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Effect of Some Agricultural Treatments on Growth and Productivity of Potatoes

Yasser M. M. Osman, Ahmed M. EL-Anany and Sayed M. Rizk*

Potato and Vegetatively Propagated Vegetables Research Department, Horticultural Research Institute (HRI), Agricultural Research Centre (ARC), Giza, Egypt.

***Corresponding author:** sayedmansor22@yahoo.com

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Abstract: This study was conducted on the potato plant (*Solanum tuberosum* L.), cv. Spunta to evaluate the effect of the number of eyes on seed tuber piece (STP) i.e., containing one, two, or three eyes using different planting distances (10, 15, 20, and 25 cm) between plants, and the resulting combinations on vegetative growth, yield, its components and the savings in seed quantity. The experiment was conducted during both summer seasons of 2023 and 2024 growing on clay soil at Kaha Vegetables Research Farm, Horticultural Research Institute, Agricultural Research Center, Egypt. The results showed that the most positive effect obtained from the seed tuber pieces treatments and the interaction with planting distances was the use of a single-eye piece with a 10 cm planting distance, which led to an increase in productivity proportional to the economical amount of seed used. However, the results also showed that using a seed piece with three eyes and planting at a distance of 10 or 15 cm between plants resulted in higher productivity than the previous treatment. However, considering the quantity of seed used in the latter treatment with the higher yield, it appears disproportionate to the increased seed quantity used in planting. The cost of the seeds is not comparable to the selling price of the crop to the consumer (local market). Based on the study conducted, it was found that using a seed piece with a single eye and planting at a distance of 10 cm is the best combination due to its economic advantages and increased yield, in addition to its superiority over the other treatments in production of seed tubers in the ideal sizes of seed.

Key words: *Solanum tuberosum*, tubers, seed piece, planting distances.

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1. Introduction

Potatoes (*Solanum tuberosum* L.) are acknowledged as the primary vegetable crop and the fourth essential food crop in the world regarding consumption, after rice, wheat and maize. Potatoes are vegetative propagated crop using seed tubers, which significantly influence plant growth and yield. Seed tubers represent 60–70% of the total expenses incurred in production **(Mayakaduwa *et al*., 2017)**. For this reason, it is a common practice to divide seed tubers into segments, with differences in both the size and technique of cutting **(VanderZaag**

and DeMagante, 1989; Hossain *et al*., 2011; Mayakaduwa *et al*., 2017; Diop *et al*., 2019). Seed tuber size and row spacing are among the key factors affecting potato yield **(Masarirambi *et al*., 2012)**.

