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Roots and Nutrient Distribution under Drip Irrigation and Yield of Faba Bean and Onion

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Abstract

Drip irrigation proved to efficiently provide irrigation water and nutrients to the roots of plants, while maintaining high yield production. This research was established to study the root and nutrient distribution under drip irrigation. Faba bean and onion plants were cultivated in the experimental farm of the Faculty of Agriculture of Suez Canal University in Ismailia city with the application of normal fertilizers to soil. The data showed that soil moisture content in the soil planted with faba bean increased with the horizontal distance between drippers, contrariwise moisture content decreased with horizontal distance with the soil planted with onion. The data showed the vertical distribution of root length, root length density and specific root length of faba bean and onion decreased with increasing soil depth. The data showed that ammonium and nitrate pattern at the soil planted with the both plants increased between drippers and laterals. The peak concentration was recorded 35 mg/kg at 60 - 80 cm soil depth for faba bean and onion, indicating that the NO_3-N leaching was low by drip irrigation. Available phosphorus was higher at the surface layer than the subsurface layer at the soil planted with faba bean and onion. Available potassium tended to move both horizontally and downward under drip irrigation.

Keywords

Drip Irrigation, Root Length Density, Nutrient Distribution

1. Introduction

Irrigation is the artificial application of water which aims to maintain the soil moisture required for an optimum in plant growth. The crop response to irrigation methods was often different [1], and the effect of irrigation development of crop root systems also differed from irrigation technique to another because of differences in soil water regimes. The changes of soil moisture, which is related to irrigation method, not only significantly affect the spatial distribution of crop roots and the efficiency of nutrition and water adsorption, but also directly affect the biomass of shoots [2].

Drip irrigation proved to efficiently provide irrigation water and nutrients to the roots of plants, while maintaining high yield production. Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of the impact of the sprinkler, which replaced flood irrigation. This is because high water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface runoff as well as minimal deep percolation [3].

Very significant differences in root growth exist among crops and effective rooting depths from 0.2 m to more than 1 m have been reported [4]. It is important to know the root growth of the vegetables and crops when trying to optimize the nutrients use efficiency in vegetable production both at the crop level and at the crop rotation level.

Information on root growth can also be used to design crop rotations. By placing deep-rooted crops at points in the rotation where available nutrients present in deeper soil layers, total losses can be reduced significantly. By placing shallow rooted crops only where little nutrients are available in deeper soil layers, nutrients losses after these crops can be reduced [4].

The aim of the present work was to study the distribution of roots and nutrients under drip irrigation system and growth parameters of faba bean and onion.

2. Materials and Methods

The study was conducted at the experimental site of Agricultural College of Suez Canal University during the winter season (2014/2015) at 30˚37'15.09"N and 32˚16'1.43"E. The soil of the experimental site was sandy in texture, very low in organic matter (0.3%) with pH (7.2) and EC (2.4 dSm^{-1}). The average climate conditions of the site of the experiment during the growing season were illustrated in **Table 1**. The available N, P and K were 35, 7, 70 mg/kg, respectively before the initiation of the experiment according to [5]. The faba bean (Giza 716) seeds were sowed and twenty-eight day old seedling of onion (Giza 20) were transplanted in double rows to the main field on 18/11/2014, with the spacing of 20 cm between the rows and 30 cm between the plants in a row. The experiment was laid out in a randomized complete block design having three replicate 3 × 3 m in a plot. Normal fertilizers applied to soil with drip irrigation. The levels of fertilizers adopted in the study were 47.6 kg N/ha, 47.6 kg P_2O_5/ha and 71.4 kg K_2O/ha for faba bean and 357 kg N/ha, 71.4 kg P_2O_5/ha and 114.2 kg K_2O/ha for onion plants. The normal fertilizers used in the experiment were ammonium nitrate, potassium sulphate and Diammonium phosphate. The first dose of the fertilizers added to the soil after one month after germination and then every two weeks until the maturity of the crops.

To study moisture content and nutrients distribution in the soil, samples were

Table 1. Monthly average temperature, relative humidity and evaporation during the growing season.

Months	Average temperature (C˚)		Average relative humidity (%)		Average evaporation (mm)
	Max.	Mini.	Max.	Mini.	
November 2014	28.6	14.3	88.9	34.8	2.9
December 2014	26.9	12.0	89.3	33.8	2.7
January 2015	22.4	10.0	86.9	44.8	2.3
February 2015	22.9	9.61	84.6	31.8	2.3
March 2015	28.5	14.5	89.3	26.0	2.8
April 2015	29.8	13.3	87.4	21.2	3.1
May 2015	35.1	18.5	86.4	21.1	4.3

collected according to [6] method using tube auger from the experimental area. Soil moisture was determined gravimetrically. Samples were air dried ground and sieved through a 2 mm screen and analyzed for available Nitrogen, phosphorus and potassium using standard procedures described by [5].

To study root distribution, root length, root length density and specific root length in the field, soil cores were removed using a 20 cm tall auger with an internal diameter of 10 cm. The cores were washed to collect the deep to 80 cm and one every 20 cm. Samples were collected at the end of the experiment. A similar method was obtained by [7].

Parameters assessments: After physiological maturity, ten plants from each of faba bean and onion were taken at random select for measuring plant height (cm), number of branches, number of pods, pods dry weight of plant, 100 seed weight (g) and seed yield of faba bean and number of leaves, bulb diameter (mm), bulb height (mm) and bulb fresh weight (g) of onion. The plant samples of faba bean and onion dried at 70˚C after that the samples were grinding and stored for analysis. Mineral content (N, P, K) of faba bean and onion plants were evaluated by [8] methods.

3. Results and Discussion

3.1. Moisture Distribution

The distribution of the water in the soil occurs along the hydraulic gradient between the wet and the dry soil, laterally by means of capillary action and vertically due to gravitation. In sand soil, the water moves more vertically than horizontally [9]. Drip irrigation system should apply water uniformity so that each part of the irrigated area receives the same amount of water. Wetting pattern in the soil and the spatial distribution of soil water depend on soil hydraulic properties, drip discharge rate, spacing and their replacement, irrigation amount and frequency, crop water uptake, rates and root distribution pattern [10].

