GSC Advanced Research and Reviews
eISSN: 2582-4597 CODEN (USA): GARRC2
Cross Ref DOI: 10.30574/gscarr
Journal homepage: https://gsconlinepress.com/journals/gscarr/

(REVIEW ARTICLE)

A review: Effect of nitrogen fertilization and planting distances on the growth and yield of maize

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GSC Advanced Research and Reviews, 2024, 20(01), 248–259

Publication history: Received on 06 June 2024; revised on 18 July 2024; accepted on 20 July 2024

Article DOI: https://doi.org/10.30574/gscarr.2024.20.1.0266

Abstract

The influence of planting distances (PD) and nitrogen fertilizers (NF) on growth of maize yield, were tested at two PD of 15 and 20 cm, and three NF levels 100 ,120and 140 kg.ha-1. The experiments were conducted in a factorial experiment under complete randomized design with three replications. The results showed that the PD of 20cm was significantly better than the PD of 15 cm in all studied conditions. The RDW, NGE, 1000-WG, PVI and TGY , 58.17 g , 620 grain.ear-1, 507g , 72.03cm, and 5.851 ton.ha-1, the treatment NF of 140 kg.ha-1cm was significantly superior to the levels of 100 and 120 kg.ha-1 in all studied conditions. With the exception of the physical soil characteristics represented by the density and porosity of the soil, best results were achieved with a planting distance of 15 cm and a nitrogen level of 100 kg.ha-1

Keywords: Maize; Irrigation system (SDIS); Levels nitrogen fertilizer (NF); Planting distances (PD); Soil physical properties

1. Introduction

Maize is one of the significance grass crops after wheat and rice, its grains and derivatives have a nutritional importance, and used in human nutrition when they are ripe or unripe. They are also used in the flour industry after mixing them with wheat flour, it is also used in the manufacture of animal feed, and it is an excellent source of energy because it contains high levels of fat and starch [1,2], maize is one of the most important basic grain crops cultivated on a very large scale in the world, such as wheat, rice and maize, it has taken on increasing economic importance in the nutritional aspect of man and the main source of animal feed [3,4]. Soil characteristics improvement to prepare a suitable bed for germination in order to create the appropriate conditions for plant growth, as well as to increase the crop productivity, when preparing the soil optimally to suit the methods of cultivation and irrigation, in addition to choosing the machine that is of great importance in improving the soil characteristics and increasing the crop productivity, improper selection of cultivation methods will lead to negative results that will be reflected in the soil properties, such as compacting the soil and increasing its density, thus decreasing all growth and yield characteristics [5,6]. The researchers adopted multiple methods to find solutions to the dilemma of the irrigation water scarcity and to maintain crop productivity when using drip irrigation methods [7,8].

Study of [9,10], that the deal with the drip irrigation method according to the approved scientific foundations to provide suitable moisture to improve the plant growth, and increase the final yield, [11,12]. Nitrogen fertilizers are added in various ways to the soil according to the nature of the fertilizer, surrounding conditions and soil properties, one of the common methods is mixing with the surface layer, its adding a spread on the surface before irrigation, it may be added

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dissolved with the irrigation water, by feeding near the plant. [13-15] , the commonly used fertilizers in most countries of the world because of its high nitrogen content, ease of handling and cheap price, the practical benefit of nitrogen fertilizer has been accompanied by many defects and damages, especially after adding it to calcareous or alkaline soils, and these indicators reduce the positive and effective role of the applied importance of nitrogen fertilizer. yellow maize plant needs fertilizers in parallel with what it requires of nitrogen, without it, the building processes stop, the rate of active absorption decreases in the plant root system, and the fertilization rate deteriorates, the balanced addition of it to the soil and spraying in the stages of demolition means the continuity of the vital and reproductive action of the yellow maize plant [16,17]. The maize final yield grain is the final evaluation of all biological activities during the plant growth period and is determined by the basic growth components, represented by plant height, stem thickness, 1000 grain weight and number of grains per ear [18,19]. The soil characteristics improvement depends mainly on the cultivation methods and the addition of fertilizers and water with us to the soil, this guarantees a decrease in the bulk density ratios, which is offset by an increase in the total porosity ratios of the soil. The reason for this is due to the soil hardening when large fertilizers quantities are added to the soil. [20,21]. Implantation distances have a major role in rising, with the maximal the distance, the better growth conditions are created through the nutrients suitable availability for growth, and this is reflected positively in increasing the yield [22,23]. The drip irrigation method increases soil moisture in the root zone, and this leads to soil fragmentation and the small work particles that fill the existing pores, thus reducing the density of the soil and increasing its porosity compared to traditional irrigation methods such as immersion method [24,25]. The study aims to find out the effect of nitrogen fertilizers and planting distances on the growth and yield of maize