The quantity of seed tubers utilized per hectare is considerable, ranging from 1.8 to 2.2 tons/hectare, and therefore, an unsuitable seed tuber size and row spacing can lead to significant waste of potatoes **(Badoni and Chauhan, 2011)**. The amount of seed potatoes required can be reduced by up to 40% if seed tubers of an optimal size are used **(Singh and Sharma, 2008; Kabir *et al*., 2004),** due to the high cost of potato seed tubers it is economically advantageous to cut larger seed tubers into smaller pieces to obtain the maximum number of planting pieces, thus reducing the seed cost. However, it is not clear how many "eyes" (sprouting points) should be retained on each cut piece to ensure a successful crop **(Harnet *et al*., 2014).** The close spacing in rows (20 cm) for the Jalenie variety resulted in a greater yield of potato tubers and a marketable yield per hectare compared to other spacing. Increasing density of plant or using larger seed pieces effectively reduces the average of size tuber **(Iritani *et al*., 1983)**. However, high stem density leads to increased yield, but it negatively affects tuber size, with growth being limited due to competition between stems **(Gulluoglu and Arioglu, 2009)**. Studies have shown that the size of potato tubers has an impact on potato production, affecting germination, plant growth, and final yield **(Struik, 2007)**. Also cutting the tubers affects the siz and weight of the seed tubers, although it is possible to grow potato plants from a single tuber, which can be cut into pieces containing one, two, or three eyes **(Mangani *et al*, 2015; Mangal *et al*., 2024)**. Research has shown that larger seed tubers produce a higher overall yield than smaller ones **(Adhikari, 2005; de Almeida *et al*., 2016; Ebrahim, *et al*., 2018; Webster *et al*., 2018; Harnet *et al*., 2014; Kumar *et al*., 2023; Regasa *et al*., 2022).** Furthermore, Research has shown that larger seed tubers produce a higher overall yield than smaller ones **(Adhikari, 2005; de Almeida *et al*., 2016; Ebrahim, *et al*., 2018; Webster *et al*., 2018).** The advantage of using larger seed tuber pieces diminishes as their size increases beyond a certain point **(Iritani, *et al*., 1983)**. This is because the number of eyes on a tuber increases only slightly with increasing tuber size. Therefore, it is necessary to determine the minimum size of a seed tuber piece that contains a specific number of eyes. Researchers have observed that each eye on a potato tuber is capable of producing at least one stem under commercial growing conditions, an optimal yield is typically achieved with 2.5 to 3.5 stems per plant **(Bohl *et al*., 1994)**. Moreover, in recent years in summer season plantation some Egyptian farmers cutting imported seeds to small pieces containing one eye as a mean to reduce high cost of imported seeds. This study aims to determine the optimal the number of eyes present on each tuber and the appropriate plant spacing to achieve the highest yield per unit area in summer season plantation which it is the source of seeds for winter and full seasons.

2. Materials and Methods

A field experiment was performed at the Vegetable Research Station in kaha, Horticulture Research Institute (HRI), Agricultural Research Center, Egypt during the two successive summer seasons 2023 and 2024 to study the effect of the response of the number of eyes of a potato seed to different planting distances and its reflection on vegetative growth, yield, and quality traits.

2.1. Experimental Design

The treatments were arranged in a split plot design where the main plots contained the seed pieces treatment and the distance between seed pieces were arranged in the sub plot. The experiment included twelve treatments, three main plot treatments (one, two and three eyes in seed tuber piece) and four sub-plot treatments (10, 15, 20 and 25 cm).

Plant spacing	No of plant	
	m^2	Fed.
10 centimeters	13.33	56000
15 centimeters	8.89	37333
20 centimeters	6.67	28000
25 centimeters	5.33	22400

Each treatment included three replicates and the area of the experimental unit was 12 m^2; 4 rows (A length of 4 meters and a width of 0.75 meters for row). Where vegetative samples were taken from the second line, crop samples and chemical analysis from the third line. The variety used in the study was Spunta seeds obtained from the Potato and Vegetable Vegetatively Propagated Vegetables Research Dep., (HRI). Planting date was on 2/1/2023 in the first season and on 5/1/2024 in the second season.

All the agricultural operations according to technical recommendations for potatoes in summer season by Egyptian Ministry of Agriculture and Land Reclamation. The cultivation was carried out in clay soil that was laboratory analyzed and its results are presented in Table 1, according to the procedures, established by Jackson (1973) and the average of the obtained data are shown in Table 1.

Table (1). Physical and chemical properties of the experimental soil

Physical properties			Chemical properties		
Seasons					
Items	2023	2024	Items	2023	2024
Sand %	19.55	19.37	Available N (ppm)	95.56	92.77
Silt %	18.65	19.33	Available P (ppm)	5.54	4.63
Clay %	61.80	60.18	Available K (ppm)	209.44	211.36
			pH	7.6	7.2

2.2. Recorded data

2.2.1. Vegetative growth parameters

After 45 days from planting germination percentage was determined as the followed equation (Germination% = (number of germinated seed tubers/total number of seeds planting) X 100). Measurements of the vegetative growth were carried out after 90 days of planting. Five plants were randomly selected to determine the average plant length, number of stems per plant, as well as both fresh and dry weight of the leaves and stems.

