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Effect of Drainage and Fertilization on the Faba Bean Crop in the Clay Soil

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ABSTRACT

A field experiment was carried out at North Nile Delta, Kafr El-Shiek Governorate, Egypt (31°22′ 53″ N latitude and 30°31′ 15″ E longitude) in two consecutive winter seasons 2020/2021 and 2021/2022, to examine the effect of distance from drain line (above drain line, 7.5m and 15m distance from drain line) and type of fertilization (mineral, organic and bio fertilizer) on some soil physio-chemical properties, quality yield and yield component of faba bean crop. Results indicated that: Above the drain line, both soil salinity and water table salinity decreased more than they did 7.5 and 15 meters away from the drain line. Above drain, the relationship between soil salinity and distance from drain line is more strong. The soil bulk density was lower above the drains than in that between drains. The average bulk density for the first season were 1.23, 1.30 and 1.34 g cm^{-3} for above drain line, 7.5m and 15m distance between the drain lines, respectively. For the second season, the equivalent figures were 1.14, 1.16, and 1.21 g cm^{-3}. Fine capillary pores (FCP) were found to be lower near the drains and to grow far from the drains, while quickly drainable pores (QDP) and slowly drainable pores (SDP) were found to be greater above the drain and to progressively decrease towards the midway between drains. Above drains the mean values of QDP, SDP and FCP are 12.55, 10.80 and 18.16%, respectively. 11.64, 9.89, and 21.83% are the equivalent values at 7.5m distances from drains line; 9.68, 9.76, and 24.81% are the corresponding values at 15m distances from drains line. A modest drop in pH values was observed. The greatest available N, P and K content in soil were raised up to 65.1, 10.66 and 644 mg/kg after 1st and up to 70, 13.2 and 600.6 mg/kg after 2nd harvesting season, respectively for organic fertilizer. Yields of faba beans were lower far from drain line than they were above it. The major grain yield were 13.13, 12.61 and 12.37 $ardabfed^{-1}$ for above drain line, 7.5m and 15m distance from drain line for two seasons, respectively. The corresponding main values of straw yield were 3.74, 3.25 and 2.3 ton fed^{-1}, respectively. A highly increase in yield and yield component (number of pod per plant, number of seed per pod, weight of hundred seed, seeds and straw yield) of faba bean result of mineral fertilization. Increases in nutrient content (nitrogen, phosphorus, and potassium) of faba bean seeds were seen across all treatments. Based on the results of the current study, the combinations between distance above drain line and mineral fertilizer are considered as superior increasing faba bean crop output and quality requires enhancing the soil's biological and chemical qualities.

Keywords: Drainage, Soil moisture, Clay Soil, Yield, Yield component, mineral, organic and bio fertilizers, Faba Bean.

1. Introduction

In order to prevent low permeable clay soils degrading, drainage is crucial. There is a significant region of heavy clay soils with limited permeability in the northern section of the Nile Delta in Egypt. Soil drainage systems remove surplus water and lower water tables, resulting in drier soil with improved topsoil structure, more infiltration, a lower bulk density and increased permeability, aeration, hydraulic conductivity, and porosity in the soil (Moukhtar *et al.,* 2010). Soil salinization and waterlogging are

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avoided thanks to drainage's primary purpose (Ayars *et al.,* 2006a). In general, a better drainage system in the soil leads to better soil qualities, which in turn increases agricultural yields and quality (Antar *et al.,* 2012 and Antar *et al.,* 2016). According to Yli-Halla *et al.,* (2009), the dropping of the groundwater table by subsurface drainage has noticeable affected the structure development of final clay soils.

The faba bean (*Vicia faba* L.) has a high nutritional value for human nourishment and serves as a break crop in Egypt's grain rotation system, making it the most significant legume crop in the country. The globe over, it ranks as the third most important feed grain (Singh *et al.,* 2013). About 85 percent of Egypt's faba bean plantings are located in the northern section of the country (El-Galaly *et al.,* 2008). The use of fertilizers, whether chemical, biological, or organic, is crucial in plant care. Adding the right amount of fertilizer can boost your crop yields, develops the nutrient element concentration in plant tissue and enhance the soil's macro and micronutrient condition. Soil deterioration, nutrient loss, and a decline in beneficial microbes are just a few of the environmental issues that may be traced back to the usage of chemical fertilizers (Parajuli *et al.,* 2019). The preservation of soil health, the growth of crops, the improvement of their quality, the reduction of production costs, and the maintenance of natural resources all depend on the use of bio fertilizer and organic fertilizer rather than chemical fertilizers (Oad *et al.,* 2004, Elturabi, 2019 and Foda *et al.,* 2021). Inoculating faba beans has been shown to boost yield and yield components, including shoot and root length, dry weight, and the number of nodules per plant. The yield and protein density were said to improve as a result (Babiker *et al.,* 1995). Using organic manure for crop production has several benefits, including enhancing the soil's physical, chemical, and biological qualities and gradually releasing nutrients as they are broken down by soil microbes (Risse *et al.,* 2001; Ali *et al.,* 2014 and Elturabi, 2019). Additionally, manure is a good source of important plant nutrients like P, N, and K, and it increases the dry matter yield of faba bean plants by enhancing their nodulation, growth, and yield characteristics and NPK absorption by the growing plants (Singh, 2005; Farid *et al.,* 2018 and Elsagan, 2020). In both seasons, however, the mineral content of NPK and protein seeds was higher than that of organic and bio fertilizer. (Elturabi, 2019).

Therefore, the goal of this research was to determine the effect of distance from drain line and types of fertilizer on some soil properties and quality yield of faba bean plants.

2. Materials and Methods

Two field experiments were carried out in the North Nile Delta Motobus District, Kafer El-Shiek Governorate, Egypt (31°22′ 53″ N latitude and 30°31′ 15″ E longitude) during two winter seasons of 2020/2021 and 2021/2022, to evaluate the effect of distance from tile drain line and type of fertilization (mineral, organic and Bio-fertilizers) on soil properties, quality yield and yield component of Giza 843 faba bean (*Vicia faba* L*)* cultivar. The field was provided by tile drain spaced at 30 m and 1.2 m depth with 0.1 % slope. Distributed soil samples were collected at depths of 0-15, 15-30 and 30-45 cm from soil surface before experiment and they subjected to chemical analysis according to Page *et al.,* (1982). Table (1) displays some soil parameters for the region under study. The experiment included three replicates and was set up in a split plot design, with the main plots being allocated to different distances from the drain line and the sub plots being assigned to different nitrogen sources as follows:

Main plots: distance from drain line

D1- Above drain line.
D2- 7.5m far from drain line.
D3- 15m far from drain line (midway between tow drain).

Sub plots: nitrogen sources:

F1- Mineral fertilizer (N-fertilizer as Urea) at a rate of 30 Kg N/fed, with a 10-kg N starter dosage and two 20-kg N/fed applications one month apart. The first N application occurred during the Mohayah irrigation (30 days after planting).
F2- Organic fertilizer as farm manure (10 m^3 fed^{-1}) was worked into the top 30 centimeters of soil before planting faba beans.
F3- Bio- fertilizer (*Rhizobium leguminosarum* isolate no. R-102, from Sakha bacterial lab) were inoculated to faba bean before sowing (600 g/fed).

On the 10th of November throughout both growing seasons, faba bean seeds were planted. Before planting, the experimental plots were given a single application of 22.5 kg P_2O_5/fed of single super phosphate fertilizer (15.5%P_2O_5). After a month of growth, 24 kg/fed K_2O of potassium sulphate (48 percent K_2O) was applied. Everything else done in the field was done as recommended according to the Egyptian Ministry of Agriculture.

Table 1: The initial of some soil properties for the experimental field.

