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كلية الدراسات العليا **Sudan University Of Science and Technology**

College of Graduate Studies

Assessment Of Fertilizer types and microdoses on growth yield and yield components of Wheat(*Triticum aestivum*).

تقيم انواع الاسمدة والجرعات الصغيرة علي النمو والإنتاجية ومكوناتها في القمح (*Triticum aestivum*)

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DEDICATION

I dedicate this work to:

My beloved Parents:

My wonderful mother Hassania and kind father Hassan, my sisters and my brothers.

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Above all, my thanks and praise to almighty Allah who provided me with health, strength and patience to bring this work to its conclusion.

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Abstract

The experiment was conducted at the Demonstration Farm of the Faculty of Agricultural Sciences, Sudan University of science and Technology, Sudan, during the winter growing seasons of 2018/2019.to Study effect of the fertilizer types and microdosing on growth yield, yield component of wheat. The experimental design was a split- plot based on randomized complete block design with four replications. The main plot composed of three fertilizer types(mono Ammonia phosphate, NPK and Urea)in randomized complete block design. Subplots consisted of five doses (0, 1g,2g,3g and 4g) of each of the three types of compound. Growth parameters investigated included plant height, number of tillers per square meter, leaves per plant, spike length, fresh weight, dry weight, 1000grain weight, grain per spike, yield per plant and yield per hectare. In this study the general trend was that increase in fertilizer dose high significantly increased, fresh weight, dry weight, tiller per row meter, spike length, yield per plant, yield per hectare where significant increased plant height, number of leaves per plant and grain per spike. Generally the results show that there were highly significant differences in growth and yield parameters between the fertilizer types and doses.

المستخلص

أجريت التجربة في مزرعة العرض التوضيحي لكلية العلوم الزراعية ، جامعة السودان للعلوم والتكنولوجيا ، السودان ، خلال مواسم النمو شتاء 2019/2018. لدراسة تأثير انواع الاسمدة والجرعات الصغيرة على النمو والانتاجية ومكوناته في القمح. كانت الطريقة التجريبية المطبقة عبارة عن تجربة عاملية مجزأة على أربع نسخ متماثلة. المعاملة الرئيسية تتألف من ثلاثة أنواع من الأسمدة (أحادية أمونيا الفوسفات ، NPKويوريا) في تصميم كتلة كاملة العشوائية. تتألف المعاملات الفرعية من خمس جرعات (0 ، 1 جرام ، 2 جرام ، 3 جرام ، 4 جرام) من كل نوع من أنواع المركبات الثلاثة. شملت معلمات النمو التي تم بحثها ارتفاع النبات ، وعدد الخلف لكل متر مربع ، وأوراق النبات ، وطول السنبلة ، والوزن الرطب ، والوزن الجاف ، ووزن 1000 حبة ، والحبوب لكل سنبلة ، والمحصول لكل نبات ، والمحصول لكل هكتار. في هذه الدراسة ، كان الاتجاه العام هو أن الزيادة في كمية الأسمدة زادت بشكل كبير من ، الوزن الرطب ، الوزن الجاف ، طول السنبلة، ووزن 1000 حبة ، وعدد الخلف لكل متر مربع ، المحصول لكل نبات ، المحصول لكل هكتار وكان هنالك ايضا زيادة في طول النبات، عدد الأوراق للنبات والحبوب لكل سنبلة . بشكل عام أظهرت النتائج وجود فروق ذات دلالة إحصائية في معايير النمو والإنتاج بين أنواع الأسمدة والجرعات.

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Introduction

Wheat *(Triticum aestivum***L.**) is the most important cereal crop of the world. Among the food crops, wheat is one of the most abundant sources of energy and protein for the world population (Salem *et al*., 2007). The importance of bread wheat as a staple food in economy can not be ignored. Wheat is one of the most important strategic crops in terms of food security.In the Sudan wheat is the main staple food crop in urban areas and second to sorghum in many irrigated rural areas. In Sudan.Fertilizer microdosing is the application of tiny doses of fertilizers in the planting hole at sowing, or next to the plant two to three weeks after planting. Microdosing is affordable to the poor because of the reduced investment cost, and it results in more rapid early growth, thus avoiding early season drought, and an earlier finish, avoiding or reducing the impact of end of season drought while increasing crop yields (Tabo *et al*., 2006, Tabo *et al*. 2007). Farmers use a number of techniques to enhance production and limit soil degradation.These strategies include crop rotation, the use of nitrogen fixing crops, increasing organic matterin the soil, and minimal tillage, among others. In terms of fertilizer applications, the Food and Agriculture Organization of the united status (FAO) recommends the "judicious use of mineral fertilizers," using precision approaches to promote soil health (Collette *et al*., 2011). Similarly،the targeted application of small quantities of fertilizer has been promoted as a sustainable 'step up the ladder' of agricultural intensification (Aune&Bationo, 2008). While recommended dosages have been determined through government-sponsored research, these recommended doses are often unaffordable for the rural poor or unattainable given limited availability. In response, researchers at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) developed a technique known as fertilizer microdosing, involving the precision application of small (less than the recommended dosage) quantities of inorganic fertilizer.Previous studies in West Africa in particular, have found microdosing to be an economically advantageous technique, while also addressing limited access (both physical economic) to inputs, as compared to alternative fertilizer application techniques, such as broad casting at recommended dosages (Camara *et al*., 2013; Hayashi et al., 2008; Tabo *et al*.,2011; Twomlow *et al*., 2010).Wheat production in Sudan started thousands of years ago on the fertile soil of banks of the Nile in northern and River Nile State. Recently, however, the demand for the crop increased as a result of the increase in urbanization, increase in population and also due to the change in the consumer's taste (Elamin, 2000). The low productivity of wheat in the Sudan could be attributed to a number of obstacles and constraints. Top of these non availability of high yielding varieties adaptable to stress environment, and suitable for cultivation in marginal lands, coupled with other constraints, such as plant density, irrigation restrictions, harvesting practices, biological factors, and nutrition or fertilization practices (Ageeb, 1993).The main objectives of this work are:

