during the pre-bloom and full-bloom phases tended to increase fruitfulness in many cultivars (Molitor and Keller, 2016).

Yield: Data in Table 4 shows that all treatments affected the average yield per vine. Generally, increases in yield tend to result from increases in cluster weight and numbers per vine. In the case of covering the vines with clear plastic sheets, the soil addition of N 45 units + K 75 units, fed^{-1} resulted in high bud fertility producing the highest yield. Also, the high relative humidity under the plastic cover produced larger berries compared to the open field. Greenspan (1994) and Brackmann *et al*. (2000) both

Table 3. Effect of different Rates of nitrogen and potassium fertilization under open field and plastic cover conditions on bud behavior of Early Sweet grapevine during the two successive seasons 2019 and 2020

Treatments		Bud burst %		Bud fertility %		Fruitfulness %	
		2019	2020	2019	2020	2019	2020
Open field	N 60 units + K 100 units	75.1	76.2	25.5	26.0	30.2	31.3
	N 45 units + K 75 units	77.0	78.5	27.2	27.6	31.9	32.7
	N 30 units + K 50 units	72.7	73.6	23.0	24.2	27.9	28.0
Plastic cover	N 60 units + K 100 units	82.3	82.1	28.4	29.1	33.3	34.1
	N 45 units + K 75 units	84.5	84.4	30.8	31.0	35.4	35.8
	N 30 units + K 50 units	74.8	75.7	24.7	25.4	29.5	30.5
	New L.S.D at 5%	0.6	0.6	0.9	0.8	0.7	0.8

Table 2. Effect of different rates of nitrogen and potassium fertilization under open field and plastic cover conditions on microclimatic data beneath the vine canopy of Early Sweet grapevine during the two successive seasons 2019 and 2020

Treatments		Canopy temperature (°C)		Sunlight intensity (1000 Lux)		RH(%)	
		2019	2020	2019	2020	2019	2020
Open field	N 60 units + K 100 units	39.43	40.21	65.33	66.10	62.33	63.13
	N 45 units + K 75 units	37.29	37.05	71.62	70.45	57.17	53.70
	N 30 units + K 50 units	36.60	35.94	79.57	80.61	47.55	48.77
	New L.S.D at 5%	1.66	1.57	1.17	1.13	0.91	0.89
Plastic cove	N 60 units + K 100 units	45.34	44.63	42.31	43.21	80.63	78.49
	N 45 units + K 75 units	38.24	39.19	51.41	49.52	71.41	69.81
	N 30 units + K 50 units	33.21	36.40	55.07	54.76	64.53	64.40

highlighted that employing certain agricultural techniques to raise relative air humidity can result in the development of larger berries. This phenomenon could be attributed to a reduction in berry transpiration. Conversely, excessively low relative air humidity may lead to significant weight loss in the berries. Covering increased the yield per vine compared to the open field in addition to cluster weight and berry size, which were the greatest under-covering and progressively decreased under the open field condition.

Concerning the effect of microclimate, changes in berry mass seemed coherent with the microclimatic changes observed, where it increased with the higher mean relative air humidity (Novello *et al.* 1999). In a previous study, the effect of covering on yield, cluster weight and berry size indicated that covered vines gave significant values in both study seasons (Souza *et al.,* 2015). However, concerning the uncovered treatments vines receiving N 60 units + K 100 units fed^{-1} was the best. Ola *et al.* (2016) also stated that the maximum number of clusters/vine was observed when N 60 units + K 100 units fed^{-1} was applied to the vines. A significant reduction in the yield and its component was accompanied by reducing the nitrogen and potassium rate to N 30 units + K 50 units fed^{-1} in Superior Seedless grapevines. On the other hand, the Riesling grapevine displayed positive correlations between yield and temperature (Molitor and Keller, 2016).

Biochemical characteristics of berries

Total soluble solids (TSS %), Titratable acidity and TSS / acid ratio: TSS has significant differences between the treatments (Table 5). The highest values were obtained from the vine treated by N 45 units + K 75 units fed^{-1} followed by N 60 units + K 100 units under the plastic cover, which gave lower values as the higher the nitrogen fertilizer rate, the higher the vegetative growth, which usually decreases TSS% and increases acidity, this is consistent with the work of Bedrech and Mustafa (2017).