Soil depth (cm)	Particle size distribution			Texture grade	EC (dS/m)	pH	SAR	Bulk density (g/cm^3)	Organic matter (%)	Available NPK (ppm)		
	Sand %	Silt %	Clay %							N	P	K
0-15	19.17	35.25	45.58	Clayey	1.65	7.71	3.49	1.15	2.01	37.1	7.6	569.4
15-30	18.79	30.42	50.79	Clayey	2.36		5.8	1.21				
30-45	14.32	22.51	63.17	Clayey	3.15		8.61	1.41				
Mean	17.43	29.39	53.18	Clayey	2.39		5.97	1.26				

Table 2: Some chemical analyses of organic fertilizer (F2) used in the experiment.

Seasons	Bulk density (g/cm^3)	Moisture content (%)	Ec 1:10 (ds/m)	pH	Organic matter (%)	Available nutrients (mg / kg):		
						N	P	K
2020-2021	0.21	31.04	3.95	8.71	45.7	12902	1571	27922
2021-2022	0.23	31.97	3.8	8.6	44.1	12969	1559	27899

Before the experiment and after harvesting the 1st and 2nd seasons from treatments instillation, soil samples obtained at 0- 15, 15-30 and 30- 45 cm below the soil's surface to analyzed physically and chemically. Saturated soil paste extract was analyzed for salinity using the method described by Page *et al.,* (1982). To keep an eye on the water table, observation wells were above and between drains at 15m and 7.5m away from the tile drain, as Dieleman and Trafford, (1976) suggested. In order to determine the salinity of the water table in each plot, samples were taken from the observation well. Drying the soil samples at 105°C to constant weight allowed us to estimate the soil's moisture content (%), as calculated by Singh, (1980). All treatments had core sampling technique to determine soil bulk density and total porosity of the different layers of soil profile, as specified by Campbell, (1994). De Leenher and De Boodt, (1965) used moisture retention curves to determine the pore size distribution of soil. Quickly drainable pores (QDP) are those that can hold water at a head pressure of 0.00 to 100 cm, whereas slowly drainable pores (SDP) may store water at a head pressure of 100 to 330 cm. There are two types of pores that keep soil moist: fine capillary pores (FCP) that keep water at a suction head of 15.0 atm, and water holding pores (WHP) that keep water between field capacity (330cm head) and wilting point (15000cm head). In the field, we used the auger-hole technique described by Van Beers, (1970) to determine the soil's hydraulic conductivity (K).

After faba beans were harvested soil samples (0-30 cm) were sampled from the treated plots. To be ready for chemical analysis, the obtained soil samples were allowed to air dry. Soil chemical composition was measured using established protocols. (Page *et al.,* 1982) and (Jackson, 1973). The Kjeldahl technique was used to calculate the soil's available nitrogen content (Cottenie *et al.,* 1982).

Both April 29th and 30th, 2021 and 2022, were successful harvest days for faba beans. Harvested faba bean seeds were oven dried at 70 degrees Celsius, fine crushed, and analyzed for nitrogen, phosphorus, and potassium content. Sulphuric acid and percloric acid were used to break down seed and straw samples (Jackson, 1967). Standard procedures were used to determine the levels of nitrogen, phosphorus, and potassium in the digested plant material (Page *et al.,* 1982). Kjeldahl technique, following AOAC method 979.09, was used to calculate the crude protein content (N× 6.25) **(**Upadhyay *et al.,* 2012**).** At harvest, we collected representative samples of faba beans and counted the number of pods per plant, the number of seeds per pod, and the weight of 100 seeds to calculate the seed yield (ardabfed^{-1}) and the straw production (tonfed^{-1}). Dry yield (kg/fed) was multiplied by N% (N content in percentage either for seeds or straw) to get N-uptake (kg/fed). The yields of faba bean seeds and straw were measured and analyzed statistically using the ANOVA method as described by Sendecor and

Cochran (1980). Duncan's multiple range test (Duncan, 1955) was used to analyze the differences between treatments.

3. Results and Discussion

3.1. Soil and water table salinity

Table 3 shows that there is a correlation between water table salinity and soil salinity. However, the salinity of the water table is much lower above the drain line than it is between drains. The values of water table salinity are 1.98, 2.47 and 3.5 dSm^{-1} in the 1st season and 1.55, 2.23 and 3 dSm^{-1} in the 2nd season in observation wells above drain line, 7.5m far from drain line and midway between drains (15m), respectively. One possible explanation is that the water table is lower along the drain line because the drainage system is more effective there, and/or because the soils directly above the drain line have been disturbed, allowing water to flow easily down and salts to be leached, resulting in higher concentrations of leached salts in the area close to the drain lines. These findings are consistent with those of Abo Waly *et al.,* (2012) and (Antar *et al.,* 2013).

Table 3 shows that increasing of soil depth, the salinity of the soil increases. The seasonal range for soil salinity from the surface to 30 centimeters deep was 0.794 to 1.85dSm^{-1}. Similar numbers may be seen between 1.23 and 3.15 in the 30-45 cm layer. Because of the high porosity of the surface layer, salts may be easily leached off. The influence of elevation above the drain line on soil salinity is greater than that of distance between drain lines. Sodium salts that have leached from the soil near the drain line might be to blame. These findings are consistent with those of Ibrahim, (1999) and Antar *et al.,* (2013).

Table 3: Soil and water table salinity averages beneath a faba bean plant as affected by the distance from a drain line.

Distance from drain line	Soil depth (cm)	First season 2020/2021		Second season 2021/2022	
		Soil salinity (dSm^{-1})	Water table salinity (dSm^{-1})	Soil salinity (dSm^{-1})	Water table salinity (dSm^{-1})
D1	0-15	0.794	1.98	0.94	1.55
	15-30	1.06		0.988	
	30-45	1.55		1.233	
Mean		1.13		1.05	
D2	0-15	1.04	2.47	1.07	2.23
	15-30	1.27		1.144	
	30-45	2.01		2.04	
Mean		1.44		1.42	
D3	0-15	1.082	3.5	1.09	3.00
	15-30	1.85		1.547	
	30-45	3.15		2.42	
Mean		2.03		1.69	

D1: Above drain **D2:** 7.5m distance **D:3** 15m distance

3.2. Effect of distance from drain line and fertilization on organic matter, pH and EC of soil:

Fig (1) indicates a minor drop in soil pH after faba bean harvesting in both seasons, and this drop may be ranked as follows; mineral > organic > bio fertilizer. Possible causes include declining organic matter and decreased buffering capacity in the soil. These findings are consistent with Khater *et al.,* (2004). The lowest value was achieved from bio fertilizer (7.16 and 7.49) in the 1st and 2nd season, respectively. Lowered soil pH from a combination of bio-fertilizer-released active microorganisms and naturally occurring acids or acid-forming substances also increasing microorganisms population led to increase CO_2 concentration which led to the present data (Nasef *et al.,* 2009).

Concerning EC values Fig (2) evidences a drop in value as a result of adding bio and mineral fertilizer. While organic fertilizer led to increasing EC. Values of salt in organic treatments may have increased, which might explain the rise in EC. Under the bio fertilizer treatment, the EC value was 0.79 dSm^{-1}, the lowest of all of the conditions tested. To best reduce soil EC, the interventions might be categorized as follows: bio fertilizer > minerals fertilizer. It's possible that bio fertilization boosted salt leaching because it increased soil porosity and aggregation (Zaka *et al.,* 2005 and Khalil, 2019).

Regarding organic matter content Fig (3) demonstrate that after faba bean harvesting second season, it was lower than those after first season. The highest values were obtained under organic fertilizer treatment (3.13 and 3.03%) in the 1st and 2nd season, respectively. Soil organic matter may be oxidized and decomposed quickly in the first season, but the decomposition process may take a long time (Khalil, 2019).