2.2.2. Yield and its component at harvest time

Measurements were taken on the yield and its components at harvest time, 120 days after planting as follows: Number of tubers/ plant, total yield of tuber/fed. (Ton) was calculated.

2.2.3. Quality of characteristics

1- The percentage of tubers dry matter calculated by taking sample weighing 100 grams from fresh tubers and dried in the oven at a temperature of 65°C for 72 hr.

2- For each experimental unit produced tubers were graded into three sizes, i.e. small size tubers (28-35mm), medium size tubers (35-55mm) and large size tubers (above 55).

3- Dry matter (%) and starch content of tubers according to **A.O.A.C. (1990),** Specific gravity was calculated as average of three grades for each treatment according to the methods of **Murphy and Goven (1959)** by the following formula: Specific gravity = Weight in air/ (Weight in air - Weight in water).

2.3. Statistical Analysis

The data that were recorded during the study years were subjected to statistical analysis of variance according to **Snedecor and Cochran (1989)**. Means were compared according to L.S.D. at 5%.

3. Results

3.1. Vegetative growth parameters

Results in Tables 2 and 3 show that the germination rate and characteristics of vegetative growth (plant height, number of branches, number of leaves, and fresh and dry weight of both branches and leaves), recorded the highest values obtained in a significant way when planting seed tuber piece (STP) containing three eyes compared to those STP- containing two eyes or containing one eye, except for the dry weight of the leaves, which led to an increase, but it did not reach the level of significance in two growing seasons.

Table (2). Vegetative growth characters of potato plants as affected by number of eyes and planting distances as well as their interactions during 2023 and 2024 seasons

Treatments		Germination (%)		Plant length (cm)		Average Number of leaves/plant		Average Number of stems/plant)	
		2023	2024	2023	2024	2023	2024	2023	2024
Number of eyes									
1		94.34	95.38	45.31	48.06	72.06	71.93	4.03	4.31
2		96.42	97.36	49.87	51.62	74.00	73.75	5.31	5.56
3		98.81	98.08	50.93	54.43	76.87	76.93	5.50	5.87
LSD at 5%		**2.92**	**1.34**	**2.69**	**0.58**	**1.43**	**2.37**	**0.58**	**0.21**
Planting distances									
10 cm		96.18	96.17	49.6	54.01	67.92	67.04	4.05	4.41
15 cm		95.65	97.33	50.56	53.23	75.03	73.93	4.61	4.97
20 cm		95.79	95.89	47.79	50.34	76.36	76.37	5.38	5.63
25 cm		98.47	98.35	46.79	47.90	77.92	79.48	5.61	5.97
LSD at 5%		**0.92**	**0.74**	**2.28**	**0.79**	**0.69**	**0.63**	**0.44**	**0.48**
Interactions									
Number of eyes	**Distances******								
STP1e*	**10 cm**	93.63	95.59	48.06	50.31	64.31	63.18	3.27	3.64
	15 cm	94.12	95.57	47.06	49.97	72.97	72.52	3.60	3.97
	20 cm	92.29	92.93	43.06	46.31	74.64	74.18	4.27	4.64
	25 cm	97.33	97.43	43.06	45.64	76.31	77.85	4.60	4.97
STP2e**	**10 cm**	94.84	95.91	53.20	54.04	68.33	66.66	4.31	4.64
	15 cm	95.34	98.37	51.54	53.70	74.00	74.00	4.97	5.31
	20 cm	97.51	97.19	47.87	51.37	75.33	75.00	5.97	5.62
	25 cm	98.01	97.93	46.87	47.37	78.33	79.33	5.97	5.97
STP3e***	**10 cm**	100.08	97.02	47.77	57.68	71.12	71.27	4.58	6.31
	15 cm	97.52	98.06	53.10	56.02	78.12	75.27	5.25	4.95
	20 cm	97.60	97.54	52.43	53.35	79.12	79.93	5.91	6.29
	25 cm	100.08	99.68	50.43	50.68	79.12	81.27	6.25	6.62
LSD at 5%		**1.60**	**1.29**	**3.96**	**1.37**	**1.19**	**1.10**	**0.76**	**0.83**

*: (STP 1e) the other contains only one eye, **: (STP2e) the piece contains two eyes, ***: (STP3e) the piece contains three eyes, ****: (10, 15, 20 and 25 cm) distances between each plant.