The moisture distribution of the soil planted with faba bean was increased with the horizontal distance between drippers at the surface layer 0 - 20 cm. The peak value of the soil moisture was 12% at the 60 cm horizontal distance at 40 - 60 cm depth. The moisture distribution at depths 0 - 20, 20 - 40, 40 - 60, 60 - 80 cm closed to be uniform, and the same trend observed at the vertical distance illustrated at Table 2 and Figure 1.

For the soil planted with onion, the soil moisture content decreased with horizontal distance (2.9% to 2.0%) at 60 cm and fluctuated with depth but it could be described as the moisture content remain constant with depth. At the vertical distance, the percentage of soil moisture increased from 1.30% to 1.7% at 30 - 60 cm (Table 3, Figure 2). These results compatible with [11] who found that Surface drip irrigation allows water to move faster both vertically and horizontally and produced a wide surface wetted area at the top of the soil.

3.2. Root Distribution

The data in the Table 4 showed the vertical distribution of root length density and specific root length of faba bean and onion under drip irrigation system.

Table 2. The moisture distribution (%) of the soil planted with faba bean under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	5.27	3.43	3.64	2.50	3.32
20 - 40	4.95	2.83	3.60	3.33	2.83
40 - 60	4.42	3.67	12.3	3.40	2.43
60 - 80	4.45	3.83	3.96	3.73	3.85

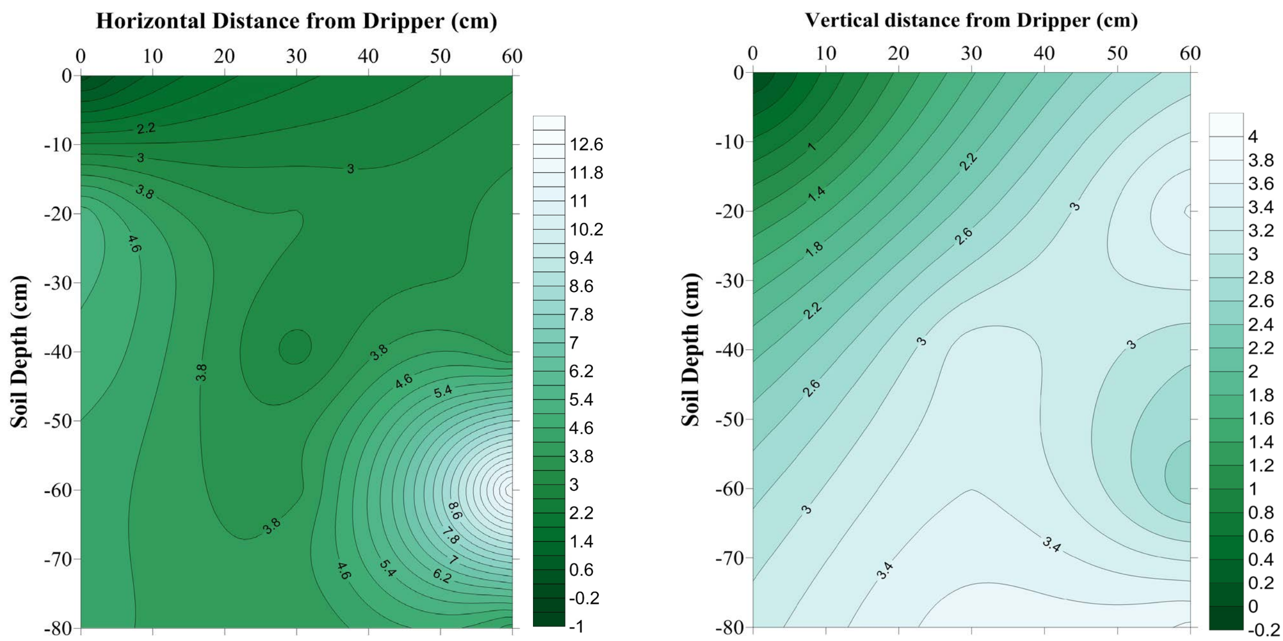

Figure 1. The moisture distribution of the soil planted with faba bean under drip irrigation.

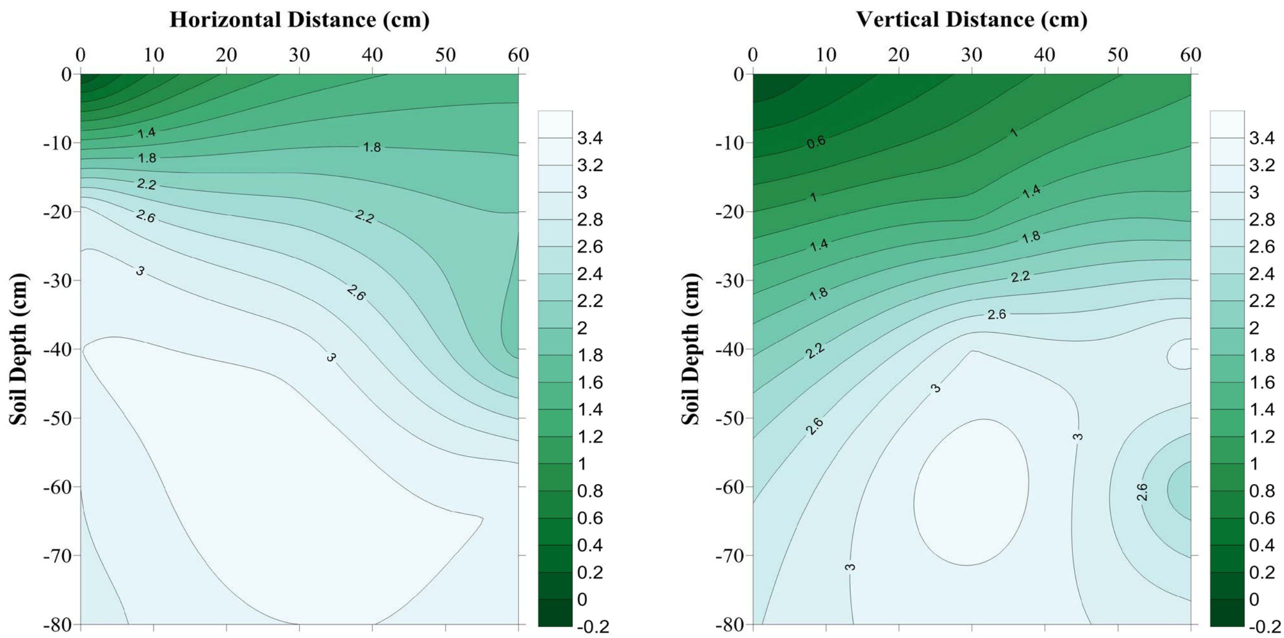

Figure 2. The moisture distribution of the soil planted with onion under drip irrigation.