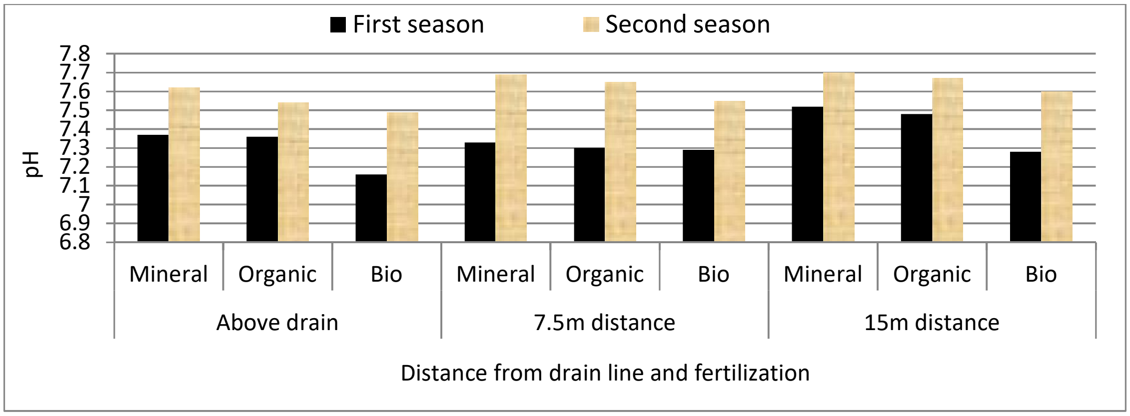

Fig 1: Effect of distance from drain line and fertilization on soil pH during the two growing winter seasons after feba bean harvest.

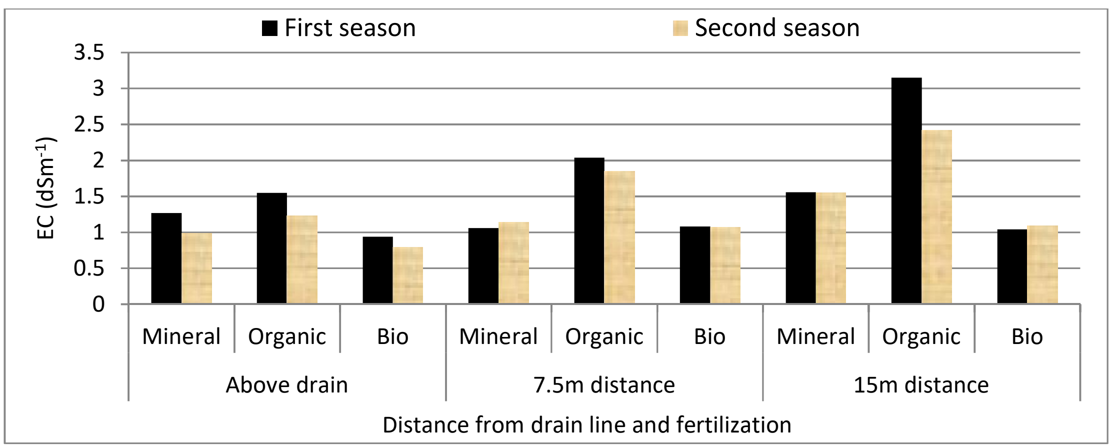

Fig. 2: Effect of distance from drain line and fertilization on soil EC (dSm-1) during the two growing winter seasons after feba bean harvest.

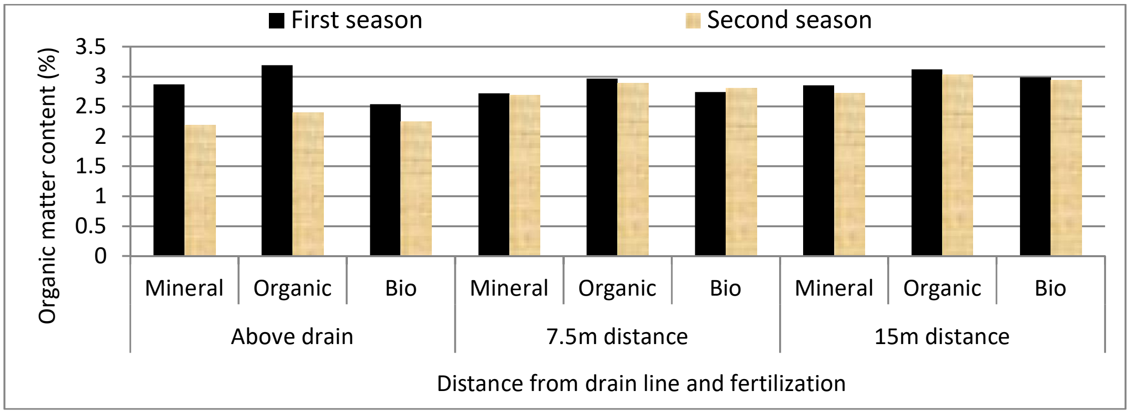

Fig. 3: Effect of distance from drain line and fertilization on soil organic matter (OM%) during the two growing winter seasons after feba bean harvest

3.3. Soil bulk density and soil porosity

The capacity of soil to hold water, air, and heat is directly related to its bulk density, which is a measure of the soil's structural health (Richards, 1954). The bulk density of the soil increased dramatically with depth for all of the investigated profiles, as shown in Table 4. This may have happened because the earth became more compact as a consequence of the added weight of the layers. This result was in harmony with those obtained by Antar *et al.,* (2012). Soil bulk density was found to be lower above the drains than between drains. For the first season, the average soil bulk density values were 1.23 g cm^{-3} above the drain line, 1.30 g cm^{-3} at 7.5 m distance between the drain line and 1.34 g cm^{-3} at 15 m distance between the drain line. The equivalent readings for the second season were 1.14, 1.16, and 1.21 g cm^{-3}.

The acquired data provided in Table (4) demonstrated a virtually inverse trend when comparing soil porosity to bulk density. For all treatments, increasing depth led to greater bulk density while decreasing depth led to greater total porosity.

3.4. Hydraulic conductivity

According to Table (4), hydraulic conductivity was greater above the drains than it was between them. Above the drain line, the hydraulic conductivity was 3.5 and 5.1 cm day^{-1} greater than it was 7.5 and 15 meters away from the drain in the first season, and 6.7 and 8.4 cm day^{-1} greater in the second. Similar results were obtained by Antar *et al.,* 2012 and Alakukku and Turtola, (2010).

Table 4: Soil bulk density (gcm^{-3}), total porosity (%) and hydraulic conductivity (cm day^{-1}) under faba bean crop for all treatments.

Treatments	Soil depth (cm)	First season 2020/2021			Second season 2021/2022		
		Bulk density (gcm^{-3})	Total porosity (%)	Hydraulic conductivity (cm day^{-1})	Bulk density (gcm^{-3})	Total porosity (%)	Hydraulic conductivity (cm day^{-1})
D1	0-15	1.074	59.47	12	1.06	60.00	15.6
	15-30	1.257	52.57		1.14	56.98	
	30-45	1.364	48.53		1.21	54.34	
	Mean	1.23	53.52		1.14	57.11	
D2	0-15	1.094	58.72	8.5	1.08	59.25	8.9
	15-30	1.392	47.47		1.16	56.23	
	30-45	1.401	47.13		1.23	53.58	
	Mean	1.30	51.11		1.16	56.35	
D3	0-15	1.154	56.45	6.9	1.12	57.74	7.2
	15-30	1.415	46.60		1.19	55.09	
	30-45	1.451	45.25		1.31	50.57	
	Mean	1.34	49.43		1.21	54.47	

D1: Above drain **D2:** 7.5m distance **D:3** 15m distance

3.5. Pore size distribution (average for two seasons)

Table 5 displays the pore size distribution of the investigated soil, broken down into four categories: slowly drainable pores (SDP), rapidly drainable pores (QDP), fine capillary pores (FCP), and water holding pores (WHP). Since more water will be evacuated by gravity near the drains, the results reveal that the percentage of SDP and QDP is highest above the drain and progressively decreases toward the halfway between drains. The percentage of FCP and WHP is lower close to the drains and higher farther away. The data shows above drains result in mean values of 10.80% for SDP, 12.550% for QDP, 15.26% for WHP, and 18.18% for FCP. 9.89%, 11.64%, 18.34%, and 21.84% are the equivalent values at 7.5m distances from drains; 9.76%, 9.68%, 20.84, and 24.81% are the similar values at 15m distances from drains. These findings are consistent with Wahdan *et al.,* (1992) and Antar *et al.,* (2012).