Tables (2) and (3)also shows that the effect of planting distances (10, 15, 20, 25 cm) on the characteristics and traits of vegetative growth (germination rate, branches number, leaves number, fresh weight and dry weight of both branches and leaves) recorded the highest values as the planting distances

increased respectively between seed pieces, except for the trait of plant height, which was the opposite of the other traits of vegetative growth, as it recorded a noticeable decrease as the planting distances increased. Table (3) also shows that the dry weight of the leaves increased with increasing planting distances, but it did not reach the statistical significance during the two study seasons. The interaction between the effect of the number of eyes on the seed piece and the planting distances on the germination percentage, plant height, branches number, leaves number, fresh weight and dry weight of both branches was significant with the highest values showed both seasons (Table 2 and 3).

Table (3). Vegetative growth characters of potato plants as affected by number of eyes and planting distances as well as their interactions during 2023 and 2024 seasons

Treatments		Fresh weight of leaves(g)		Dry weight of leaves(g)		Fresh weight of stems(g)		Dry weight of stems(g)	
		2023	2024	2023	2024	2023	2024	2023	2024
Number of eyes									
1		235.31	230.58	20.888	20.93	119.44	120.46	12.36	12.53
2		265.38	260.79	21.881	21.97	123.94	124.75	12.49	12.53
3		291.06	289.37	22.594	22.54	127.78	128.68	12.65	12.55
LSD at 5%		**16.04**	**5.83**	**NS**	**NS**	**1.79**	**3.43**	**0.10**	**0.09**
Planting distances									
10 cm		221.07	214.03	21.246	20.98	120.00	121.05	12.10	12.13
15 cm		247.74	234.62	21.490	21.38	121.93	122.05	12.31	12.30
20 cm		276.29	274.42	21.979	21.66	124.72	125.26	12.62	12.69
25 cm		310.57	317.92	22.435	23.24	128.23	130.15	12.96	13.02
LSD at 5%		**5.16**	**5.29**	**NS**	**NS**	**1.22**	**0.94**	**0.04**	**0.04**
Interactions									
Number of eyes	**Planting distances**								
STP1e*	**10 cm**	211.90	207.86	20.53	20.36	115.22	115.66	12.08	12.10
	15 cm	219.90	211.19	20.67	20.56	117.41	117.65	12.14	12.14
	20 cm	244.90	237.66	21.03	20.76	120.41	122.16	12.39	12.46
	25 cm	264.56	265.62	21.30	22.06	124.74	126.36	12.81	12.84
STP2e**	**10 cm**	221.83	213.43	21.28	21.09	119.23	121.38	12.09	12.12
	15 cm	241.83	229.46	21.61	21.49	122.82	122.96	12.30	12.28
	20 cm	281.83	277.03	21.94	21.82	126.38	125.69	12.64	12.68
	25 cm	316.00	323.26	22.68	23.49	127.32	128.96	12.93	13.06
STP3e***	**10 cm**	229.48	220.81	21.91	21.48	125.54	126.13	12.15	12.16
	15 cm	281.48	263.21	22.18	22.08	125.58	125.53	12.48	12.47
	20 cm	302.15	308.58	22.95	22.41	127.37	127.93	12.82	12.92
	25 cm	351.15	364.88	23.31	24.18	132.63	135.13	13.14	13.15
LSD at 5%		**8.94**	**9.09**	**NS**	**NS**	**2.12**	**1.64**	**0.07**	**0.07**

*: (STP 1e) the other contains only one eye, **: (STP2e) the piece contains two eyes, ***: (STP3e) the piece contains three eyes, ****: (10, 15, 20 and 25 cm) distances between each plant.