Table 3. The moisture distribution (%) of the soil planted with onion under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	2.9	2.3	2.0	1.3	1.7
20 - 40	3.2	3.1	1.9	3.0	3.1
40 - 60	3.0	3.4	3.2	3.4	2.2
60 - 80	2.9	3.2	3.0	3.1	2.9

Table 4. Distribution of root length density and specific root length of faba bean and onion along soil profile under drip irrigation.

Plant	Soil depth (cm)	Root length density		Specific root length
		($cm \cdot cm^{-3}$)	%	$cm \cdot g^{-1}$ root dry weight
Faba bean	0 - 20	0.59 ± 0.012	72	18.41 ± 1.83
	20 - 40	0.23 ± 0.008	28	7.3 ± 0.52
	40 - 60	-		-
Onion	0 - 20	0.37 ± 0.015	71	35.12 ± 3.7
	20 - 40	0.152 ± 0.02	29	14.44 ± 2.5
	40 - 60	-	-	-

The root length density and specific root length decreased with increasing soil depth and the spatial distribution of roots was the basis for determining soil moisture changes at different soil depths. This results because of the close association of crop root growth with soil water. Similar reports were reported by [12] [13] [14] [15] [16].

Under drip irrigation, 72% of root length density of faba bean was found at 0 - 20 cm layer and 28% of root length density was at 20 - 40 cm and below this depth, the roots disappeared from the 40 - 60 cm depth. Specific root length in the upper layer 0 - 20 cm was higher (18.41 $cm \cdot g^{-1}$ root dry weight) than the subsurface layer (20 - 40 cm).

With regard to the root length density of onion at the top layer was 71% of the total root length density with the soil depth. In this respect, [17] stated that onion had very slow rooting depth penetration only about 0.2 mm day^{-1} C°. Similarly faba bean roots, the roots of onion weren't found at the soil depth 40 - 60 cm. The value of specific root length at the top layer was 35.12 $cm \cdot g^{-1}$ root dry weight. This because drip irrigation allows frequent application of shallow irrigation depths. A similar finding was reported by [18].

3.3. Nutrient Distribution

Irrigation introduces water rate into the soil along with salts dissolved in it. During irrigation, water with micro and macro elements is spread on the surface of the field. At drip irrigation, water is applied in one spot [19], and nutrient distribution in the soil depends on the form of nutrient ions, the moisture content of the soil and other reacting ions present in the soil solution, crop water uptake rates, and root distribution patterns. The availability of nutrients at the root zone of the crops influences the uptake and yield of the crop. Leaching, volatilization, and fixation of nutrients in the soil are some of the factors that affect the availability of soil nutrients [6].

3.3.1. Available Nitrogen

Nitrogen is the most important determinant nutrient for plant growth and crop yield. The behavior of N in the soil system is complex, yet an understanding of the basic N processes, is essential for a more efficient N management program. Major N processes in the soil are: mineralization, immobilization, denitrification and nitrification, and leaching. The most efficient way is to understand processes that contribute to N losses in soil and how can mineralization and nitrification be harnessed to improve N content in the soil. In coarse-textured soil, leaching is a dominant process that results in N losses. Nitrate-nitrogen (NO_3-N) is soluble and moves readily with soil water becoming a potential source of ground water pollution. Ammonium Nitrogen is less subjected to leaching from the soil compared to nitrate because of its adsorption in the Cation Exchange Capacity. However, losses of ammonium nitrogen through leaching occur in a coarse-textured soil with a low Exchange Capacity. Leaching is major N loss mechanism in coarse textured soil. Therefore, a proper understanding of N movement in coarse-textured soils can reduce N losses through leaching in the soil [20] [21].

At the end of the season, ammonium availability was studied at the soil planted with faba bean under drip irrigation (**Table 5** & **Figure 3**). The NH_4^+-N

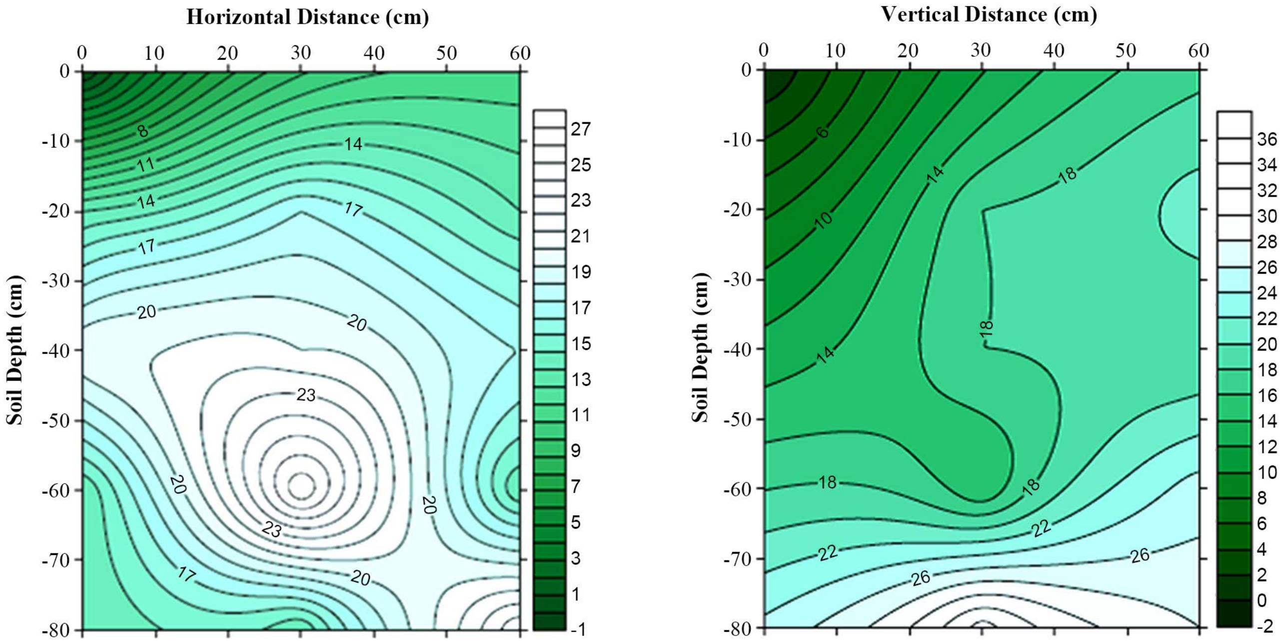

Figure 3. Ammonium-nitrogen distribution of the soil planted with faba bean under drip irrigation.