Table 5: Pore size distribution (QDP, SDP, WHP, and FCP %) with soil depths for all treatments (average for two seasons).

Treatments	Depth(cm)	QDP (%)	SDP (%)	WHP (%)	FCP (%)
D1	0-15	13.55	11.82	14.27	16.99
	15-30	12.36	10.86	14.88	17.71
	30-45	11.75	9.72	16.62	19.79
D2	0-15	12.27	10.51	17.39	20.70
	15-30	11.48	10.37	18.09	21.54
	30-45	11.17	8.79	19.55	23.27
D3	0-15	10.93	10.52	18.71	22.27
	15-30	9.34	9.73	20.74	24.69
	30-45	8.77	9.03	23.08	27.47

D1: Above drain **D2:** 7.5m distance **D:3** 15m distance

3.6. Soil moisture contents

One of the boundaries that may reveal the condition of the soil's structure and, by extension, its water, air, and temperature regimes, is the soil's moisture content. (Figs. 5 and 6) show how the soil's moisture is redistributed depending on how far it is from a drain line. The data showed that soil moisture levels were highest two days after irrigation and gradually decreased to their lowest levels before the next watering. Water loss occurs via transpiration and evaporation, and the water table gradually drops with time after irrigation, led to soil moisture contents ranged from 33.24 to 39.87% after 2 days and from 16.89 to 29.29% after 14 days from irrigation.

Table 6 shows that the distance from the drain line has a significant impact on the amount of moisture in the soil. In above the drains line soil moisture content are lower than that between drain lines and are superior in surface soil layers. Soil moisture content falls more rapidly above drain lines than between drains, and this trend persists until the following watering. Above drain, soil moisture levels decrease by (2.07, 7.86 and 8.39%) and (3.4, 5.65 and 7.02%) than that at 7.5m distance from drains and about (7.38, 9.23 and 24.92%) and (6.16, 8.52 and 25.12%) than that at a distance of 15m from drain lines for 2, 10, and 14 days after irrigation, in the 1st and 2nd seasons, respectively. Possible explanation: better drainage in the vicinity of the drain lines. However, soil that has been subjected to periodic cycles of soaking and drying has less compacted soil and better soil qualities. Additionally, drainage led to a lower water table, which enabled the top soil layer to dry out, shrink, and develop water passage ways, facilitating the transport of water more easily into drains (Antar *et al.,* 2013).

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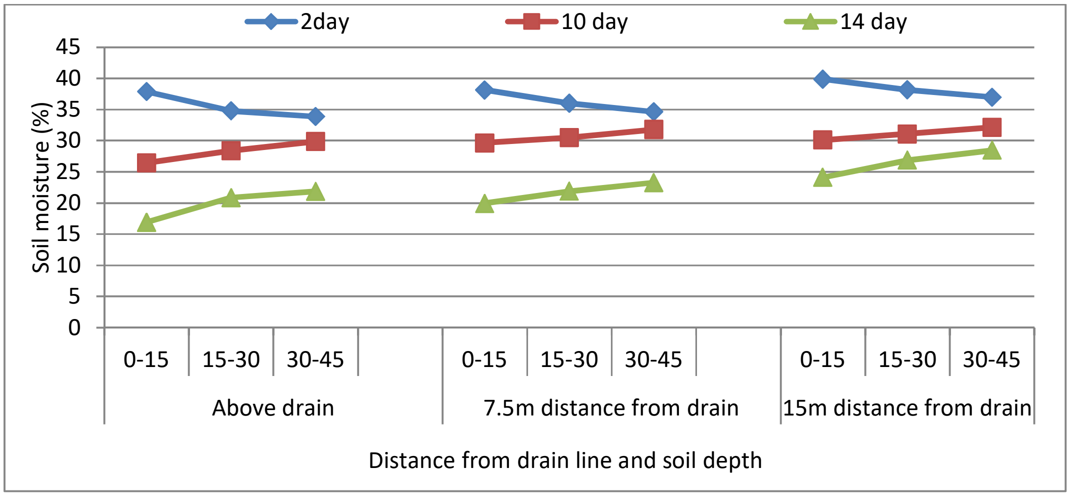

Fig. 5: Soil moiture content (%) after 2, 10 and 14 days from irrigation with distance from drain line and soil depth frist season.

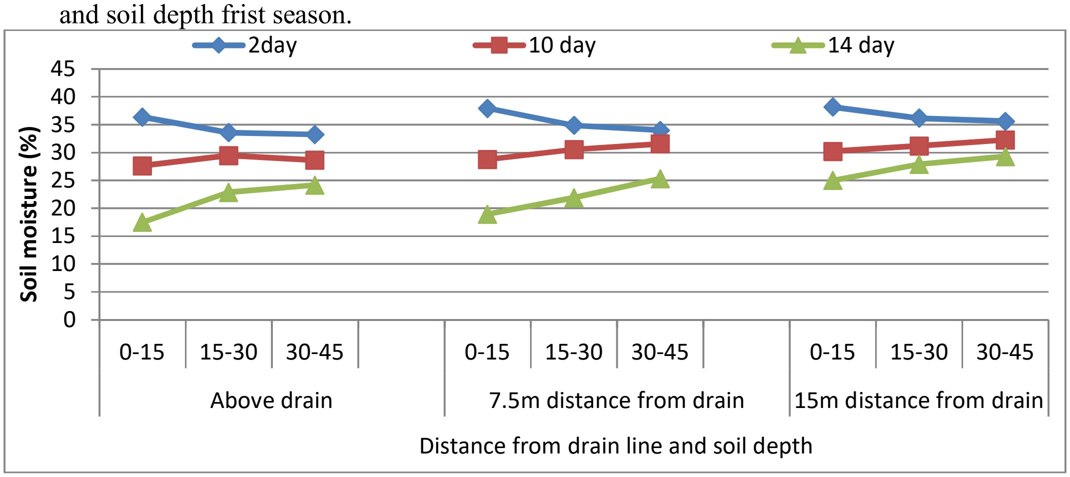

Fig. 6: Soil moisture content (%) after 2, 10 and 14 days from irrigation with distance from drain line and soil depth second season.