3.2. Yield and its components

Plants grown from STP-two eyes and STP-one eye produced fewer tubers compared to those grown from tubers containing STP-three eyes (Table 4). However, it was observed that the number of tubers produced from the crop was directly proportional to the increase in the number of eyes on the

tuber in both studied seasons, while the lowest number of tubers was obtained from tuber pieces containing one eye in the seed tuber piece. An inverse relationship was found between the number of tubers formed and the weight of the tubers in plants grown not only from tubers containing STP-three eyes, but also in plants containing STP-one eye or STP-two eyes; as the number of tubers decreases, the weight of the tubers increases, reaching its maximum in the yield of tubers containing STP-one eye. It was found that the number of tubers is directly proportional to the number of aerial stems on the plant, but inversely proportional to the weight of the tubers formed. Table (4) also shows that the effect of the number of buds (STP-three eyes, STP-two eyes, STP-one eye) on the yield decreased as the number of buds decreased. That is, the fewer the buds on the seed piece, the lower the yield, and vice versa. However, the effect of planting distances between plants (10, 20, 15, 25 cm) was the opposite of the effect of the number of buds. In other words, the greater the distance between plants, the lower the yield. The largest planting distance (25 cm) recorded a minimum yield of 14.977 tons/feddan and 14.726 tons/feddan in the 1st and 2nd seasons, respectively. Conversely, the lower the planting distance, the higher the yield. The less planting distance (10 cm) recorded a maximum yield of 17.094 tons/feddan and 17.019 tons/feddan in the 1stand 2nd seasons, respectively.

Table (4). Yield and its components of potato plants as affected by number of eyes and planting distances as well as their interactions during 2023 and 2024 seasons

Treatments		Yield (ton /fed.)		28- 35 mm (%)		35- 55 mm (%)		>55 mm (%)	
		2023	2024	2023	2024	2023	2024	2023	2024
Number of eyes									
1		15.586	15.552	3.91	3.88	42.68	41.64	53.41	54.07
2		16.178	15.931	4.92	4.89	44.28	43.41	50.80	51.69
3		16.387	16.346	5.92	5.82	45.40	45.66	48.68	48.52
LSD at 5%		**0.074**	**0.049**	**7.91**	**0.10**	**0.27**	**0.71**	**0.90**	**0.59**
Planting distances									
10 cm		17.094	17.019	8.61	8.57	50.77	50.06	40.63	41.37
15 cm		16.434	16.377	5.95	5.87	44.72	44.62	49.33	49.50
20 cm		15.695	15.650	2.97	2.94	41.05	41.02	55.99	56.04
25 cm		14.977	14.726	2.14	2.08	39.95	39.11	57.91	58.81
LSD at 5%		**0.063**	**0.037**	**0.12**	**0.07**	**0.66**	**0.72**	**0.87**	**1.18**
Interactions									
Number of eyes	**Distances****								
STP1e*	**10 cm**	16.905	16.794	7.12	7.08	49.61	48.83	43.27	44.10
	15 cm	16.068	15.977	5.41	5.46	43.28	41.90	51.32	52.64
	20 cm	15.225	15.148	1.89	1.83	39.36	40.21	58.75	57.95
	25 cm	14.145	13.878	1.21	1.17	38.49	37.24	60.30	61.60
STP2e*	**10 cm**	17.00	16.667	8.92	8.84	50.50	49.85	40.58	41.31
	15 cm	16.426	16.119	5.52	5.54	45.86	44.39	48.61	50.08
	20 cm	15.812	15.526	2.89	2.88	40.74	41.41	56.36	55.70
	25 cm	15.472	14.980	2.36	2.31	40.00	38.00	57.64	59.69
STP3e*	**10 cm**	17.376	17.256	9.78	9.80	52.19	51.51	38.03	38.69
	15 cm	16.808	16.718	6.92	6.62	45.02	47.59	48.06	45.79
	20 cm	16.048	15.962	4.12	4.12	43.04	41.43	52.84	54.45
	25 cm	15.313	15.019	2.85	2.76	41.36	42.10	55.79	55.15
LSD at		**0.109**	**0.085**	**0.22**	**0.12**	**1.15**	**1.25**	**1.50**	**2.05**