Potassium lessens the respiration rate, leading to reducing sugar consumption (Abeer, 2011). TSS/acid ratio was significantly increased in response to increasing the levels of K. The only effect of high K fertilization was an increase in total soluble solids and a decrease in acid concentration (Abd Elrazek *et al.,* 2011). Additionally, at harvest, covered grapes had higher TSS concentration, TSS / TA ratio (Calderón-Orellana *et al.,* 2021).

On the other hand, increasing fruit exposure to light penetration, as in the open field, has been linked to enhanced accumulation of soluble solids with an opposite trend for acidity, where clusters displayed lower acidity as a consequence of higher temperatures (Gehan *et al.,* 2020).

Table 5. Effect of different rates of nitrogen and potassium fertilization under open field and plastic cover conditions on the chemical characteristics of berries of Early Sweet grapevine during the two successive seasons, 2019 and 2020

	Treatments	TSS (%)		Titratable acidity (%)		TSS / acid Ratio	
		2019	2020	2019	2020	2019	2020
Open field	N 60 units + K 100 units	15.5	15.7	0.60	0.59	25.8	26.6
	N 45 units + K 75 units	14.1	14.6	0.72	0.69	19.6	21.2
	N 30 units + K 50 units	13.7	14.0	0.76	0.73	18.0	19.2
Plastic cover	N 60 units + K 100 units	16.5	16.3	0.55	0.57	30.0	28.6
	N 45 units + K 75 units	17.0	16.9	0.42	0.46	40.5	36.7
	N 30 units + K 50 units	14.8	14.9	0.67	0.64	22.1	23.3
	New LSD at 5%	0.3	0.4	0.04	0.03	1.6	1.2

Chemical characteristics of the vegetative growth

Total chlorophyll content in leaves (SPAD): Total chlorophyll content in leaves displayed in Table 6 reveals that under both the cover and uncovered vines, N 45 units + K 75 units fed^{-1} and N 60 units + K 100 units fed^{-1} resulted in the highest values respectively. Since berry temperature can increase linearly with sunlight exposure (Bergqvist *et al.,* 2001), the highest berry temperature observed on the sun-exposed side of the canopy under NS orientation suggests increased solar radiation. It is well known that sunlight induces stomatal aperture and activates chlorophylls and some photosynthetic enzymes to convert the assimilated carbon into sucrose in cytosol and starch in the chloroplast. The illumination advantage probably favored the stomatal conductance and photosynthetic rate, increasing the starch accumulation (Geigenberger, 2011). Also, high light intensities, as in open field conditions, may damage leaf chlorophylls, decreasing photosynthetic efficiencies (Köse, 2014). The nitrogen compound is closely related to the green color of the leaf; therefore, chlorophylls were used as a nitrogen status indicator (Huerta *et al.*, 2013). Higher differences between covered and uncovered vines may be ascribed to an easier stomatal opening under plastic covering since the transpiration process is restricted under low solar radiation (Doaa, 2018).

Percentage of N and K content in leaf petioles: We can notice from the concerned results in Table 6 of the present study that the vines receiving N 60 units + K 100 units fed^{-1} whether under plastic cover, or in the open field, recorded the highest values of N and K content % in leaf petioles. However, covering Early Sweet gave the highest significant increase in the percentage of N and K content in leaf petioles during the two seasons of study than the uncovered vines and element values were declining by decreasing the N and K rates in the other treatments. Al-Moshileh and Al-

Table 4. Effect of different rates of nitrogen and potassium fertilization under open field and plastic cover conditions on yield of Early Sweet grapevine during the two successive seasons 2019 and 2020

	Treatments	Average berry size (cm^3)		Average berry weight (g)		Average cluster weight (g)		Average number of cluster/ vine		Average yield (kg)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Open field	N 60 units + K 100 units	4.45	4.56	4.82	4.91	478.4	532.3	31.9	32.5	15.3	17.3
	N 45 units + K 75 units	4.16	4.22	4.25	4.32	415.6	498.7	31.2	31.8	12.9	15.9
	N 30 units + K 50 units	3.96	4.01	4.03	4.13	380.7	461.4	30.5	30.1	11.6	13.9
Plastic cover	N 60 units + K 100 units	4.87	4.96	4.95	5.11	505.3	572.1	32.9	33.7	16.7	19.2
	N 45 units + K 75 units	5.27	5.34	5.39	5.45	550.4	610.5	34.8	35.2	19.2	21.4
	N 30 units + K 50 units	4.38	4.51	4.54	4.63	460.9	520.8	32.0	32.1	14.7	16.7
	New L.S.D at 5%	0.11	0.13	0.14	0.15	21.0	21.0	0.4	0.5	1.0	1.1