3.7. Effect of distance from drain line and types of fertilizers application on the availability of NPK (mg/kg soil) in the soil:

Figures 7, 8, and 9 show that the availability of nitrogen, phosphorus, and potassium was significantly impacted by the distance from the drain line and the kind of fertilizer used. The NPK in the soil is increased by using any kind of fertilizer. However, when comparing organic fertilizer, mineral fertilizer and bio fertilizer, the greatest primary values for available N, P, and K content in soil were achieved with organic fertilizer. Available N, P and K content in soil were increased up to 65.1, 10.66 and 644 mg/kg after 1st and up to 70, 13.2 and 600.6 mg/kg after 2nd harvesting season, respectively for organic fertilizer. This development may be explained by the fact that organic fertilizer, by acting as a natural chelating agent, increased the soil's availability of nitrogen, phosphorus, and potassium; moreover, it increased the soil's organic carbon status and its availability of nitrogen, phosphorus, potassium, and sulfur, therefore maintaining soil health according to the findings of Khalil, (2019) and Tiwari *et al.,* (2002). Mineral fertilization had done low soil available NPK (44.6, 9.19 and 423.7mg/kg soil) and (32.67, 7.5 and 452.4mg/kg soil) than organic one for 1st and 2nd season, respectively. This result agrees rather well with those obtained by Zaghloul *et al.,* (2015) total nitrogen, phosphorus, and potassium levels were found to be lowest in soil that had only been fertilized using artificial fertilizers. While mineral fertilizers may accelerate plant growth in the short term, they do nothing to enhance the health of the soil or the diversity of its inhabitants. The high water solubility of mineral fertilizers means that nutrient runoff from fields may pollute water sources like streams and ponds (Frank, *et al.,* 2002).

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The lowest soil available NPK (44.6, 9.19 and 423.7mg/kg soil) and (32.67, 7.5 and 452.4mg/kg soil) were found with bio fertilization in 1st and 2nd season, respectively. Organic acids with biological action produced by microflora may contribute to the bio fertilization effect by increasing nutrient solubilization (NPK) (Khafagy *et al.,* 2019).

Above drain line was the best treatment compared to 15m and 7.5m distance from drain line in terms of the availability of all three soil macronutrients (N, P, and K). This might be because the drainage system is more efficient close to the drain line than it is farther away. Which enhances oxidation states on contrary points far from drain line encourage reduction which enhances denitrification and nutrients fixation. Similar results were obtained by Gendy *et al.,* (2009) and Paulo, (2010).

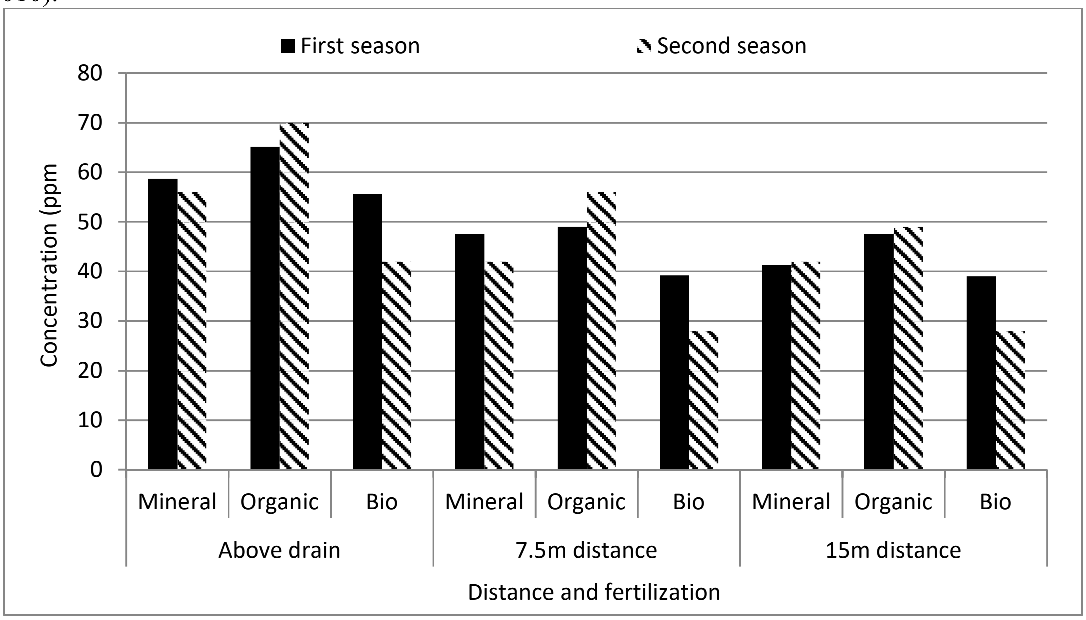

Fig. 7: Effect of distance from drain line and fertiliation on soil available nitrogen content (ppm).

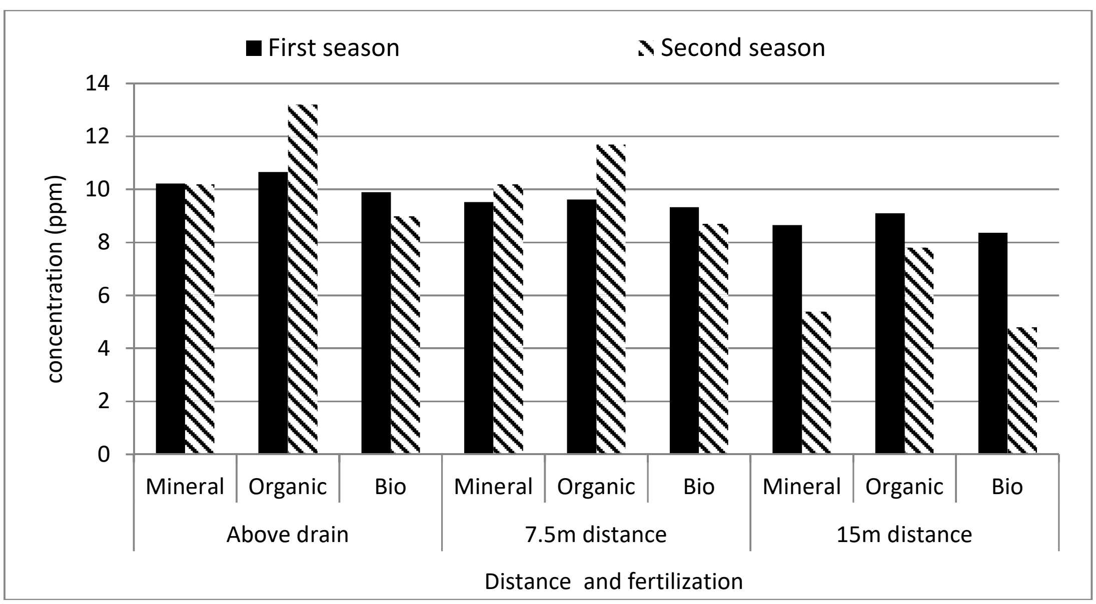

Fig. 8: Effect of distance from drain line and fertiliation on soil available phosphorus content (ppm).

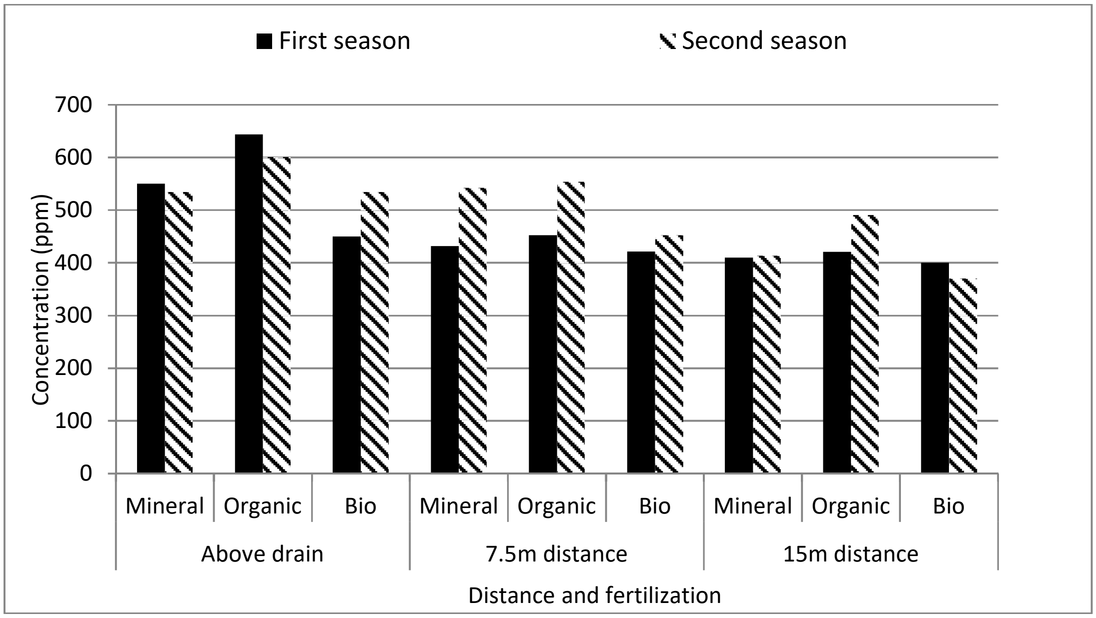

Fig. 9: Effect of distance from drain line and fertiliation on soil available pottasum content (ppm).