*: (STP 1e) the other contains only one eye, **: (STP2e) the piece contains two eyes, ***: (STP3e) the piece contains three eyes, ****: (10, 15, 20 and 25 cm) distances between each plant.

Table 4 also shows that the effect of the number of eyes (STP-three eyes, STP-two eyes, STP-one eye) on different tuber yield grade (size) varied according to the number of eyes on the seed piece. Using STP-three eyes recorded the highest percentage of small diameters tubers (28-35 mm) compared to using (STP-one eye or STP-two eyes). STP-one eye recorded the lowest reading for diameters (28-35 mm) and (35-55 mm), where these diameters recorded (3.91%-3.88%) and (42.68%- 41.64%) respectively of the total yield. This was followed by the seed piece containing STP-two eyes, which recorded (4.92%-4.89%) and (44.28%-43.41%) respectively. However, the seed pieces containing STP-three eyes recorded the highest percentage of the small diameters (5.92%–5.82% and 45.40%–45.66% respectively) during the two studied seasons. Alternately, Table 4 shows that the highest yield of large tuber (above 55) yield recorded when seed piece containing STP-one eye was used in both seasons (53.41% - 54.07%, respectively), followed by STP-two eyes, which recorded (50.80% - 51.69%, respectively), while the lowest reading obtained from planting STP-three eyes, which recorded 48.68% - 48.52%, respectively during the two growing seasons. As for the effect of the distance between planted seeds, on different sizes potato tubers yields, the 10 cm distance recorded the highest percentage of yield for the two small sizes (28-35 mm and 35-55 mm), recording 8.61%-8.57% and 50.77%-50.06% in both seasons, respectively. This was followed by a distance of 15 cm, recording 5.95%-5.87% and 44.72%-44.62% for the two small sizes in both seasons, respectively. The distance of 20 cm between planted seeds, recording 2.97%-2.94% and 41.05%-41.02%. Finally, the distance of 25 cm recorded the lowest of small sizes, recording 2.14%-2.08% and 39.95% -39.11% respectively during the two agricultural seasons. Conversely, the highest yield of the big size tubers (above 55 mm) recorded the highest percentage at a distance of 25 cm (57.91%-58.81%), followed by the distance of 20 cm (55.99%-56.04%), then the 15 cm (49.33%-49.50%), and finally the 10 cm (40.63%-41.37%).

Table (5). Yield and its components of potato plants as affected by number of eyes and planting distances as well as their interactions