1-To study the effect of fertilizer types and doses

2-To determine the most suitable dose

3-To use microdosing as new technique

CHAPTER TWO

Literature review

2- Background and Justification:-

2.1-Adaptation;-

Sudan is the largest country in Africa with about 1.88 million square kilometers of land. Climate varies from desert to semi-desert in the north, to savannah in the centre and to humid tropical in the south. The variation in climatic conditions creates a good environment for diversification of crops. The arable cultivated land is estimated to be 84 million hectares. However, the annually cultivated area is about 17 million hectares. The country has two major agricultural production sectors, namely, the irrigated and the rain fed. The area under irrigation is around 2.1 million hectares. The main crops grown under irrigation are cotton, sorghum, wheat, sugar cane, groundnuts, vegetables, and fodder and fruit trees. The major water sources are the Blue Nile, the White Niles. The river Nile and seasonal rivers and streams. Major irrigated schemes are the Gezira, Rahad and New Halfa. And White Nile schemes, River Nile State schemes and the private and cooperative schemes on the main Nile. The rain fed sector, which extends from central Sudan, to western and southern Sudan, is the larger of the two sectors (15 million ha). The main crops grown in the rain fed sector are sorghum, pearl millet and sesame (Haj *et al.*, 2007).

The government Quarter Century Plan (2002-2027), among others, focuses on i) increased production of food crops ii) increased agricultural products and reduced imports and iii) introduction of new crops. The plan is to double the area under irrigation to reach 4.2 million hectares. Furthermore, the government approved an investment encouragement act where priorities are given to projects that address food security by increasing wheat production, focus on least developed areas, promote export capability of the country, aim at integrated rural development and increase job opportunity. Sudan has known wheat production since time immemorial. Production, till the Second World War, was confined to a total area of 12 thousand hectares along the narrow stretch of the rich Nile-alluvial soils north of Khartoum. Yield was high enough to cover the needs of the northern region and the major cities and towns across the country. The rest of the population was dependent on sorghum in central and eastern Sudan and on cassava in southern Sudan. However, increased urbanization and associated changes in food traditions have increased the demand for wheat from less than 100 thousand tons per annum to over one million tons. The gap between production and consumption was used to be bridged through international aids, loans and by direct purchase. However, due to social, economic, political changes and the current international food crises together with soaring wheat prices, bridging the food gap through international co-operation and/or direct purchase is rather difficult and makes interventions, leading to increased local production to attain self-sufficiency an unequivocal necessity.Traditionally, the crop is produced in the River Nile and the Northern states, where temperature is moderately suitable. However, unavailability of land, the high cost of irrigation and competition with high value crops such as vegetables, fruit trees and beans limited the area allocated to wheat. Population pressure and the attendant increase in the demand for food together with availability of land, established irrigation systems, infrastructure and absence of major pests and diseases foster introduction of the crop into the harsh environments south of Khartoum, where climatic criteria, especially high temperature, and short season, deny high yield potentials (Mohamed, 2000).

2.2-Wheat production in Sudan

Wheat is a strategic crop in Sudan. It is Sudan's second most important cereal food crop in terms of consumption after sorghum. The wheat seed storage proteins are a major source of protein in the human diet, and are responsible for the properties of wheat doughs that allow a wide range of food products(Claudia *et al*., 2007). Over the past few years, wheat production, which is almost entirely irrigated, has been declining due to diminishing yields and soaring input costs. Since 1999, the Government liberalized the wheat production regime and removed all support programs. These moves have prompted many farmers to drastically reduce wheat cultivation and/or switch to more lucrative cash crops, such as vegetables and oilseeds. Gezira, White Nile, New Halfa, River Nile and Northern States are the main suppliers for wheat crop .The overall area under wheat in the year (2005/06) exceeded 290,360 feddan (122 000 hectares). Although the State with its relatively cooler weather and fertile alluvial soils, has comparative advantages over other parts of the country in producing relatively high-value crops (wheat, faba beans, citruses, mangos, dates, certain spices and medicinal plants) (Elawad,2004).