3.8. Yields and yield component

Table (6) displays data on faba bean yields and yield components in relation to the different distance from drain line and fertilization. Maximum values for pods per plant, seeds per pod, hundred seed weight, seed yield, and straw yield **(**13.78, 3.78, 107.56 g, 12.67 ardabfed-1 and 3.00 ton/fed) and (15.74, 3.97, 108.52 g, 12.73 ardabfed-1 and 3.19 ton/fed) were achieved from above drain line treatment in the 1st and 2nd seasons, respectively, followed by 7.5m distance from line treatment in both seasons. Results showed also that there is increase in faba bean yield and yield component of this study with reduce the distance from drain line. Higher faba bean yields and yield components may have resulted from drainage's capacity to condition the water-air connection in the root zone, hence increasing nutrient mobility in the root zone and stimulating further vegetative development. These results somewhat agree with those obtained by Moustafa *et al.,* (1987) and Antar, (2013).

Regarding, the effect of fertilization on yield and yield component combined data in Table (6) reveal that mineral fertilizer was superior treatment compared to others than organic and bio fertilizer. While application of organic fertilizer followed by bio fertilizer were inferior. Both seasons showed this trend. Treatment of mineral fertilizer had given the best average values of number of pods per plant, number of seeds per pod, weight of hundred seeds, seeds and straw yields (14.89, 4.22, 98.09 g, 12.22 ardabfed^{-1} and 2.97 tonfed$^{.-1}$) and (15.66, 4.41, 98.94 g, 12.27 ardabfed^{-1} and 3.15 tonfed$^{.-1}$) in 1st and 2nd season, respectively. This may be because mineral fertilizer's nitrogen is more readily available and efficient than organic fertilizer's nitrogen, both of which contain about the same amount of nitrogen but take much longer to decompose and liberate (Cooke, 1972). This result was in harmony with that obtained by AL-Deen Al-Leela *et al.,* (2019). Nitrogen's supportive function in the synthesis of protoplasm, proteins, amino acids, nucleic acids, and numerous enzymes and energy transfer materials may explain why mineral-N fertilizer improves plant development characteristics (Zaki and El-Din, 2007). Using of organic materials is safe for human health and environment. Organic fertilizer increase yields and yield component but lower than mineral. This may be because organic manure improves the soil's chemical, physical, and biological qualities by boosting soil organic carbon and the soil's ability to store nutrients (Souza *et al.,* 2010); soils' water-holding and cation-exchange capacities are increased, their bulk density is decreased, and the behaviors of various elements are enhanced (Ali *et al.,* 2014). In addition to the primary nutrients that plants need, such nitrogen, phosphorus, and potassium, manure also delivers many of the supplementary nutrients that plants need to thrive (Elsagan *et al.,* 2020). Results from the two-season bio fertilization experiment also reveal that the use of bio fertilization increased yields and their constituents. This might be because biological processes like nitrogen fixation and rock phosphate solubilization make essential nutrients (nitrogen, phosphorus) accessible to the plant, allowing it to thrive (Rokhzadi *et al.,* 2008 and Khalil, 2019). In contrast to the unchecked use of mineral-N fertilizers, which has been linked to negative effects on human health and the environment, bio fertilizer increases plant production while maintaining excellent quality Hellal *et al.,* (2011).

Table 6 further shows that the distance from the drain line and fertilization treatments significantly affected faba bean production and yield components in both growing seasons. The greatest averages for pods per plant, seeds per pod, weight of hundred seeds, seeds and straw yields (19, 4.67, 108.55g, 13.09 ardabfed-1 and 3.59 ton fed^{-1}) and (19.97, 4.77, 109.52 g, 13.16 $ardabfed^{-1}$ and 3.88 $tonfed^{-1}$) for above drain line with mineral fertilizer in the 1st and 2nd seasons, respectively. The results obtained herein seem to be in correspondence with Ahmed, (2016) and Aboseif *et al.,* (2022) who reported that inorganic (mineral) fertilizer and organic manure improved physical and chemical properties of soils and had a direct effect on plant growth, leading to higher dry matter yields by providing plants with all of the macro and micronutrients they needed during the growing season. Improvements in soil characteristics due to a deeper water table have an effect on water-air interactions in the root zone and root penetration, leading to increased faba bean production and yield components as treatment distance decreases from the drain line. Findings were consistent with those of Moustafa *et al.,* (1987).

Table 6: The impact of drainage line distance and fertilizer on faba bean yield and yield components throughout two growing seasons.

Treatments		First season 2020/2021				
		Number of pods/ plant	**Seeds per pods**	**Weight 100 Seed(g)**	**Seeds yield ($ardabfed^{-1}$)**	**Straw yield ($tonfed^{-1}$)**
Distance from drain line (D)						
D1		13.78	3.78	107.56^{a}	12.67^{a}	3.00^{a}
D2		11.44	3.56	95.81^{b}	11.67^{b}	2.48^{b}
D3		10.22	3.11	84.42^{c}	11.33^{b}	1.98^{c}
F-Test		Ns	Ns	***	**	***
LSD 0.05				1.02	0.36	0.09
Fertilization (F)						
F1		14.89^{a}	4.22^{a}	98.09^{a}	12.22^{a}	2.97^{a}
F2		11.78^{b}	3.44^{b}	96.17^{b}	11.93^{a}	2.64^{b}
F3		8.78^{c}	2.78^{b}	93.53^{c}	11.52^{b}	1.65^{c}
F-Test		***	**	***	***	***
LSD 0.05		2.41	0.77	0.81	0.3	0.09
Interactions between distance from drain line and fertilization						
D1	**F1**	19.00	4.67	108.55^{a}	13.09	3.59^{a}
	F2	14.33	4.00	107.39^{ab}	12.59	3.19^{b}
	F3	8.00	2.67	106.73^{b}	12.33	2.22^{d}
D2	**F1**	14.00	4.33	99.72^{c}	11.86	3.15^{b}
	F2	10.67	3.33	97.41^{d}	11.79	2.60^{c}
	F3	9.67	3.00	90.41^{e}	11.35	1.68^{e}
D3	**F1**	11.67	3.67	85.99^{f}	11.72	2.16^{d}
	F2	10.33	3.00	83.82^{g}	11.38	2.12^{d}
	F3	8.60	2.67	83.46^{g}	10.88	1.65^{e}
F-Test		Ns	Ns	***	Ns	***
LSD 0.05				1.4		0.15