2. Material and methods

Study was showed in the Babylon area, which is located about 90 km away from the Baghdad city, using irrigation system subsurface drip irrigation system(SDIS). Fig 1. on three the nitrogen fertilizer levels (NF) of 100 , 120 and 140 kg N.ha^{-1} under two planting distances (PD) of 15 and 20cm. [26,27,28] Planting distances were determined for this experiment by the planter machine (Fig.2). Renewable energy (energy clean) was adopted to operate the pumping units.

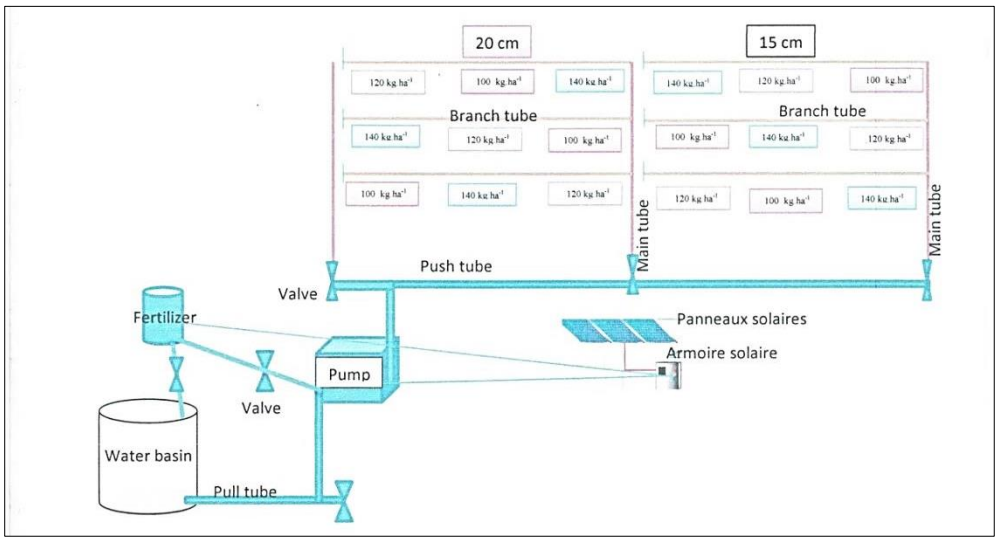

Figure 1 Drip irrigation system

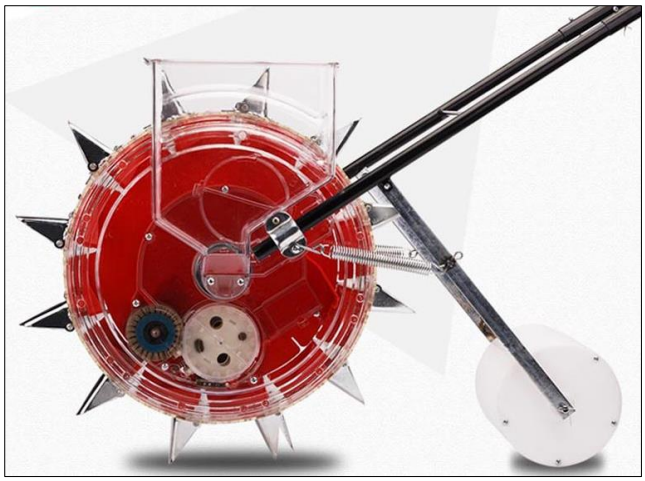

Figure 2 Maize planting machine (planter type)

The soil was stirred with a moldboard plow to a depth of 24 cm, it was pulled by a tractor (MSF-285s type). The physical and chemical soil properties were calculated, as in Table (1).