Table 5. The distribution of ammonium nitrogen (mg/kg) in the soil planted with faba bean under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	30	60
0 - 20	14	18	14	18	21
20 - 40	21	21	18	18	18
40 - 60	14	28	14	14	25
60 - 80	14	14	25	35	28

concentration was increased up to 30 cm at all depths at the horizontal distance. The highest available NH_4^+-N (21 and 28 mg/kg) was found at depth 20 - 40 and 40 - 60 cm, respectively) horizontally at the distance of 30 cm. The NH_4^+-N concentration decreased horizontally at 60 cm. At the vertical distance, 0 - 30 and 30 - 60 cm, the NH_4^+-N increased with depth from 0 - 80 cm and increased from 0 - 30 to 30 - 60 cm with 18 to 21 mg/kg at 0 - 20 cm depth.

With regard to the soil planted with onion, the ammonium distribution illustrated in Table 6 and Figure 4. Ammonium concentration increased up to 30 cm (35 mg/kg) then declined to 20 mg/kg at 60 cm, horizontally and with soil depth. The NH_4^+-N increased with the increase in vertical distance 0 - 30 cm and 30 - 60 cm in 20 - 40, 40 - 60 and 60 - 80 cm. At the surface layer, the concentration of NH_4^+-N decreased from 42 mg/kg to 35 mg/kg) at 30 - 60 cm.

With regarding to the NO_3^--N concentration of the soil planted with faba bean, the data showing that NO_3^--N concentration decreasing horizontally up to 60 cm at the depth of 0 - 20 cm. The highest concentration of NO_3^--N was found horizontally at 30 and 60 cm with the depth of 20 - 40 cm and 60 - 80 cm,

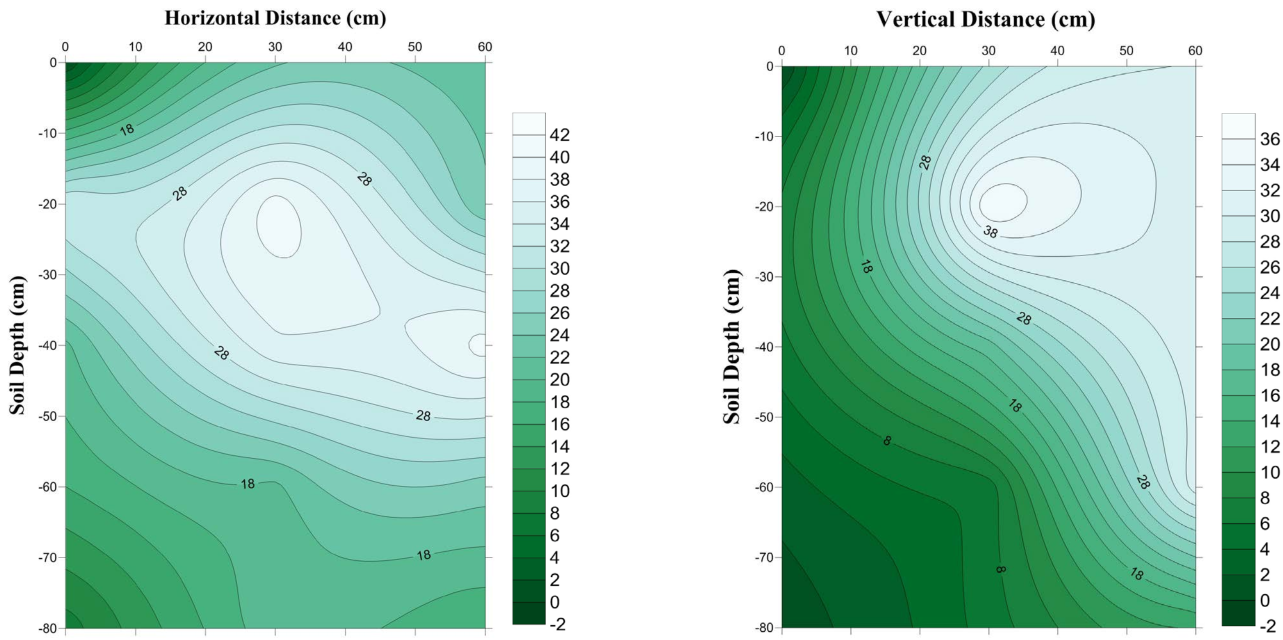

Figure 4. Ammonium-nitrogen distribution of the soil planted with faba bean under drip irrigation.

Table 6. The distribution of ammonium nitrogen (mg/kg) in the soil planted with onion under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	28.0	35.0	20.0	42.0	35.0
20 - 40	17.5	31.5	35.0	21.0	35.0
40 - 60	14.0	17.5	21.0	7.00	35.0
60 - 80	7.00	17.5	14.0	7.00	14.0

respectively. The data in Table 7 & Figure 5 showed that the nitrate move slowly at the soil depth and horizontally between the drippers and this may be due to the root distribution of faba bean at the surface layer consumes the nitrate from the soil solution. At the vertical distance between the laterals, the NO_3^--N content increased from 0 - 30 to 30 - 60 cm at depths from 0 - 60 cm. The peak concentration of NO_3^--N was found 35 mg/kg at 60 - 80 cm depth. It could be concluded that the NO_3^--N leaching was low by drip irrigation.

Nitrate movement at soil planted with onion showed at Table 8 and Figure 6. The distribution of NO_3^--N throughout the profile varied horizontally and vertically. At 0 - 20 cm, the NO_3^--N concentration declined with the horizontal distance to 60 cm from 35 to 21 mg/kg. In the depth of 20 - 40 cm, the NO_3^--N decreased at 30 cm to 21 mg/kg then increased to 35 mg/kg at 60 cm between drippers at depths 40 - 60 cm and 60 - 80 cm. Along the lateral, the NO_3^--N increased from 21 to 25 mg/kg at 30 - 60 cm in 0 - 20 cm soil depth. Hence, more quantity was available in the upper layer of soil under the drip irrigation system. A Similar conclusion was reported by [1].