Table 6: Continued

Treatments		Number of pods/ plant	Seeds per pods	Weight 100 Seed(g)	Seeds yield (ardabfed^{-1})	Straw yield (ton fed^{-1})
		Second season 2021/2022				
Distance from drain line (D)						
D1		15.74^{a}	3.97	108.52^{a}	12.73^{a}	3.19^{a}
D2		12.41^{b}	3.79	96.80^{b}	11.69^{b}	2.62^{b}
D3		11.90^{c}	3.34	85.28^{c}	1.35^{c}	2.05^{c}
F-Test		*	Ns	***	***	***
LSD 0.05		3.04		1.14	0.28	0.16
Fertilization (F)						
F1		15.66^{a}	4.41 ^{a}	98.94^{a}	12.27^{a}	3.15^{a}
F2		12.74^{b}	3.68^{ab}	97.14^{b}	11.95^{a}	2.77^{b}
F3		10.74^{c}	3.01^{b}	94.52^{c}	11.56^{b}	1.94^{c}
F-Test		***	***	***	**	***
LSD 0.05		2.02	0.74	0.8	0.34	0.09
Interactions between distance from drain line and fertilization						
D1	**F1**	19.97	4.77	109.52^{a}	13.16	3.88^{a}
	F2	15.30	4.23	108.36^{ab}	12.63	3.31^{b}
	F3	11.97	2.90	107.70^{b}	12.41	2.38^{d}
D2	**F1**	14.97	4.57	100.69^{c}	11.87	3.26^{b}
	F2	11.63	3.57	98.27^{d}	11.80	2.83^{c}
	F3	10.63	3.23	91.45^{e}	11.41	1.77^{f}
D3	**F1**	12.63	3.90	86.63^{f}	11.78	2.32^{de}
	F2	11.30	3.23	84.79^{g}	11.41	2.17^{e}
	F3	9.63	2.90	84.42^{g}	10.86	1.67^{f}
F-Test		Ns	Ns	***	Ns	***
LSD 0.05				1.38		0.15

D1: Above drain **D2:** 7.5m distance **D:3** 15m distance **F1:** Mineral **F2:** Organic **F3:** Bio
Ns, *, ** insignificant, significant at 0.05 and 0.01 level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

3.9. Effect of distance from drain line and fertilization on NPK (%) content in seed and straw of faba bean

Tables 7 and 8 provide two seasons' worth of data on the effects of drain line distance and mineral, organic, and bio fertilizer on levels of nitrogen (N), phosphorus (P), and potassium (K) in faba bean seeds and straw, respectively. Concerning to the distance from drain line, above drain line achieve a statistically significant increased (NPK) in faba bean seeds and straw. Values for all three macronutrients (N, P, and K) in seed and straw were order 15m distances <7.5m distances < above drain line treatments throughout both seasons.

Regarding the effect of fertilization treatments, the greatest percentages of NPK (4.14, 0.42, 2.7 and 3.7, 0.54, 2.36 %) in seeds and (2.93, 0.21. 2.03 and 2.87, 0.2, 1.92%) in straw were resulted from mineral fertilizer in both seasons, respectively. Generally, NPK percentage in seeds and straw for the two seasons were high in mineral than organic and bio fertilizer as a result of increasing amounts of available nitrogen in the root zone. This result was harmony with Elturabi, (2019). Serana *et al.,* (2010) observed that using inorganic fertilizers resulted in a greater harvest than using just organic manure.

The combination of above drain line with mineral fertilizer was superior for seed (4.46, 0.44, 2.88 and 4.06, 0.54, 2.6) and straw (3.27, 0.28, 2.33 and 3.14, 0.26, 2.12) NPK percentage in 1st and 2nd season, respectively, followed by the combination of D2 (7.5m distance from drain line) and F2 (farmed manure) treatments. Since nitrogen plays an important role in the creation of protoplasm, proteins, amino acids, nucleic acids, numerous enzymes, and materials involved in the transfer of energy, it is possible that mineral-N fertilization has a stimulating effect on the development characteristics of plants. A greater faba bean yield and yield component may be achieved with the use of drainage due to its positive influence on root zone water-air interaction and nutrient mobility. These findings agreed with those of Moustafa *et al.,* (1987) and Antar, (2013). Nutrient contents in plants were hypothesized to be spreading in a manner roughly parallel to the distribution of accessible nutrient contents in soil, these results could be enhanced by Khater *et al.,* (2004).

3.10. Effect of distance from drain line and fertilization application on crude protein (%) and N-uptake (kg fed^{-1}) in seed and straw

Tables 7 and 8 show that the percentage of crude protein in seeds and straw was considerably influenced by both the distance from the drain line and the fertilization treatments. Crude protein content in seeds and straw increased as their remoteness reduced from the drain. Therefore, the highest values of the crude protein percent of seeds (26.44 and 22.61%) and straw (18.91 and 17.99) in the 1st and 2nd seasons respectively were recorded under above drain line. Relating to the effect of fertilization treatments, the highest values of the crude protein percent (25.92 and 23.47%) in seeds and (18.79 and17.76%) in straw were resulted from mineral fertilizer in the 1st and 2nd seasons, respectively. Fertilization and how far away it is from a drain line treatments had highly significant effects of crude protein content of seeds and straw in both seasons. The highest crude protein percent (27.85 and 25.44%) in seeds and (20.64 and 19.59%) in straw were obtained under above drain line with mineral fertilizer for 1st and 2nd seasons, respectively. Similar results were obtained by Antar (2005).

Table 7: Faba bean seeds percent of NPK, crude protein (%) and N-uptake (kg fed^{-1}) as affected by distance from drain line and fertilization and statistical analysis in two seasons of the study.

Factors		1st season				
		N (%)	P (%)	K (%)	Protein (%)	N-uptake, (kg fed^{-1})
Distance from drain line (D)						
D1		4.22^{a}	0.40^{a}	2.45^{a}	26.44^{a}	82.97^{a}
D2		4.06^{b}	0.38^{b}	2.43^{a}	25.27^{b}	73.47^{b}
D3		3.39^{c}	0.37^{b}	2.27^{b}	21.19^{c}	59.64^{c}
F-Test		***	**	*	***	***
LSD 0.05		0.09	0.02	0.16	0.33	1.6
Fertilization (F)						
F1		4.14^{a}	0.42^{a}	2.70^{a}	25.92^{a}	78.62^{a}
F2		3.97^{b}	0.39^{b}	2.31^{b}	24.62^{b}	73.56^{b}
F3		3.56^{c}	0.35^{c}	2.14^{c}	22.33^{c}	63.9^{c}
F-Test		***	**	***	***	***
LSD 0.05		0.1	0.01	0.11	0.12	2.11
Interactions between distance from drain line and fertilization						
D1	**F1**	4.46	0.44	2.88^{a}	27.85^{a}	90.43
	F2	4.30	0.42	2.33^{bc}	26.81^{b}	83.93
	F3	3.90	0.36	2.15^{cd}	24.55^{d}	74.54
D2	**F1**	4.28	0.39	2.81^{a}	26.72^{b}	78.73
	F2	4.15	0.35	2.33^{bcd}	25.65^{c}	75.90
	F3	3.74	0.38	2.16^{cd}	23.45^{e}	65.79
D3	**F1**	3.67	0.36	2.41^{b}	23.18^{f}	66.70
	F2	3.44	0.35	2.28^{bcd}	21.41^{g}	60.84
	F3	3.05	0.31	2.12^{d}	18.99^{h}	51.37
F-Test		Ns	Ns	*	***	Ns
LSD 0.05				0.19	0.21	

Table 7: Continued.