Treatments		Tubers number		Starch%		Tubers dry matter (%)		Tubers specific gravity (g/cm^3)	
		2023	2024	2023	2024	2023	2024	2023	2024
Number of eyes									
1		6.62	6.43	14.37	14.01	20.25	20.25	1.080	1.080
2		8.06	7.68	14.02	13.77	20.22	20.19	1.080	1.079
3		8.31	8.06	13.99	13.96	20.19	20.16	1.080	1.079
LSD at 5%		**0.21**	**0.43**	**NS**	**NS**	**0.04**	**0.01**	**NS**	**NS**
Planting distances									
10 cm		6.97	6.81	13.93	13.51	20.03	19.99	1.078	1.078
15 cm		7.30	7.14	14.08	13.93	20.19	20.18	1.079	1.079
20 cm		7.41	7.47	14.21	14.12	20.25	20.24	1.080	1.080
25 cm		8.97	8.14	14.29	14.10	20.42	20.39	1.082	1.080
LSD at 5%		**0.64**	**0.61**	**NS**	**NS**	**0.03**	**0.01**	**3.690**	**1.114**
Interactions									
Number of eyes	**Distances****								
STP1e*	**10 cm**	6.29	6.60	14.14	13.53	20.06	20.12	1.078	1.078
	15 cm	6.62	6.27	14.27	14.09	20.21	20.20	1.080	1.080
	20 cm	6.29	6.60	14.60	14.17	20.30	20.29	1.081	1.080
	25 cm	7.29	6.27	14.47	14.26	20.43	20.40	1.082	1.081
STP2e*	**10 cm**	7.31	6.27	13.86	13.27	20.04	19.97	1.078	1.078
	15 cm	7.97	7.60	13.99	13.75	20.19	20.18	1.079	1.079
	20 cm	7.64	8.27	14.04	14.17	20.24	20.23	1.080	1.080
	25 cm	9.31	8.60	14.20	13.90	20.42	20.41	1.082	1.080
STP3e*	**10 cm**	7.31	7.56	13.80	13.72	19.98	19.89	1.078	1.077
	15 cm	7.31	7.56	13.97	13.96	20.17	20.15	1.079	1.078
	20 cm	8.31	7.56	14.00	14.01	20.20	20.21	1.080	1.080
	25 cm	10.31	9.56	14.19	14.16	20.41	20.38	1.082	1.080
LSD at 5%		**NS**	**1.06**	**NS**	**NS**	**NS**	**0.03**	**NS**	**NS**

*: (STP1e) the other contains only one eye, **: (STP2e) the piece contains two eyes, ***: (STP3e) the piece contains three eyes, ****: (10, 15, 20 and 25 cm) distances between each plant.

Regarding the tuber starch content did not reach statistical significance during the two study seasons (Table 5). Specific gravity, however, decreased with a decrease in the number of eyes on the seed tubers and increased with increasing spacing between plants. Dry matter content also increased with increasing spacing between plants.