Table 6. Effect of different rates of nitrogen and potassium fertilization under open field and plastic cover conditions on the chemical characteristics of the vegetative growth of Early Sweet grapevine during 2019 and 2020 seasons.

	Treatments	Total chlorophyll (SPAD)		Leaf petiole content				Total carbohydrates (%)	
				N %		K%			
		2019	2020	2019	2020	2019	2020	2019	2020
Open field	N 60 units + K 100 units	30.6	29.1	1.76	1.75	0.34	0.36	20.3	20.9
	N 45 units + K 75 units	28.5	28.7	1.67	1.67	0.29	0.30	19.5	19.8
	N 30 units + K 50 units	22.7	20.9	1.35	1.37	0.17	0.18	16.3	16.8
Plastic cover	N 60 units + K 100 units	24.1	24.3	1.86	1.87	0.38	0.39	18.9	18.9
	N 45 units + K 75 units	33.9	33.8	1.59	1.57	0.26	0.26	21.2	22.0
	N 30 units + K 50 units	25.2	26.0	1.43	1.48	0.20	0.21	17.4	17.6
	New LSD at 0.05 %	0.8	0.7	0.06	0.06	0.02	0.01	0.6	0.7

Rayes (2004) reported a similar finding, stating that a significant increase in leaf petiole content of N and K was observed as the potassium fertilizer rate was increased. This could be ascribed to the high temperature under the plastic cover, which can cause high evapotranspiration and increase the concentration of solid elements in leaves and petioles. Considering the effect of covering conditions, the highest significant N and K values were measured in the leaves of covered vines grafted on the Freedom rootstock (Doaa, 2018).

Total carbohydrates (%): Data in Table 6 shows that cane content of total carbohydrates was significantly affected by different rates of N and K under covered and uncovered vines in the studied seasons. The highest significant values of these contents were attributed to vines receiving N 45 units + K 75 units fed^{-1} under a plastic cover and N 60 units + K 100 units fed^{-1} in the open field. These results coincided with those of Mullins *et al.* (1992), who demonstrated that potassium travels easily throughout the vine and can be involved in carbohydrate transport and metabolism. In addition, the carbohydrate content of plants grown under low light intensity and high temperature (covered conditions) was higher than those grown in the open field. Carbohydrate accumulation correlated with photosynthesis efficiency in the plants since high light intensities, as in the open field conditions, may damage leaf chlorophylls and as a result, photosynthetic efficiencies may decrease (Köse, 2014).

Physical characteristics of the vegetative growth: It is obvious from the recorded data that there were significant differences among treatments in the physical characteristics of the vegetative growth parameters (Table 7). The highest values were obtained from treating the vines of N 60 units + K 100 units fed^{-1} followed by N 45 units + K 75 units fed^{-1} under a plastic cover and in the open field. It is obvious that the shoots were too dense under plastic cover, in the higher rate of N and K (N 60 units + K 100 units fed^{-1}). As a result, light in the fruiting zone was reduced, reducing fruit quantity and quality (Archer and Hunter, 2004). Moreover, high N-supply improved the leaf area as stated by Abd Elrazek *et al.* (2011). Besides, a high amount of nitrogen positively stimulates vegetative growth, reducing the quality of grapes (Ferrara *et al.,* 2018).

In general, transparent plastic cover had a significant effect on shoot length and leaf surface area, where the values were higher than in uncovered vines. However, the difference in pruning weight was observed between vines growing under covered and uncovered conditions, and it increased by covering the vines with transparent plastic sheets. The increment of leaf area under the cover indicates an adaptive mechanism of grapevines in response to low light intensity, causing an increase in photosynthesizing leaf area rather than in dry weight. Increased surface leaf area under plastic cover also confirms that individual leaves were larger but thinner as less structural material per unit area is accumulated in the leaves in response to low light stress (Chavarria *et al.,* 2012). Similarly, shaded conditions yielded significantly higher shoot lengths, where low light intensities and high temperature under plastic cover elongated shoot lengths.