2.3-Microdosing

Fertilizer microdosing is the application of tiny doses of fertilizers in the planting hole at sowing, or next to the plant two to three weeks after planting. The technology increases fertilizer use efficiency and yield while minimizing the cost of inputs. The results reported here show that solving the soil fertility problem unleashes the yield potential of improved crop varieties, roughly doubling yield. Two crucial advantages of microdosing are its adoptability and profitability. High rates of fertilizer have been recommended to farmers for a long time to maximize yields, but farmers could not afford to do so. By using much lower rates of fertilizer than the recommended rate, in more efficient ways that deliver economically optimum returns, farmers are much more able and inclined to adopt the practice, and are increasingly doing so. Once fertilizer microdosing is adopted, it establishes a pattern for future productivity as farmers become accustomed to increasing their investments in inputs in order to generate increased returns. Microdosing is thus a strategic first step on a sustainable development pathway, in addition to generating large benefits itself. The microdosing technology has been demonstrated and promoted in Burkina Faso, Mali and Niger during the past few years with very encouraging results. Sorghum and millet yields increased by 45 to 120 % in comparison with farmer practice while farmers' incomes went up by 50 to 130 %. This paper highlights these outstanding past results and the on-going efforts to further scale-up the technology(Dougbedji, *et al*., 2008).Fertilizer micro-dosing is the localized placement of small amounts of mineral fertilizer (4 grams of phosphorus) in the planting hole at sowing, or at the base of newly emerged plants, instead of spreading fertilizers evenly across the fild. Use of improved planting pits (a rainwater harvesting technique that incorporates use of organic matter) instead of sowing seed in raised earth mounds encourages infitration of rainwater and increases soil moisture levels. Building on previous successes with microdosing, the Integrated Nutrients and Water Management (INWM) project for food security in the Sahel is testing the combined use of micro-dosing with soil moisture management, in order to determine any increase in fertilizer use efficiency. In particular the project is targeting food crops managed by poor rural men and women (Ramadjita *et al*., 2008).

2.4-Effect of microdosing

The results showed that fertilizer microdosing has great potential to improve crop yields and profitability, in a range of environments and rainfall situations. Overall grain yield increases using microdosing were double the yields obtained from the farmers traditional practice. The technology offers the resource poor small scale farmers a good opportunity to reduce risks to investment under the unpredictable environment of the semi-arid tropics while it enables a significant increase in crop yield. Because of the low rates of fertilizers used, farmers can reduce greatly their costs of production. As farmers see the benefits obtained from these small quantities of fertilizer, they are more willing to invest in fertilizers and increase fertilizer use(Dougbedji,*etal*.,2008).The fertilizer microdosing technology is therefore an entry point for increased use of fertilizers in farmers fields, which can lead to sustainable development. As with any promising technology there is a need to build the capacity of various stakeholders including extension agents, NGOs and researchers to enhance the dissemination of the technique as well as ensuring the sustainability of the systems.

Demonstrations and farmers field schools approach have proven to be an effective means for the promotion of this technology. An issue that requires further investigation is the possibility of soil mining arising from using the fertilizer microdosing technology. As grain yields increase and very little organic matter(OM), including crop residues, are returned into the soil there is the likelihood that nutrient imbalances will develop with time. There is therefore a need to ensure that organic matter is added and incorporated into these soils to improve their structure so that their capacity to store adequate moisture and nutrients even after crops are harvested is enhanced (Ramadjita *et al*., 2008).

CHAPTER THREE

Materials and Methods

3.1-Research site;-

The experiment was conducted at the experimental farm, Sudan University of Science and Technology. College of Agricultural Studies, Shambat (Lat.15^0 40 N, Long. 32^0 32 E and at of 380 meters above sea level) during winter season (during the period from November 2018 to February 2019 winter season). The experiment was designed to study and assese of fertilizer type and doses on performance of wheat growth, yield and yield components. The experiment was arranged in asplit plot based on a randomized complete block design with four replications. The main plot was allotted for the three types of fertilizers, the Urea(46% N), NPK(20.20.20) and Monoamonium phosphate (MAP,12.61.0). The sub plot was denoted to the amount added (zero, 1, 2, 3 and 4 g). The three types of fertilizer was added to the experiment at sowing date and together with watering intervals which was conducted every 10-13 days. Planting was at 4meters-long, 70 cm between ridges and 20 cm between holes. Seed rate was 3-5 seeds/holes. And the seeds were sown manually. Weeding was done manually whenever needed.Variety is Argeen obtained from Department of Crop Science College of Agriculture University of Bahri.