Factors		2nd season				
		N (%)	**P (%)**	**K (%)**	**Protein (%)**	**N-uptake (kg fed^{-1})**
		Distance from drain line (D)				
D1		3.65^{a}	0.50^{a}	2.32a	22.61^{a}	72.26^{a}
D2		3.19^{b}	0.47^{b}	2.09b	20.19^{b}	57.84^{b}
D3		3.01^{c}	0.42^{c}	1.91c	19.02^{c}	53.18^{c}
F-Test		***	**	***	***	***
LSD 0.05		0.05	0.01	0.05	0.17	1.33
		Fertilization (F)				
F1		3.70^{a}	0.541^{a}	2.36a	23.47^{a}	70.58^{a}
F2		3.28^{b}	0.461^{b}	2.1b	20.55^{b}	60.96^{b}
F3		2.88^{c}	0.39^{c}	1.86c	18.01^{c}	51.75^{c}
F-Test		***	***	***	***	***
LSD 0.05		0.0.09	0.02	0.05	0.14	1.82
		Interactions between distance from drain line and fertilization				
D1	**F1**	4.06^{a}	0.54	2.60^{a}	25.44^{a}	82.71^{a}
	F2	3.76^{b}	0.50	2.25^{bc}	23.46^{b}	73.69^{b}
	F3	3.14^{d}	0.47	2.12^{de}	19.54^{d}	60.4^{d}
D2	**F1**	3.72^{b}	0.50	2.31^{b}	23.48^{b}	68.37^{c}
	F2	3.06^{d}	0.48	2.05^{ef}	19.56^{d}	55.96^{e}
	F3	2.78^{e}	0.41	1.90^{g}	17.56^{f}	49.21^{f}
D3	**F1**	3.32^{b}	0.47	2.18^{cd}	21.52^{c}	60.66^{d}
	F2	3.01^{d}	0.42	2.00^{f}	18.62^{e}	53.23^{e}
	F3	2.71^{e}	0.3	1.56^{h}	16.93^{g}	45.66^{g}
F-Test		**	Ns	***	***	*
LSD 0.05		0.15		0.13	0.25	3.15

D1: Above drain **D2:** 7.5m distance **D:3** 15m distance **F1:** Mineral **F2:** Organic **F3:** Bio
Ns, *, ** insignificant, significant at 0.05 and 0.01 level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

N-uptake by faba bean seeds and straw in both seasons was also shown to be significantly affected by both the distance from the drain line and the fertilization treatments (Tables 7 and 8). When comparing seed N-uptake to that of straw, seed N-uptake was found to be much higher. Above drain line yielded the greatest N-uptake values in both seasons (82.97 and 72.26 kg fed^{-1}) for seed and (47.74 and 46.38 kg fed^{-1}) for straw, followed by 7.5 m distance then 15m distance from drain. Consistent outcomes were also achieved by Antar (2005).

The highest values of N-uptake were achieved from mineral fertilizer (78.62 and 70.58 kg fed^{-1}) in seed and (47.28 and 46.02 kg fed^{-1}) in straw, followed by organic and bio fertilizers in both growing seasons, respectively (Tables 7 and 8). In most cases, organic crops had poorer micronutrient uptake than mineral crops. Maximum nitrogen absorption was achieved with mineral and organic fertilizer followed by bio fertilizer. These results might be explained by the fact that mineral fertilizers have an immediate impact on particular enzymatic activities and depolarize the root cell membrane, increasing membrane permeability and preventing adequate nutrient absorption by the plant (Majumdar *et al.,* 2003 and Aboseif *et al.,* 2022). However, N-uptakes were substantially and highly significant in both seasons based on the interplay between distance from drain line and fertilization treatments. The highest N-uptake in seed (90.43 and 82.71 kg fed^{-1}) and in straw (62.64 and 60.13 kg fed^{-1}) was achieved from the combination of D1 (above drain line) and F1 (mineral fertilizer) in the 1st and 2nd seasons, respectively.

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Table 8: Faba bean straw percent of NPK, crude protein (%) and N-uptake (kg fed^{-1}) as affected by distance from drain line and fertilization and statistical analysis in two seasons of the study.

Factors		1st season				
		N (%)	P (%)	K (%)	Protein (%)	N-uptake, (kg fed-1)
Distance from drain line (D)						
D1		2.94a	0.21a	2.01a	18.91a	47.74a
D2		2.65b	0.18b	1.79b	17.06b	35.71b
D3		1.85c	0.16c	1.76b	11.93c	19.42c
F-Test		***	*	**	***	***
LSD 0.05		0.27	0.04	011	0.2	3.93
Fertilization (F)						
F1		2.93a	0.21a	2.03a	18.79a	47.28a
F2		2.39b	0.18b	1.89b	15.2b	34.48b
F3		2.12c	0.16b	1.63c	13.95c	21.11c
F-Test		***	**	***	***	***
LSD 0.05		0.09	0.02	0.07	0.14	2.64
Interactions between distance from drain line and fertilization						
D1	F1	3.27a	0.28a	2.33a	20.64a	62.64a
	F2	3.08a	0.20b	2.03b	19.67c	51.04b
	F3	2.48b	0.16bc	1.66d	16.43d	29.55d
D2	F1	3.20a	0.19bc	1.91c	20.32b	52.17b
	F2	2.44b	0.17bc	1.82c	15.69e	34.40c
	F3	2.32b	0.17bc	1.63d	15.17f	20.56e
D3	F1	2.32b	0.16bc	1.87c	15.40f	27.03d
	F2	1.66c	0.16bc	1.81c	10.23g	18.01e
	F3	1.58c	0.15c	1.59d	10.15g	13.21f
F-Test		***	**	**	***	***
LSD 0.05		0.25	0.04	0.12	0.24	4.56

Table 8: Continued

Factors		2nd season				
		N	P	K	Protein	N-uptake,
Distance from drain line (D)						
D1		2.87a	0.21a	1.86a	17.99a	46.38a
D2		2.57b	0.17b	1.69b	16.02b	34.54b
D3		1.78c	0.15c	1.67b	11.36c	18.72c
F-Test		***	**	*	***	***
LSD 0.05		0.083	0.02	0.11	0.32	2.88
Fertilization (F)						
F1		2.87a	0.2a	1.92a	17.76a	46.02a
F2		2.29b	0.17b	1.77b	14.38b	33.14b
F3		2.05c	0.15c	1.53c	13.24c	20.48c
F-Test		***	***	***	***	***
LSD 0.05		0.12	0.02	0.07	0.26	2.5
Interactions between distance from drain line and fertilization						
D1	F1	3.14a	0.26a	2.15a	19.59a	60.13a
	F2	3.00a	0.20b	1.88b	18.75b	49.66b
	F3	2.47b	0.16cde	1.56d	15.65c	29.34cd

D2	F1	3.10a	0.18bc	1.82bc	19.21a	50.55b
	F2	2.33b	0.17cd	1.71c	14.47d	32.88c
	F3	2.27b	0.16cde	1.55d	14.38d	20.18e
D3	F1	2.36b	0.16cde	1.78bc	14.48d	27.37d
	F2	1.56c	0.15de	1.72c	9.91e	16.89e
	F3	1.42c	0.14e	1.49d	9.69e	11.91f
F-Test		**	**	*	***	***
LSD 0.05		0.2	0.03	0.13	0.45	4.33

D1: Above drain **D2:** 7.5m distance **D:3** 15m distance **F1:** Mineral **F2:** Organic **F3:** Bio
Ns, *, ** insignificant, significant at 0.05 and 0.01 level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test**.**

4. Conclusion

However, closer proximity to the drain line resulted in better soil characteristics and higher faba bean yields by reducing water table level, soil salinity, and moisture content. The combination of above drain distance and mineral fertilizer treatment surpassed the other treatments in increasing seed and straw yields and yield component of faba bean in both seasons. It can be concluded that D1 (above drain) in combination with F1 (mineral fertilizer) treatment is the proper treatments to obtain higher improvement of soil properties and production of faba bean.

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