Table 1 The physical and chemical properties of the soil

Depth	**Texture %**			**Silt Clay loam**
	Clay	**Silt**	**Sand**	
	46	21	33	
0-24 (cm)	Soil physical properties			
	Soil bulk density (Mg m^{-3})	Total soil porosity (%)	Soil penetration resistance (Kpa)	
	1.38	47.92	1553.28	
	1.42	46.41	1686.08	
	1.44	45.66	1598.19	
VA	1.41	46.66	1612.51	
0-24	Soil chemical properties			
	E.C (ds\cm^3)	pH		
	3.48	7.69		
	Soluble cation meq\I			
	Na	K	Ca+Mg	
	11.42	14.45	56.82	
	O.C (%)	CEC (Meq\100g)	CaCo3 (%)	O.M (%)
	0.45	32.91	4	0.54

2.1. Soil Characteristics

Samples were taken to measure soil moisture, bulk density and the total porosity of soil, during the growing season after one month (1Mon), two months (2Mon), and the stage of full maturity (growth season end) . [29,30,31].

$$W_{=\frac{W_w}{W_s}\times 100} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where: W is soil humidity ratio (%), W_w is mass wet soil(kg), W_s is mass dry soil. **(**kg**)**

$$P_{b=\frac{M_S}{V_T}} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Where: P_b: Dry bulk density (mg. m^{-3}), M_S: the weight of the dried soil sample (mg), V_T: total volume of the soil sample (m^3).

$$T_{SP=}\left(1-\frac{P_b}{P_S}\right)\times 100 \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where: T_{SP}: total of soil porosity (%), P_b: dry of bulk density (mg.m^{-3}), P_S : partial density (2.65 mg.m^{-3}).

Maize Characteristics

2.1.1. Root Dry Weight (RDW)

Plants were extracted from the intermediate lines, cleaned and oven-dried for each experimental unit. [32].

2.1.2. Plant Vigor Index (PVI)

The PVI is calculated by the following Eq4. [22].

$$P_{VI=\frac{P_{L\times G_P}}{100}} \ldots\ldots\ldots\ldots\ldots \quad (4)$$

2.1.3. Number of Grains Per Ear (NGE)

This is done by grains threshing the ears and counting them using a mechanical counting device. The full and empty ears were included for each experimental unit [5].

2.1.4. **1000**-*Weight Grain (1000-WG)*

The 1000-weight grains was estimated after drying them in an oven at a temperature of 70 °C for two days, and then weighing them for each experimental unit [12].

2.1.5. Total Grain Yield (TGY)

It was calculated, according of the method used by [33,34,35]. The results were analyzed according to the design used RCBD, with LSD test at a significant level of 0.05 [36].

3. Results and discussion

3.1. Soil Physical Properties

The significant effect of soil physical properties during one month, two months and the planting season end, Table .2. The results obtained for the PD treatment of 15 cm were 1.29,1.32 and 1.33Mg.m^{-3}, soil density decrease was accompanied by an increase in its porosity ratios were 51.32,50.18 and 49.81%, respectively, while the results obtained for the PD treatment of 20cm were tended to increase soil density and decrease its porosity 1.31, 1.33,1.35Mg.m^{-3}, 50.56,49.81and 49.05% respectively, the source this accretion in planting distances leading to soil adhesion and cohesion, and this was reflected in the increase in soil density and decrease in its porosity [8,11].

The best results obtained are for the fertilization treatment 100 kg.ha^{-1}were 1.28, 1.31 and1.32 Mg.m^{-3}, and are matched by a significant increase in porosity ratios were 51.69, 50.56 and 50.18% respectively, compared to other treatments. The reason for this was that the increase in the nitrogen fertilizers ratios led to the soil hardening and the cohesion of its particles, thus increasing its density and decreasing its porosity [1,6]. The best ratios 1.26 Mg.m^{-3} and 52.45%,. These ratios were obtained from interfere between PD of 15 cm, and NF of 100kg.ha^{-1}.