3.2-Parameters Studied;-

3.2.1Plant height (cm)

The plant height was measured from soil surface to the tip of the plant and average means from five randomly selected plants from middle two rows of each plot were calculated.

3.2.2-Number of leaves/plant

The average number of leaves per plant from the five randomly selected plants from middle two rows of each plot was calculated.

3.2.3-Number of tillers/row meter

Average number of tillers per row meter from two random lengths of two middle rows was recorded.

3.2.4-Spike length (cm)

The average length of spike was measured from five randomly selected spikes from two middle rows of each plot.

3.2.5-Number of grains/spike

Average number of grains per spike was counted from five randomly selected spikes from the middle two rows of each plot was calculated.

3.2.6-1000 grain weight(g)

The grain weight was obtained by weighing 1000 grains selected at random from each plot.

3.2.7-Fresh weight (g)

five plants from randomly selected plots were weighed and the average fresh weight per plant was recorded.

3.2.8-Dry weight (g)

five plants from randomly selected plots were dried by sun, weighed and the average dry weight per plant was recorded.

3.2.9-Yield /plant (g)

five plants from randomly selected plots were taken and the average seed yield per plant was recorded.

3.2.10-Yield/hectare (Kg)

The yield per plot of (12 m^2) was converted in to kg/ha.

By the equation.

Seed weight*square meter*10000/1000

3.3-Statistical analysis

The data collected were analyzed by the standard analysis of variance means (ANOVA) using MSTATC-C. Then the means were separated using LSD**.**

CHAPTER FOUR

Results and Discussion

Plant growth and yield parameters:-

4.1-**Plant height (cm)**

The plant height was significant for the fertilizer type and interaction, while it was highly significant for dosing (Table 1).

Urea gave highly significant plant height (90.5cm) than the other two types. However, NPK and MAP gave non-significant difference (Table 2). Also there was significant difference for interaction and urea with 4g dosing which gave tallest plant height (90.5cm) where the lowest was given by the control(63cm) (Table 4).There was highly significant difference for dosing and 1g,2g and 4g gave the highest plant height(82.9cm) where as the lowest was given by the control(66.5cm) table3.This might be due to the effect of fertilization on wheat growth. Similar results were given by Ragaei, (2008). The growth rate of the plant height showed increasing rate with time and highest height was observed at 90days for MAP(Figure 1),NPK(Figure 2) and Urea(Figure 3). However, urea had the highest plant height than MAP and NPK at all growth stages. this was due to the highest amount of nitrogen in urea than in the other thus fertilizers.

4.2-**Number of leaves/plant**

The number of leaves per plant was significantly different for fertilizer type and dosing, while it was not-significant for interaction table 1.

Urea gave significantly higher number of leaves per plant(5.5) than the other two types. Howevere,NPK and MAP gave non-significant difference(Table 2). 1g,2g,3g and 4g micro dosing was non-significant and the highest was given by 4g(5.6) while the lowest was given by the control(4.7) (Table 3).The increase in number of leaves per plant with urea might be due to promotion of growth as urea had a higher nitrogen percentage than the other fertilizers. Similar results were given by Khalil *et al.*, (2011). Table 4 showed non-significant different for interaction. The growth rate of the leaves per plant showed increasing rate with time and the highest number of leaves per plant was observed at 90 days for MAP (Figure 4),NPK (Figure 5) and Urea (Figure 6). However, Urea had the highest number of leaves per plant than MAP and NPK at all growth stages.This is my be as urea contains more nitrogen which can move faster in both soil and plant.

4.3-**Spike Length (cm)**

The spike length was highly significant for fertilizer type and dosing, while it was non-significantly different for interaction (Table 1).

Urea gave highly significant spike length (9.1 cm) than the other two types. However, NPK and MAP were non-significantly different (Table 2), also there was highly significant differently for dosing and 3g dosing had the highest spike length (9.2cm) where as the lowest was obtained by control (7.5cm). The spike length increased with increasing dosing (Table 3), while there was non-significant difference for interaction (Table 4).The increase of spike length with increase of dosing might be due to the effect of increasing dose of nitrogen. The results were in agreement with Ling &Silberbush (2002), and Oko *et al*., (2003).

4.4-**Number of grains/spike**

Table (1) showed significant difference for fertilizer type and dosing, while it was not-significant different for interaction.

Urea gave significantly higher number grain per spike (32.5) than the other two types. However, NPK and MAP were not-significantly different (Table 2), 1g,2g,3g and 4g were significantly higher (31.17,31.42,31.16,32.55) than the control(29.70) (Table 3), while it was not-significantly different for interaction (Table 4).Increasing the dose in all fertilizers increase number of grains per spike as the plant benefited from the available fertilizer. These results were in accordance with Alam *et al*., (2007).