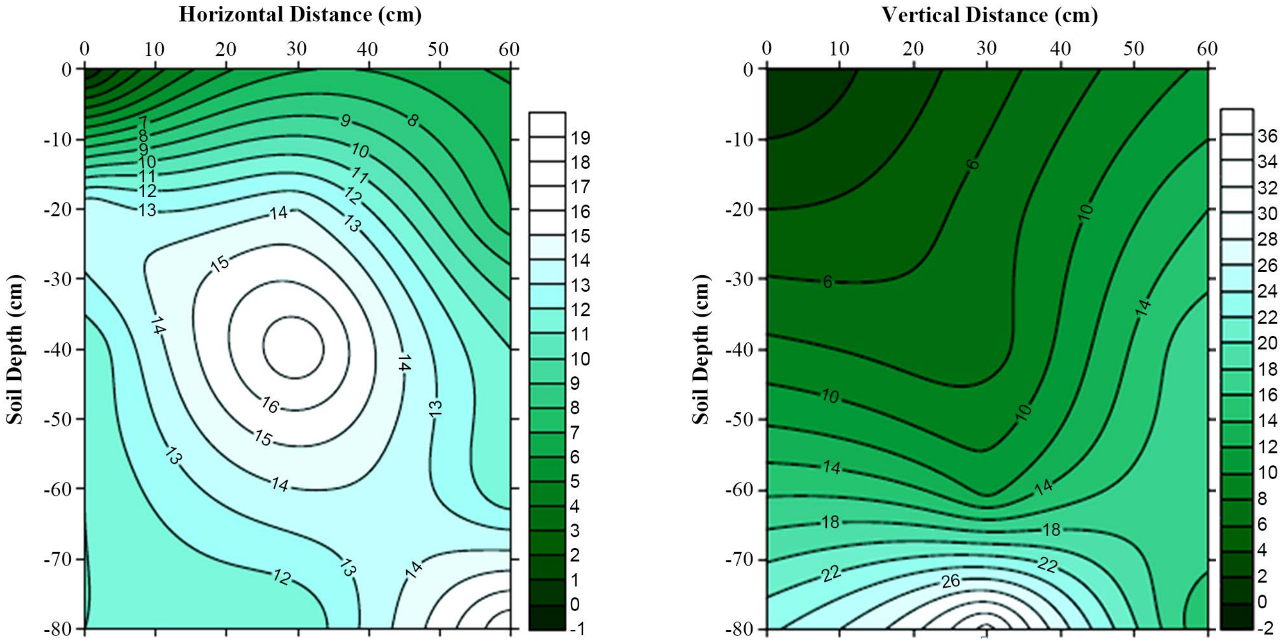

Figure 5. Nitrate -nitrogen distribution of the soil planted with faba bean under drip irrigation.

Table 7. The distribution of nitrate-nitrogen (mg/kg) in the soil planted with faba bean under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	14	14	7.0	7.0	14
20 - 40	11	18	11	7.0	18
40 - 60	11	14	11	11	18
60 - 80	11	11	18	35	14

Table 8. The distribution of nitrate-nitrogen (mg/kg) in the soil planted with onion under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	35.0	28.0	21.0	21.0	28.0
20 - 40	35.0	21.0	35.0	28.0	24.5
40 - 60	14.0	14.0	35.0	28.0	21.0
60 - 80	28.0	24.5	28.0	14.0	21.0

3.3.2. Available Phosphorus

Phosphorus is one of the most important nutrients for plant growth so in most cases applied P fertilizer can lead to higher yield. Phosphorus transport in both vertical and lateral directions was too slow for the average rate of root growth into the soil [22].

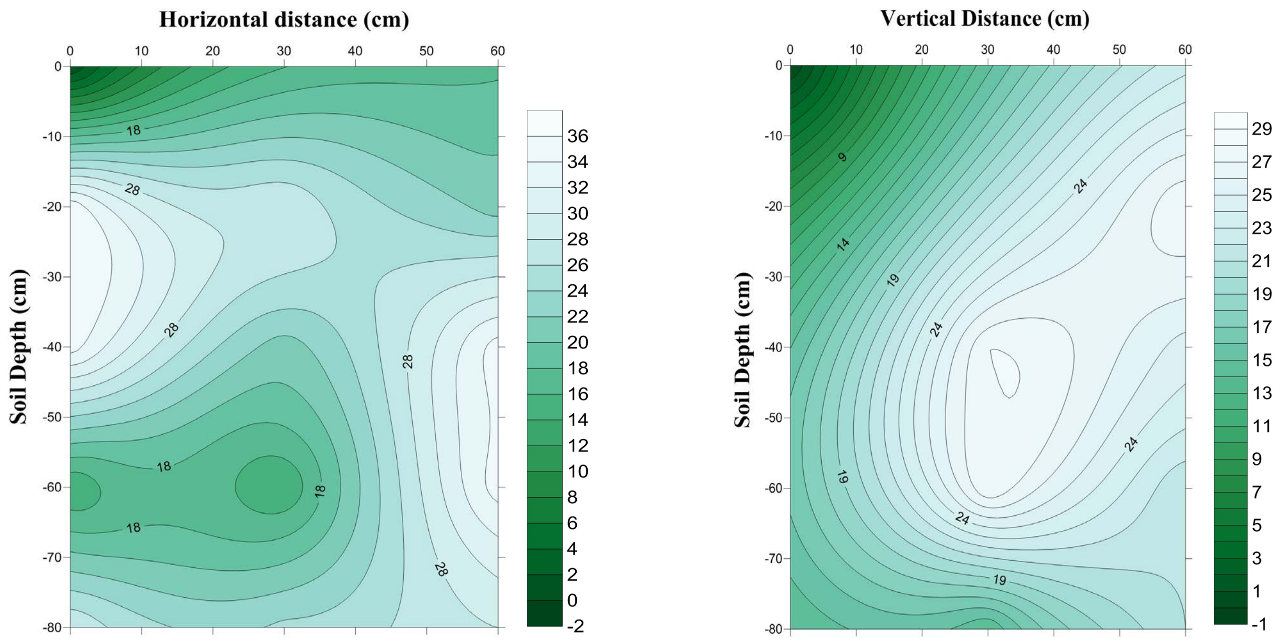

Figure 6. Nitrate-nitrogen distribution of the soil planted with onion under drip irrigation.