Table 2 Effect of PD and NF on soil physical property

PD cm	NF kg.ha^{-1}	Soil bulk density			Total of soil porosity		
		1Mon	2Mon	GSE	1Mon	2Mon	GSE
15	100	1.26	1.30	1.32	52.45	50.94	50.18
	120	1.28	1.32	1.33	51.69	50.18	49.81
	140	1.31	1.33	1.34	50.56	49.81	49.43
20	100	1.30	1.32	1.33	50.94	50.18	49.81
	120	1.31	1.33	1.35	50.56	49.81	49.05
	140	1.32	1.34	1.36	50.18	49.43	48.67
PD	15	1.29	1.32	1.33	51.32	50.18	49.81
	20	1.31	1.33	1.35	50.56	49.81	49.05
NF	100	1.28	1.31	1.32	51.69	50.56	50.18
	120	1.30	1.33	1.34	50.94	50.18	49.43
	140	1.32	1.34	1.35	50.18	49.43	49.05
LSD=0.05	PD	0.03	0.04	0.05	0.139	0.234	0.344
	NF	0.04	0.05	0.07	0.212	0.411	0.491
	PD*NF	0.06	0.07	0.09	0.346	0.605	0.715

3.2. Root Dry Weight (RDW)

Table 3 shows the significant impact of the interplay amongst planting distance and nitrogen fertilizers, the best ratio was recorded 60.13 g, when a transaction overlaps PD of 20cm and the transaction NF of 140 kg.ha^{-1}.

Table 3 Effect PD and NF on RDW

PD cm	NF kg.ha^{-1}			Mean of PD
	100	120	140	
15	52.46	55.48	59.15	56.03
20	56.09	58.16	60.13	58.17
Mean of NF	54.78	56.82	59.64	
LSD=0.05	PD	NF	PD*NF	
	1.109	1.188	1.225	

From Fig.3, the significant effect of the nitrogen fertilizers treatment on the RDW, as the treatment exceeded 140 kg.ha^{-1} by recording the maximum rate 59.64 g, as compared to the NF treatment of 100 kg.ha^{-1}, which recorded the lowest rate 54.78 g. The source for this is due to the obtainability of nutrients necessary for plant growth when the proportions of nitrogen fertilizers increase [12,17].

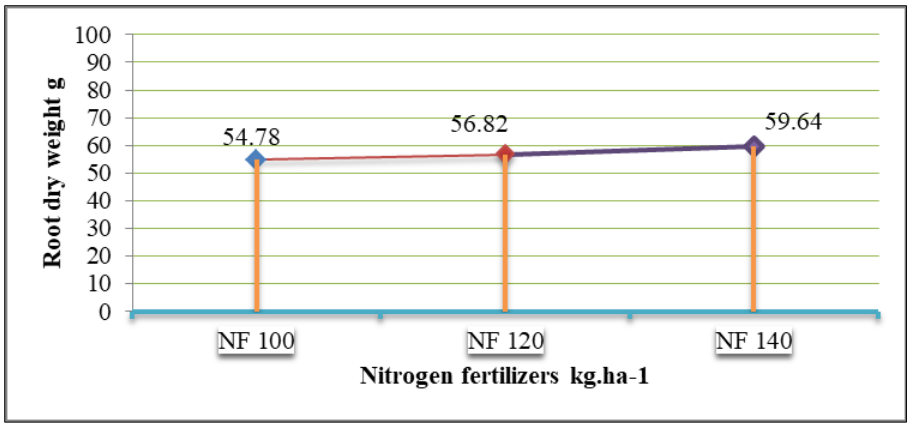

Figure 3 Effect NF on RDW

From Fig.4, the significant effect of the planting distances treatment on the RDW, as the treatment exceeded PD of 20 cm by recording the topmost rate 58.17g, as compared to the PD treatment of 15 cm, which recorded the lowest rate 56.03 g. The source for this is due to the obtainability of nutrients necessary for plant growth when the planting distances increase [5].