4.5-**Fresh Weight(g)**

The effect of fertilizer type and dosing was highly significant on fresh weight, while it was non-significant different for interaction (Table 1) .Urea gave highly significant fresh weight (203.8 g) than the other two types . However MAP and NPK showed non-significant difference (178.22g) (table 2), 3g and g4 gave highly significant difference(204.3g)than the others where as 1g,2g and control were not significant with the lowest weight for the control (147g)and highest weight by 4g(204g) (Table 3).The high fresh weight for urea can be explained by the fact that Urea contains more nitrogen than the others and the higher dose was properly utilized. Similar results were given by(Mohamed, 2016) , while there were not-significant differences for the interaction(Table 4).

4.6-**Dry weight (g)**

The dry weight was highly significantly different for fertilizer type and dosing , while there were not-significant differences for interaction (Table 1).Urea gave highly significant dry weight (49.9g) than the other two types. However NPK and MAP were non-significant different(Table 2).Similar results were given by(Mohamed, 2016). 2g,3g and 4g were highly significantly different for dry weight(51g) than the 1g and control(40g) (Table 3), while there were not-significant differences for the interaction (Table4).

4.7-**Number of tillers/row meter**

The number tillers per row meter was highly significant for fertilizer type, while it was not-significant different for dosing and interaction (Table 1).

Urea gave significantly different tiller number per row meter (217) than the other two types. However, NPK and MAP gave non-significant difference(165.2,157 plant) (Table 2).Urea might be due to the higher nitrogen content than the other two fertilizers as nitrogen promotes growth. These results were in line with Bakht *et al.*, (2010)and might be due to the fact that nitrogen is an essential element for growth and development and thus promoted the vegetative growth., there were no-significant difference for dosing and the highest number was given by 3g(186) and the lowest by control (174) (Table 3), The interaction effect on tiller number per row meter was not-significantly different (Table 4).

4.8-**Thousand grain weight (g**)

Table (1) indicated that there were highly significant difference for type and dosing, where as they were not significantly different for interaction (Table 1).

Urea and NPK gave highly significant thousand grain weight(43.3g) than the MAP (Table 2), 4g dosing gave highly significant weight for the thousand grain (42.9g) than the other doses (table 3)The increase in 1000-grain weight in 4g dosing could be related to flag leaf feeding and its closeness to spike (sink).Similar results were reported by(Rajaei *et al*.,2008),who these were noted significant differences for interaction and Urea with 2g had the highest thousand grain weight(46g) (Table 4).

4.9-Yield/plant (g)

The yield per plant was highly significant for fertilizer type and dosing, while it was non-significant different for interaction (Table 1). Urea gave highly significant yield per plant (2.9 g) than the other two types. However, NPK and MAP gave non-significant difference(table 2).1g,2g,3g and 4g gave highly significant different yield per plant(2.8 g) than the control (2.2) (Table 3).The increase in grain yield was due to the increase in applied N rate which formed a strong source.Similar results were shown by(Yasin *et al*., 2014).there were not significant difference for the interaction (Table 4).

4.10-**Yield /hectare (kg/ha)**

The yield per hectare was highly significant different at(p.0.01)for fertilizer type, dosing and interaction(Table 1).

Table (2) showed highly significant difference at for fertilizer type and urea gave the highest yield per hectare (1028.3kg/ha) where lowest yield by MAP (778.2kg/ha) (table 2), also 1g,2g,3g and 4g gave highly significant different yield per hectare(1023kg/ha) than the control (520.9kg/ha) (Table 3) the increase in yield with increased dose for all fertilizers was due to utilization of the plant to the different forms of fertilizers. Similar results were obtained by(Yasin *et al.*, 2014). While urea with 1g,2g,3g and 4g gave highly significant yield per hectare(1233kg/ha) than the others where as the lowest was obtained by the control (555kg/ha)(Table 4). Application of N had significantly increased grain weight as compared with control and increased with increase in N. These results were in agreement with (Kambhar *et al*.,2007)

Table 1:Summary of ANOVA table for wheat experiment

Source of variation	DF	Plant hight (cm)	leave/ plant	Spike Length (cm)	grain/ spike	Fresh weight (g)	Dry weight (g)	Tililer/ row meter	thousand (g)	yield/ plant	yield/ hactar (kg)
Replication	3	2.77	0.65	6.52	0.65	3.99	2.33	0.26	3.39	0.56	1.64
FERTI.. LIZER	2	10.14^{*}	4.50^{*}	8.20^{**}	11.48^{*}	15.9^{**}	96.5^{**}	13.19^{**}	15.9^{**}	30.17^{**}	52.39^{**}
EROR A	6	--	--	--	--	--	--	--	--	--	--
Concentration	4	6.53^{**}	2.69^{*}	4.19^{**}	3.44^{*}	12.77^{**}	19.6^{**}	0.28	12.8^{**}	10.01^{**}	110.76^{**}
F*C	8	1.93^{*}	0.94^{Ns}	0.20^{Ns}	0.86^{Ns}	0.27^{Ns}	1.08^{NS}	0.37^{Ns}	0.27^{*}	1.81^{NS}	6.81^{**}
EROR B	36	--	--	--	--	--	--	--	--	--	--
TOT	59	--	--	--	--	--	--	--	--	--	--
C.V		11.60	13.0	13.07	5.93	12.33	7.31	17.79	12.33	10.09	7.66