At the end of the season, data showed that phosphorus availability at the soil planted with faba bean was higher in the surface layer than the subsurface layers between drippers and laterals (**Table 9** & **Figure 7**). The peak value of available phosphorus was 47.7 mg/kg at 30 cm then it declined to 35.3 mg/kg at 60 cm. At the vertical distance between laterals the available phosphorus decreased with the distance from 32.5 mg/kg to 22.7 mg/kg) at 30 - 60 cm and decreased also with the depth to 60 - 80 cm. Phosphorus tends to accumulate at the soil top layer 0 - 20 at horizontal and vertical distance near the point of application under the drip irrigation system. This result was in agreement with [6].

Phosphorus pattern at the soil planted with onion is illustrated in **Table 10** and **Figure 8**. Available phosphorus decreased with soil depth at horizontal distance 0, 30, 60 cm. Higher phosphorus was recorded (20.6 mg/kg) at 0 - 20 cm below the dripper at the horizontal distance (0 cm). Available phosphorus decreased at 30 cm (11.8 mg/kg) then increased at 60 cm (16.8 mg/kg) in 0 - 20 cm soil depth. The same result was observed at the other depths. Available phosphorus increased with vertical distance 0 - 30 cm to 30 - 60 cm and decreased with soil depth. [22] found that phosphate movement is not directly proportional to water movement. Phosphate transport in both vertical with depth and lateral directions was too slow for the average rate of root growth into the soil.

3.3.3. Available Potassium

At the end of the experiment, potassium availability was determined at the soil planted with faba bean under drip irrigation. **Table 11** and **Figure 9** showed that the available potassium at the top layer 0 - 20 cm increased with the distance between drippers at the horizontal distance of 30 and 60 cm with the depth of 0 - 60 cm. The potassium availability was increased at 60 cm from 100 to 115 mg/kg at the horizontal distance. This may be to the leaching of potassium from the soil

Table 9. The distribution of phosphorus (mg/kg) in the soil planted with faba bean under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	35.5	47.7	35.3	32.5	22.7
20 - 40	27.5	39.1	26.0	21.0	17.4
40 - 60	21.7	22.1	8.3	15.6	9.8
60 - 80	23.2	18.7	13.4	9.8	8.6

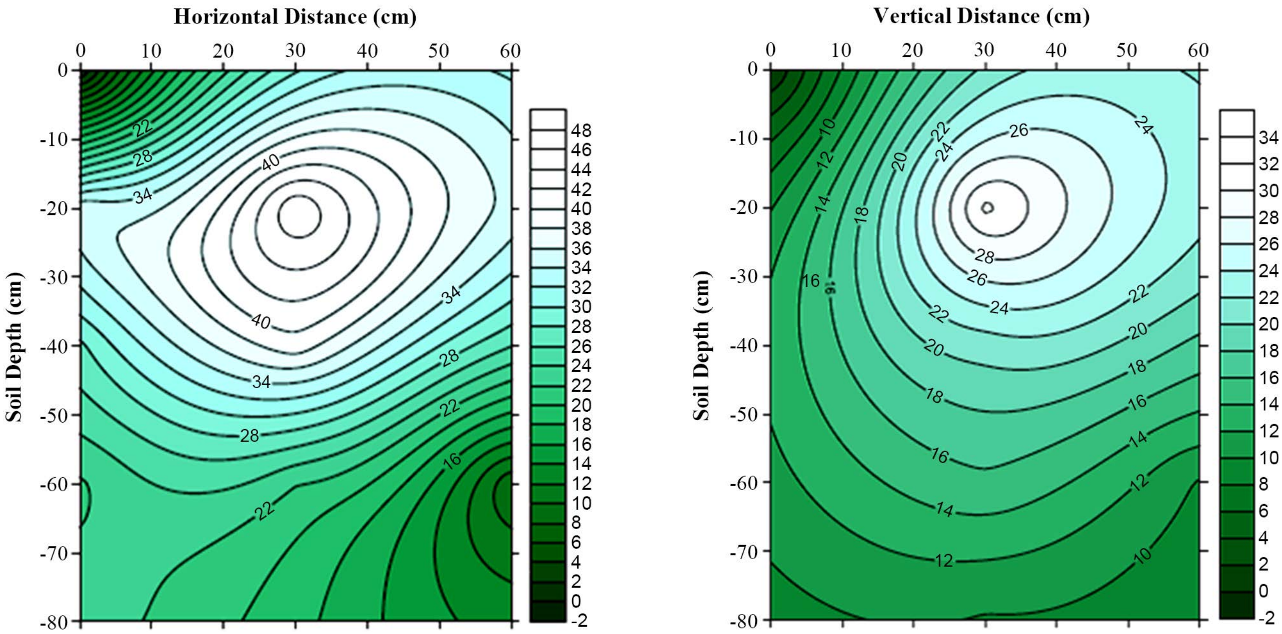

Figure 7. Phosphorus distribution of the soil planted with faba bean under drip irrigation.