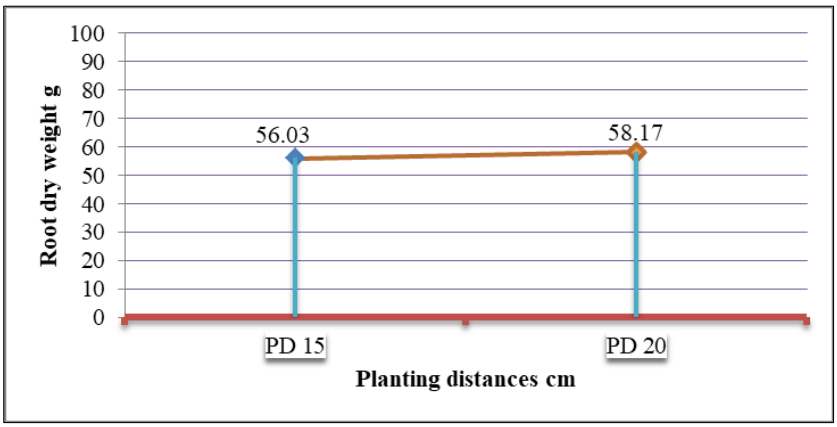

Figure 4 Effect PD on RDW

3.3. Plant Vigor Index (PVI)

Table 4 shows the significant effect of the interplay amongst planting distance and nitrogen fertilizers, the best ratio was recorded 73.19 cm, when a transaction overlaps PD of 20cm and the transaction NF of 140 kg.ha^{-1}.

Table 4 Effect PD and NF on PVI

PD cm	**NF kg.ha^{-1}**			**Mean of PD**
	100	**120**	**140**	
15	69.37	70.18	72.46	70.67
20	70.81	72.09	73.19	72.03
Mean of NF	70.09	71.13	72.82	
LSD=0.05				
	PD	NF	PD*NF	
	1.221	1.367	1.653	

The significant effect of the nitrogen fertilizers treatment on the PVI, Fig 5, as the treatment exceeded 140 kg.ha^{-1} by recording the topmost rate 72.82 cm, as compared to the NF treatment of 100 kg.ha^{-1}, which recorded the lowest rate

70.09 cm. Filling the lack of nutrients required for growth by increasing the nitrogen fertilizers concentration to improve the growth characteristics of maize plant [7,9].

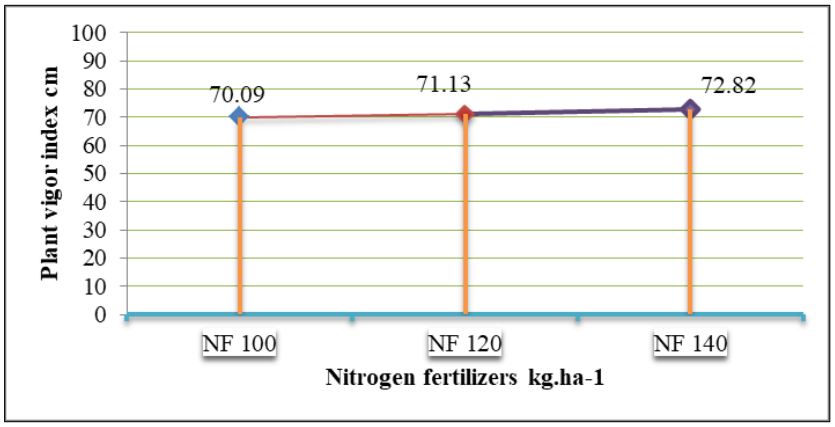

Figure 5 Effect NF on PVI

Increasing the planting distance from 15-20 cm, it led to an increase in the PVI value and the obtained results from Fig.6, were 70.67 and 72.03 cm respectively .The reason for this is attributed to improving the growth characteristics of maize plants by providing sufficient space for the growth and spread of roots[14].