NB.* indicates significant difference ,** means highly significant difference. Ns indicate non-significant difference**.**

Table 2: Means of fertilizer type for yield parameters in wheat

fertilizer	Plant hight (cm)	Leave /plant	Spike length (cm)	Grain/ Spike	Fresh weight (g)	Dry weight (g)	Tililer/ row meter	thousand (g)	Yield /plant (g)	yield/ hactar (g)
MAP	70.31^{b}	5.10^{c}	8.24^{b}	29.70^{b}	170^{b}	44.3^{b}	165.15^{c}	36.89^{b}	2.27^{c}	778.22^{c}
NPK	71.48^{b}	5.30^{b}	8.29^{b}	30.90^{b}	178.7^{b}	46.3^{b}	157.05^{c}	40.91^{a}	2.49^{b}	812.38^{b}
Urea	90.50^{a}	5.50^{a}	9.12^{a}	32.08^{a}	203.8^{a}	49.9^{a}	217.76^{a}	43.58^{a}	2.91^{a}	1028.34^{a}
Mean	77.4	5.3	8.6	31.1		46.9	180	40.7	2.6	873

Means within column followed by the same letter(s) were not significantly different according to LSD test at 5% level.

Table:3 fertilizer concentration for yield component of wheat microdosing.

Concentration	Plant hight (cm)	Leave/Plant	SPike Length (cm)	Grain/SPike	Fresh weight (g)	Dry weight (g)	Tililer/ row meter	thousand (g)	yield/ plant	yield/hactar(kg)
Control	66.6[c]	4.7[b]	7.46[c]	29.70[ab]	147[c]	40.3[b]	174.75[ab]	33.9[b]	2.18[c]	520.98[c]
1g	82.8[a]	5.4[a]	8.58[ab]	31.17[a]	179.3[b]	44.6[b]	175.25[ab]	40.4[a]	2.4[ab]	883.4[b]
2g	81.3[a]	5.4[a]	8.33[ab]	31.42[a]	186.9[b]	48[a]	181.08[a]	41[a]	2.68[a]	959[ab]
3g	75.8[ab]	5.3[a]	9.22[a]	31.16[a]	203.4[a]	49[a]	186[a]	42.2[a]	2.68[a]	977.8[ab]
4g	80.8[a]	5.6[a]	8.87[a]	32.55[a]	204.3[a]	51[a]	182.8[a]	44.7[a]	2.76[a]	1023.9[a]
Mean	77.4	5.3	8.6	31.1	184.2	46.9	180	40.7	2.6	873

Means within column followed by the same letter(s) were not significantly different according to LSD test at 5% level.

Table:4 Interaction of fertilizer and concentration of yield component of wheat microdosing.