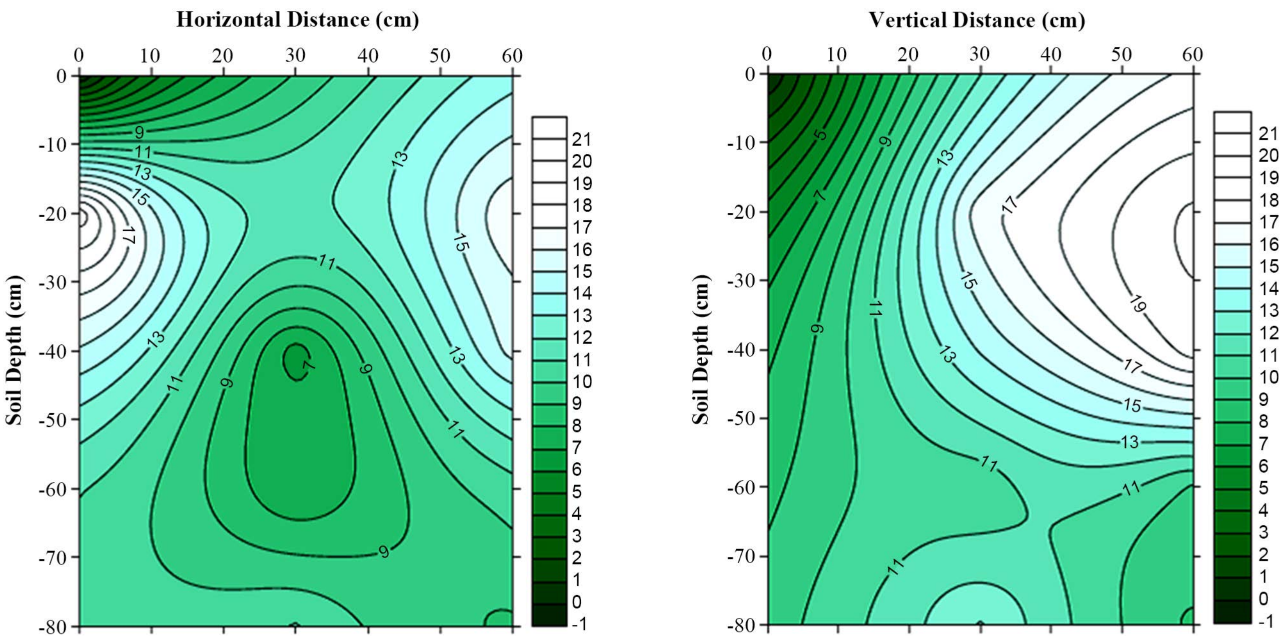

Figure 8. Phosphorus distribution of the soil planted with onion under drip irrigation.

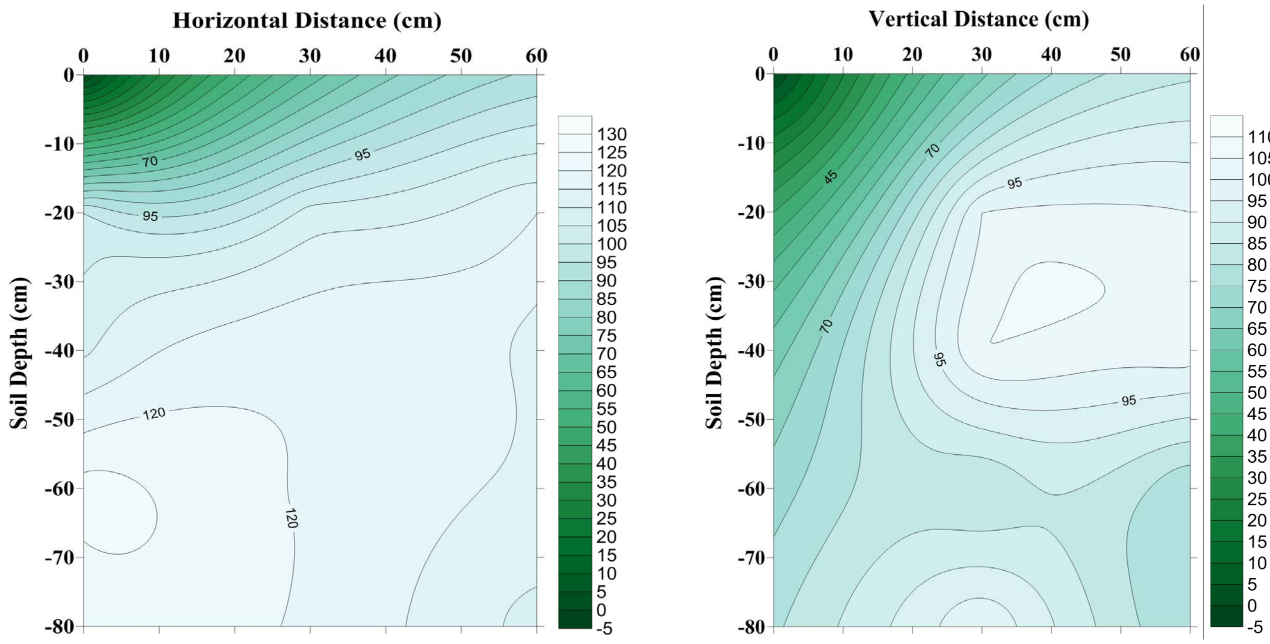

Figure 9. Potassium distribution of the soil planted with faba bean under drip irrigation.

Table 10. The distribution of phosphorus (mg/kg) in the soil planted with onion under drip irrigation.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	20.67	11.85	16.89	16.64	20.2
20 - 40	14.88	6.56	15.38	14.12	19.6
40 - 60	11.09	7.06	10.60	10.33	9.80
60 - 80	10.42	11.09	8.83	13.11	8.83

Table 11. Distribution of potassium (mg/kg) in the soil planted with faba bean under drip irrigation system.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	100	107	115	100	100
20 - 40	109	118	114	105	103
40 - 60	127	119	114	80.0	75.0
60 - 80	122	119	108	100	75.0

surface to the subsurface layers. The potassium moves both horizontally and downward under drip irrigation, resulting more uniform distribution of the available potassium in the wetted soils. With regard to the vertical distance between laterals, the movement of potassium is declined with the distance from 0 - 30 and 30 - 60 cm and with the depth. At the top layer 0 - 20 cm, the available potassium remains constant with vertical distance (100 mg/kg). These results in agreement with that obtained by [22] who found that the available potassium throughout the profile tended to move with water toward the edge of the witting front. Many studies such as [23] [24] found the same results.

Potassium pattern at the soil planted with onion under drip irrigation showed at **Table 12** and **Figure 10** that the lowest concentration of available potassium was 108 mg/kg at the horizontal distance 30 cm (between drippers) in the 0 - 20 cm depth of soil, then it increased to 112 mg/kg at 60 cm across the lateral. In 20 - 40 cm, the available K concentration decreased with the horizontal distance from 112 mg/kg to 106 mg/kg. The same trend was found at 40 - 60 cm of soil depth. These results stand in good agreement with [23] who found that regular application of irrigation water has taken down the soluble potassium to the middle layer. Across lateral, available potassium raised with vertical distance 0 - 30 cm and 30 - 60 cm in surface and subsurface layer (0 - 20 cm and 20 - 40 cm, respectively). A similar finding was reported by [17] who found that the shallow rooted plants such as onion left on average 80 kg·ha^{-1} in the soil at harvest.

Table 12. Distribution of potassium (mg/kg) in the soil planted with onion under drip irrigation system.