In addition, the high night temperature in covered vine increases respiration, providing more energy and carbon required for shoot growth (Hendrickson *et al.,* 2004). Çoban (2007) also stated that plastic covering significantly affected shoot length. Furthermore, the leaf area, main shoot growth rate and pruning weight increased under transparent plastic cover were mainly ascribed to the highest minimum air temperature as compared to uncovered treatments, as shoot growth is highly dependent on air temperature (Souza *et al.,* 2015).

The economic feasibility study: The average yield/fed (Kg), price of yield/fed (LE), cost of covering/fed (LE), cost of N/fed and K/fed (LE), the total cost/fed (LE) and the net profit/fed (L/E) for both seasons of the study was calculated (Table 8). We can calculate the amount and cost saved for each treatment

Table 7. Effect of different rates of nitrogen and potassium fertilization under open field and plastic cover conditions on the physical characteristics of the vegetative growth of Early Sweet grapevine during the two successive seasons 2019 and 2020.

	Treatments	Leaf area (cm^2)		Total LA/vine (m^2)		Shoot length (cm)		Pruning weight (kg)	
		2019	2020	2019	2020	2019	2020	2019	2020
Open field	N 60 units + K 100 units	177.2	178.9	42.8	44.1	150.2	155.6	2.98	3.21
	N 45 units + K 75 units	157.1	160.6	37.5	37.8	145.4	149.5	2.73	2.97
	N 30 units + K 50 units	100.9	102.3	19.2	19.9	130.1	135.7	2.18	2.29
Plastic cover	N 60 units + K 100 units	196.2	197.5	51.9	55.5	155.3	167.8	3.22	3.51
	N 45 units + K 75 units	138.6	140.6	34.1	35.7	141.7	144.9	2.58	2.74
	N 30 units + K 50 units	119.5	122.1	24.8	27.4	136.4	138.0	2.40	2.49
	New L.S.D at 5%	14.0	15.0	3.0	3.0	1.0	1.0	0.11	0.12

Table 8. The economic feasibility study of the mean cost per feddan and net profit for each treatment for both seasons (2019-2020)

Treatments		Average yield/ fed (Kg)	Price of yield/ fed (L.E)	Cost of covering/ fed (L.E)	Cost of N / fed (L.E)	Cost of K / fed (L.E)	The total cost/ fed (L.E)	The net profit/fed (L/E)
Open field	N 60 units + K 100 units	11,410	91,280	-	1,638	5,200	6,838	84,442
	N 45 units + K 75 units	10,080	80,640	-	1,229	3,900	5,129	75,511
	N 30 units + K 50 units	8,925	71,400	-	819	2,600	3,419	67,981
Plastic cover	N 60 units + K 100 units	12,565	150,780	25,000	1,638	5,200	31,838	118,942
	N 45 units + K 75 units	14,210	170,520	25,000	1,229	3,900	30,129	140,391
	N 30 units + K 50 units	10,990	131,880	25,000	819	2,600	28,419	103,461

from the obtained data. Treating the vines by N 45 units + K 75 units/fed under plastic cover was the most cost-effective, giving a net profit of (140,391 LE/fed) which compensates for the high price of plastic cover by diminishing the amount of nitrogen and potassium fertilization needed under the plastic cover and giving the highest yield. In addition to obtaining early harvest yield with better quality suitable for export, the price increased from 8 LE/Kg in the open field to 12 LE/Kg under the plastic cover.

In conclusion, we can deduce that covering the vines directly affects the nutrient rate and improves the efficiency of nutrient absorption. The current study focused on the effect of covering transparent plastic polyethylene on nitrogen and potassium fertilization rates. Results showed that in the case of plastic cover, the best results were obtained when the fertilization rates were reduced to N 45 units/fed + K 75 units/fed, whereas N 60 units + K 100 units fed^{-1} gave the highest values in the case of the open field. A cover provides the appropriate microclimate to enhance the absorption of nutrients and induce early bud burst and early ripening.

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