Fertilizer	Concentration	Plant height (cm)	leavs/ plant	Spike length (cm)	grain/ spike	Fresh weight (g)	Dry weight (g)	tillers/ row meter	1000 (g)	Yield/ pant (g)	Yield/ hectare (kg)
MAP	Cont	67.8^{ab}	4.8^{ab}	7.3^{b}	28.8^{ab}	137^{c}	42^{b}	170^{ab}	33^{b}	2.2^{ab}	555^{c}
	1g	72.3a	5^{a}	8.1^{ab}	30.3^{a}	170^{b}	40^{b}	145^{c}	34.9^{b}	2.2^{ab}	793.4^{b}
	2g	76.6^{a}	5.4^{a}	8.2^{ab}	29.8^{ab}	170^{b}	45^{a}	165^{b}	36.5^{ab}	2.3^{a}	840.3^{a}
	3g	67.5^{ab}	5^{a}	9.1^{a}	29.8^{ab}	185^{a}	47^{a}	180^{a}	38^{a}	2.4^{a}	850^{a}
	4g	67.5^{ab}	5.5^{a}	8.5^{ab}	30^{a}	187^{a}	45^{a}	165^{b}	41.6^{a}	2.3^{a}	852.5^{a}
NPK	Cont	63.2^{c}	4.5^{ab}	7.3^{b}	30^{a}	145^{c}	38^{c}	140^{b}	35^{c}	2.1^{ab}	494^{c}
	1g	76.8^{a}	5.8^{a}	8.1^{ab}	31^{a}	170^{b}	45^{b}	161^{a}	40^{b}	2.5^{ab}	805.4^{b}
	2g	72^{ab}	5^{a}	8.5^{ab}	30.75^{a}	185^{b}	48^{a}	160^{a}	40^{b}	2.7^{a}	876.4^{ab}
	3g	70.2^{ab}	5.8^{a}	9.1^{a}	31^{a}	197^{a}	48^{a}	158^{a}	42.6^{a}	2.5^{ab}	900^{ab}
	4g	75.3^{a}	5.5^{a}	8.5^{ab}	31.75^{a}	195^{a}	52^{a}	165^{a}	45.5^{a}	2.7^{a}	985.8^{a}
Urea	Cont	68.7^{b}	5^{ab}	7.9^{ab}	29.5^{ab}	157^{c}	40^{b}	214^{b}	33^{b}	2.3^{ab}	513.9^{c}
	1g	99.3^{a}	5.5^{ab}	90^{a}	32.3^{a}	197^{b}	47^{a}	219^{a}	45^{a}	2.8^{ab}	1051^{b}
	2g	95.3^{a}	6^{a}	9.3^{a}	33.8^{a}	205^{b}	52^{a}	218^{a}	45.7^{a}	3.03^{a}	1160^{ab}
	3g	89.7^{ab}	5.3^{ab}	9.4^{a}	32.8^{a}	227^{a}	53^{a}	220^{a}	46^{a}	3.2^{a}	1182^{ab}
	4g	99.6^{a}	5.8^{ab}	9.6^{a}	34.5^{a}	230^{a}	55^{a}	217^{a}	47.1^{a}	3.3^{a}	1233^{a}
Mean		77.4	5.3	8.6	31.1	184.1	46.9	180	40.7	2.6	873

Means within column followed by the same letter(s) were not significantly different according to LSD test at 5% level