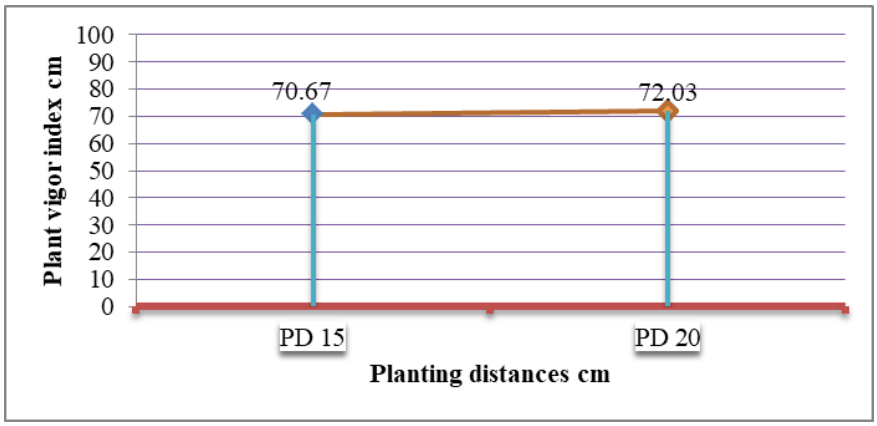

Figure 6 Effect PD on PVI

3.4. Number of Grains Per Ear (NGE)

Table 5, shows the significant effect of the interplay amongst planting distance and nitrogen fertilizers, the best ratio was recorded 663 grain.ear $^{-1}$, when a transaction overlaps PD of 20 cm and the transaction NF of 140 kg.ha^{-1}.

Table 5 Effect PD and NF on NGE

PD cm	**NF kg.ha^{-1}**			**Mean of PD**
	100	**120**	**140**	
15	565	596	608	590
20	587	611	663	620
Mean of NF	576	604	636	
LSD=0.05				
	PD	NF	PD*NF	
	4.506	6.045	8.114	

As for the planting distances, 20cm distance achieved the topmost value number of grains per ear 620 grain.ear^{-1}, as compared to of 15 cm, which recorded the lowest rate 590 grain.ear^{-1}.Fig 7. The source for this is due to the obtainability of good growth characteristics with increasing planting distances [13,18].

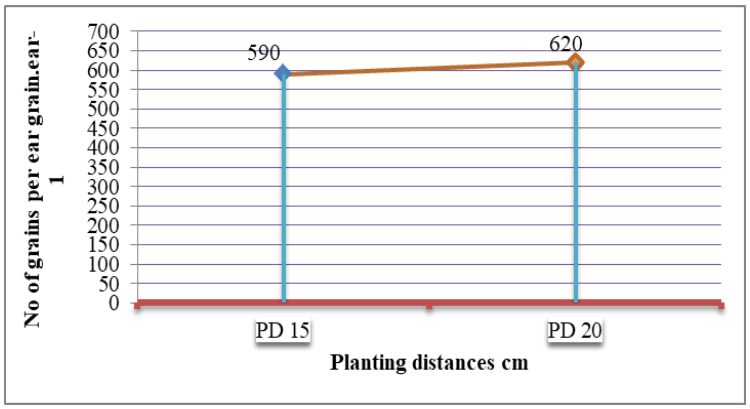

Figure 7 Effect PD on NGE

Increasing the rates of nitrogen fertilizers led to an increase in the number of grains in the ear, and the results were as follows 576, 604 and 636 grain.ear^{-1}. Fig 8. The source for the accretion in the number of grains in the ear was the soil qualities improvement with the increase in the amount of nitrogen fertilizers added [9,23].

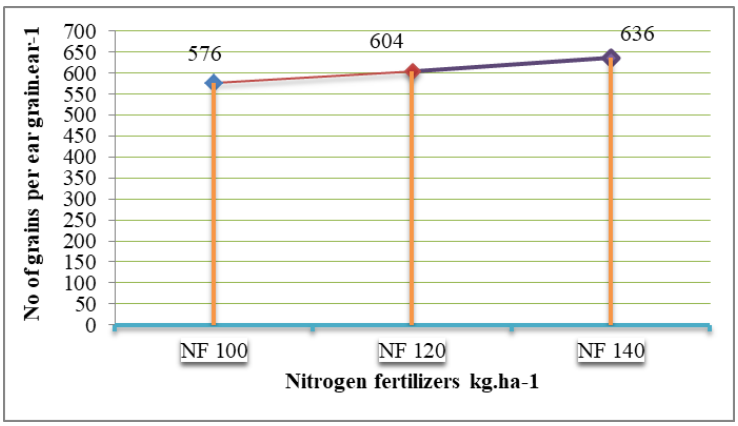

Figure 8 Effect NF on NGE

3.5. 1000-Weight Grain (1000-WG)