4. Discussion

The results obtained from this study regarding vegetative growth characteristics (Tables 2 and 3) and productivity (Table 4) showed an increase with increasing number of eyes on the seed tuber (STP-three eyes, STP-two eyes, STP-one eye). This indicates that potato plant growth and productivity are directly and positively related to the number of eyes on the seed tuber plot. This positive relationship is consistent with the findings of **Arioglu (2009) and Masarirambi *et al*. (2012)**, who explained that as the number of eyes on the planted seed tuber increases, which leads to an increase in the number of stems, increase in the number of tubers formed and thus increased productivity. The data shown in Table (2) also indicate that increasing the size of the seed piece in (STP-three eyes) leads to an increase the speed of bud emergence, and the completion of germination which may be due to the increased amount of food stored in the large seed piece, which leads to supplying the growing plants with the necessary nutrients. These results are consistent with the results of **Mangal *et al*., (2024), Kumar *et al*., (2023) and (Gulluoglu and Arioglu, 2009), Ibrahim (2021) and Dawinder *et al*. (2020)** who found that potato seed pieces with a large size and a large number of eyes have a large amount of stored food, lead to an increase in the number of stems compared to smaller seed pieces**.** Similarly, **Shakh (2001) and Shayanowaka *et al*., (2014)** reported that the number of stems and tubers increased with increasing seed piece size due to higher relative growth rates of plants compared to seed pieces with fewer eyes. Our study indicates that as the number of stems on the seed piece containing STP-one eye is reduced, this increases stem branching, which increases the density of vegetative growth. This is consistent with the results of **Fleisher *et al*. (2011); Shayanowaka *et al*. (2014)**. The data shown in Table 2 indicate that increasing the distance (10 - 15 - 20 - 25 cm) between plants led to a significant increase in all the plant vegetative growth characteristics, as there was a significant increase whether the seed piece of tubers contained three eyes, two eyes or one eye. This may be due to improving photosynthesis process and reducing competition for nutrient absorption, which is reflected positively on the plant vegetative growth. A similar effect was previously recorded by **Dawinder *et al*. (2020).** The obtained results from this study indicated that planting STP-three eyes seed pieces produced higher yield than STP-two eyes tubers, and the latter produced a higher yield than STP-one eye tubers. This may be due to the fact that the size and weight of the seed piece increases with the number of eyes on it (**Kumar *et al*., 2023; Regasa*et al*., 2022).** However, planting distance of 10 cm produced a higher yield than a distance of 15 cm, and a distance of 15 cm produced a higher yield than a distance of 20 cm, and the latter produced a higher yield than a distance of 25 cm, whether the seed piece contained three eyes, two eyes or one eye. Similar effect was previously reported by **Vanderzaag and Demagante (1989).** The results shown in Table (2) indicate that the number of tubers and tuber yield per plant increased significantly when planting seed pieces contained three eyescompared to seed pieces containing two eyes or one eye, which had the lowest values when planted at equal distances. Similar results were found by **Mahmud *et al*. (2010), Islam *et al*. (2012) and Roy *et al*. (2015)** who stated that larger seed pieces produced a significantly larger number of large tubers per plant compared to smaller ones. The results also indicated that STP-one eye cultivation produced fewer tubers with higher tuber weights compared to STP-three eyes. This is attributed to the higher number of tubers produced in the latter case, possibly due to increased competition for nutrients among the plants. The increased number of eyes in the seed tuber cuttings, resulted in a higher number of stems and roots, is a known correlation between tuber production per plant and the number of main **(Bussan *et al*., 2007).** Similarly, Mahmud ***et al*., (2010)** stated that the reduced number of tubers produced in response to planting cuttings with fewer eyes, and consequently increased weight of individual tuber yield. Also, **Ayupov *et al*. (2014)** found that cutting seed tubers results in fewer eyes, fewer stems, and fewer tubers per plant, leading to increased weight and larger size of individual tubers, especially in cases of wide spacing between plants. The obtained results showed that the increase in the average weight of the resulting potato tuber was due to the large size of the seed tubers, which provided sufficient nutrients for growth and development in the initial growth

stage. on the other side, reducing the distance between plants leads to increased competition, and thus leads to a decrease in the availability of nutrients and smaller tuber size **(Somarin *et al*. (2010); Masarirambi *et al*., 2012)**. This is consistent with. The results of this study show that the number of tubers per plant achieved a significant increase with the increase of the number of eyes on the seed piece (STP-three eyes), but the second factor (planting distances) was also consistent with the first factor, as the number of tubers increased with the increase of the distance between plants to 25 cm, which means that there is an inverse relationship between the number of tubers produced and the weight of the tuber. Similar results have been reported **Mahmud *et al*. (2010), Tahmorespour *et al*. (2013) and Ayupov *et al*. (2014).** The results presented in Table (5) show that the starch content in the tubers did not reach statistical significance during the two study seasons. Specific gravity, however, decreased with a decrease in the number of eyes on the seed tubers and increased with increasing spacing between plants. Dry matter content also increased with increasing spacing between plants. This aligns with the findings of **Mwansa *et al*. (2002)** who stated that larger tubers produce larger quantities of tubers, which may lead to higher dry matter content. Conversely, **Dawinder *et al*. (2020)** demonstrated that the dry matter content in the tubers was not statistically significant.

5. Conclusion

The current study indicated that planting STP-one eye resulted in a decrease in the number of tubers and the total tuber yield per plant at spacing of 20 and 25 cm compared to three-eyed seed pieces. However, considering that the seed quantity used in STP-one eye was only one-third (33.33%) of that used in STP-three eyes, this resulted in savings in seed costs compared to the increased yield produced by the STP-three eyes piece. Furthermore, the single-eyed seed piece, planted at a spacing of 10 cm, could be the most profitable of all treatments in terms of net profit, according to the data obtained. The study recommends the use of one eye in seed piece on 10 cm in row spacing to obtain higher yield of tubers in seed size.

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