Soil depth (cm)	Horizontal distance (cm)			Vertical distance (cm)	
	0	30	60	0 - 30	30 - 60
0 - 20	112	108	112	115	119
20 - 40	112	112	106	108	112
40 - 60	100	108	90.0	106	72.2
60 - 80	106	100	112	112	108

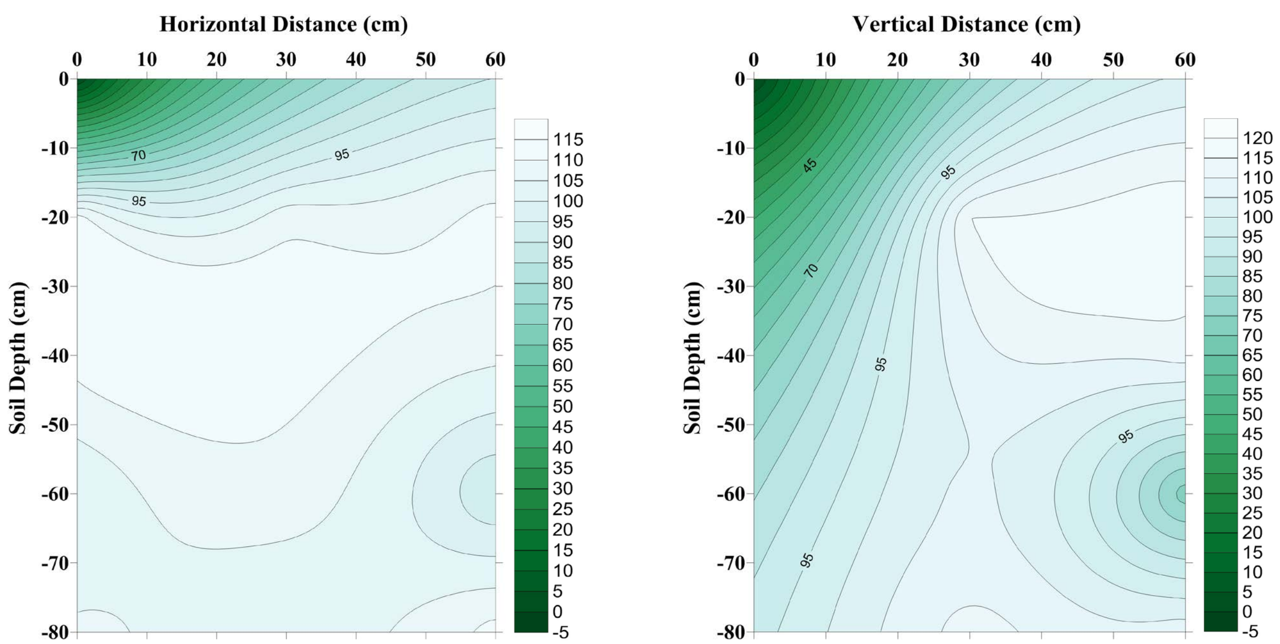

Figure 10. Potassium distribution of the soil planted with onion under drip irrigation system.

3.4. Plant Growth Parameters

Data presented in Table 13 & Table 14 show the faba bean and onion growth parameters and plant nutrient content. For faba bean, dry weight of plant was 75 g, plant height was 151.3 cm, number of branches was 7 branches for plant, pods dry weight of plant 183.7 g and average seed yield was 1102. Leaves N, P and K content were 27.7, 1.2 and 37.1 $g \cdot kg^{-1}$, respectively. Stems N, P and K content were 10.4, 0.89 and 13.1 $g \cdot kg^{-1}$. Roots content of N, P and K were 21.2, 1.7 and 7.8 $g \cdot kg^{-1}$, respectively. Seed content of N, P and K 42.6, 3.6 and 13.2 $g \cdot kg^{-1}$. For onion plants, plant length was 58 cm, number of leaves was 9.75. Bulb diameter and height were 5.96 and 4.81 cm, respectively. Fresh weight was 93.46 g. N, P and K content in leaves were 11.3, 1.5 and 13 $g \cdot kg^{-1}$ and in bulbs 11.5, 1.8 and 10.7 $g \cdot kg^{-1}$, respectively. Roots content of N, P and K were 11.2, 3.32 and 15.9 $g \cdot kg^{-1}$.

4. Conclusion

The understanding of plant root distributions and nutrient distribution pattern had become very important to develop the environmental practices including high frequency irrigation. This study was conducted in the experimental site of Agricultural College of Suez Canal University during the winter season. The data showed that soil moisture distribution was more uniformity under drip irrigation than surface and sprinkler irrigation. The distribution of root length density of faba bean roots was spread at the top layer under drip irrigation more than sprinkler and surface irrigation. The same result was observed for the distribution of onion's roots. Also, it observed that ammonium concentration was higher at the surface irrigation than drip and sprinkler irrigation, respectively. Most of the available nitrates were found in the top layer of soil at the sprinkler and drip irrigation as compared with surface irrigation in which more amounts NO_3^--N leaching down. The data showed that phosphorus availability at the

Table 13. Some growth parameters and nutrient content in faba bean plant under drip irrigation.

Plant	Dry weight of plant (g)	Plant height (cm)	No. of Branches	No. of pods	Pods dry weight of plant (g)	100 seed weight (g)	Seed yeild	Nutrient content ($g \cdot kg^{-1}$)											
								leaves			Stems			Roots			Seeds		
								N	P	K	N	P	K	N	P	K	N	P	K
Faba bean	75.02	151.3	7	38.7	183.7	48.8	1102.4	27.7	1.2	37.1	10.4	0.89	13.1	21.2	1.7	7.8	42.6	3.6	13.2

Table 14. Some growth parameters and nutrient content in onion plant under drip irrigation.

Plant length (cm)	No. of leaves	Bulb			Nutrient content ($g \cdot kg^{-1}$)								
		Diameter (mm)	Height (mm)	Fresh Weight (g)	Leaves			Bulbs			Roots		
					N	P	K	N	P	K	N	P	K
58	9.75	59.67	48.14	93.46	11.3	1.5	13	11.5	1.8	10.7	11.2	3.32	15.97

soil planted with faba bean was higher at the surface layer under drip irrigation but at the soil planted with onion, the highest concentration of available phosphorus was at surface irrigation. The potassium of the soil planted with faba bean and onion moves both horizontally and downward under drip irrigation. At the soil planted with onion, potassium decreased with increasing in soil depth.

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