Table 6 shows the significant effect of the interplay amongst planting distance and nitrogen fertilizers, the best ratio was recorded 583 g, when a transaction overlaps PD of 20cm and the transaction NF of 140 kg.ha^{-1}.

Table 6 Effect PD and NF on 1000-WG

PD cm	**NF kg.ha^{-1}**			**Mean of PD**
	100	**120**	**140**	
15	396	408	491	432
20	422	515	583	507
Mean of NF	409	462	537	
LSD=0.05				
	PD	NF	PD*NF	
	1.234	1.342	5.125	

When the PD increased, this was reflected in an increase 1000- weight grain were results 432 and 507 g respectively. Fig 9. The reason for the increase in the weight of a thousand grains was the decrease in soil density and increase in its porosity when increasing the plant roots growth distance [22].

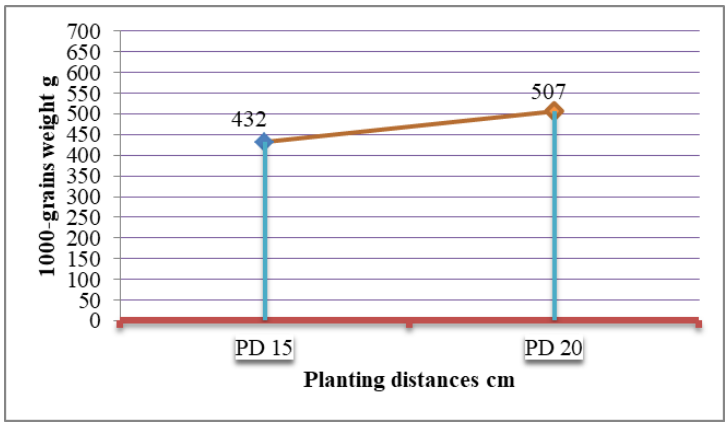

Figure 9 Effect PD on 1000-WG

The significant effect of the nitrogen fertilizers treatment on the 1000-WG, as the treatment exceeded 140 kg.ha^{-1} by recording the topmost rate 537 g, as compared to the NF treatment of 100 kg.ha^{-1}, which recorded the lowest rate 409 g. Fig 10. The reason for this is due to the availability of nutrients necessary for plant growth when the proportions of nitrogen fertilizers increase [15,21].

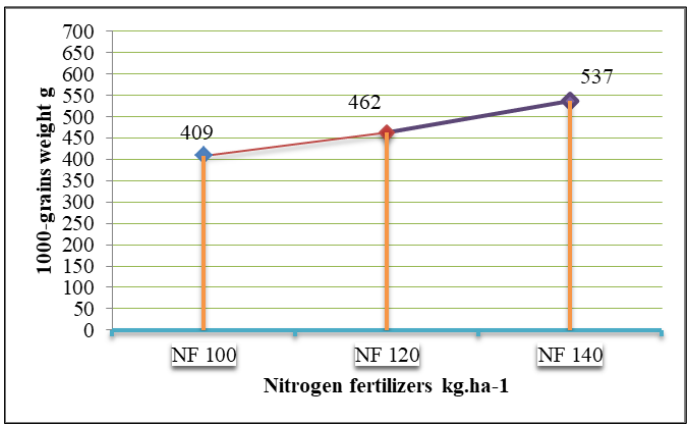

Figure 10 Effect NF on 1000-WG

3.6. Total Grain Yield (TGY)

Table 7 shows the significant effect of the interplay amongst planting distance and nitrogen fertilizers, the best value was recorded 6.706 ton.ha^{-1}, when a transaction overlaps PD of 20cm and the transaction NF of 140 kg.ha^{-1}.

Table 7 Effect PD and NF on TGY

PD cm	NF kg.ha^{-1}			Mean of PD
	100	120	140	
15	4.081	5.521	6.141	5.247
20	4.914	5.932	6.706	5.851
Mean of NF	4.497	5.726	6.423	
LSD=0.05	PD	NF	PD*NF	
	0.02	0.05	0.07	

From Fig.11, the significant effect of the NF treatment on the TGY, as the treatment exceeded 140 kg.ha^{-1} by recording the topmost rate 6.423 ton.ha^{-1}, as compared to the NF treatment of 100 kg.ha^{-1}, which recorded the lowest rate 4.497 ton.ha^{-1}. Improving the maize plant growth characteristics by providing the amounts of fertilizer necessary for growth, that lead to an increase in soil fertility, and this was reflected in an increase in the grain yield of the maize plant [6,17].

As for the planting distances, 20cm distance achieved the topmost value TGY were 5.851ton.ha^{-1}, as compared to of 15 cm , which recorded the lowest rate 5.247 ton.ha^{-1}.Fig 12. The reason for this is due to the availability of good growth characteristics with increasing planting distances, that leads total grains yield increased [1,2].

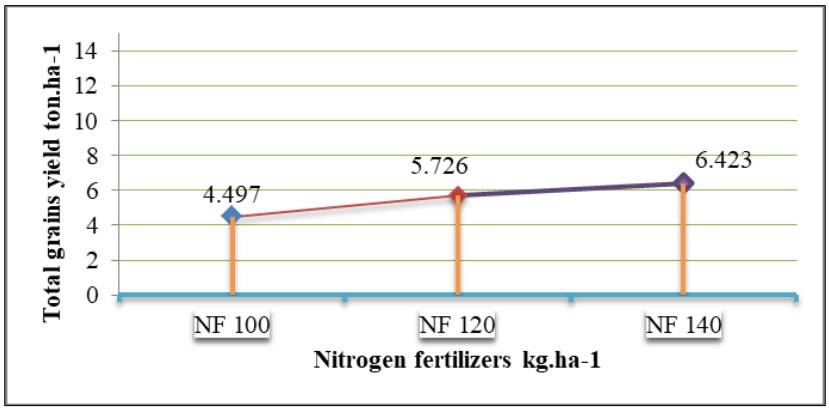

Figure 11 Effect NF on TGY

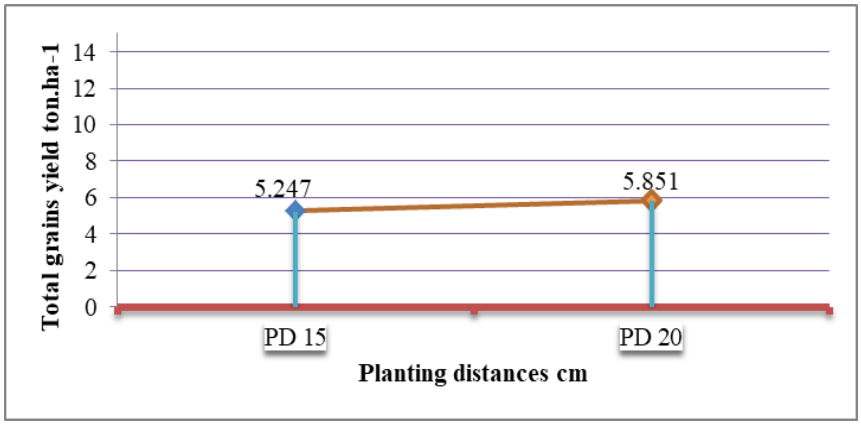

Figure 12 Effect PD on TGY

4. Conclusion

The research included studying the effect of planting distances and nitrogen level on maize growth and yield, NF level of 140 kg.ha^{-1} achieved the best results for this study, compared to the levels 100 and 120 kg .ha^{-1}, which gave poor results for this study. While the planting distances, the PD of 20 m gave the best results for the characteristics of the growth and maize yield, as compared to the PD of 15 cm, which gave unsatisfactory results for this study.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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