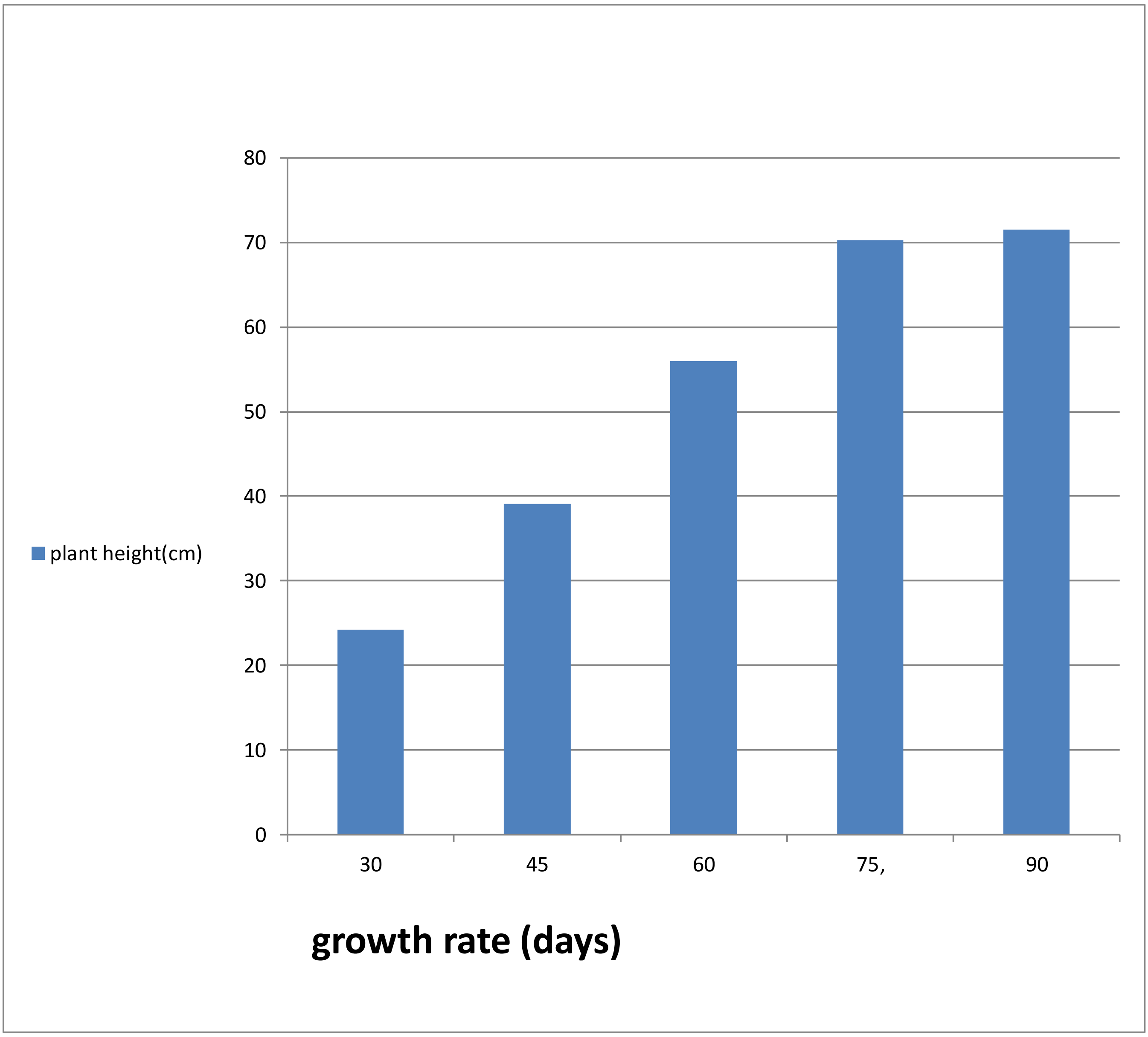

Figure (1) Effect of MAP on plant height and growth rate (days).

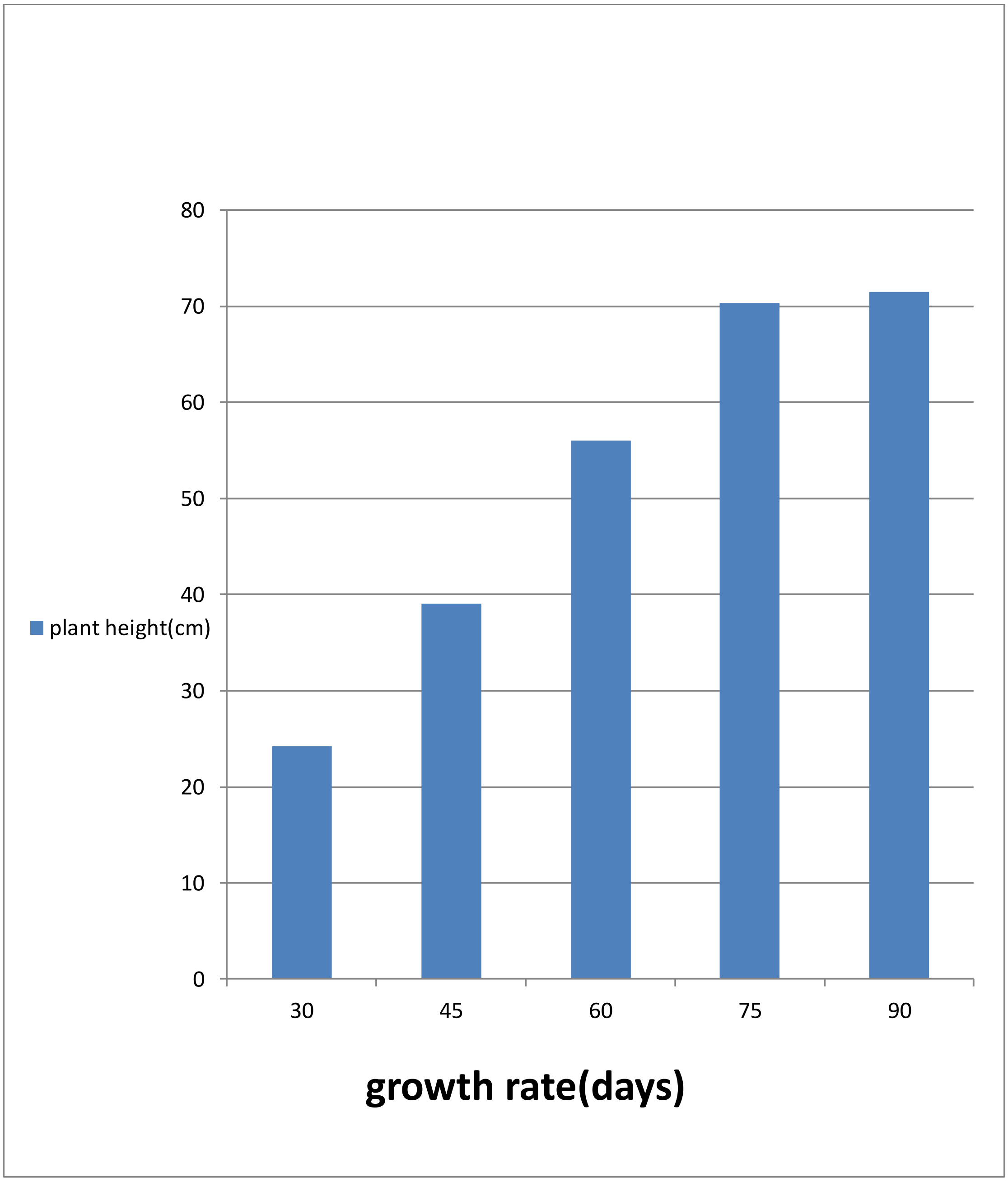

Figure (2) Effect of NPK on plant height and growth rate (days).

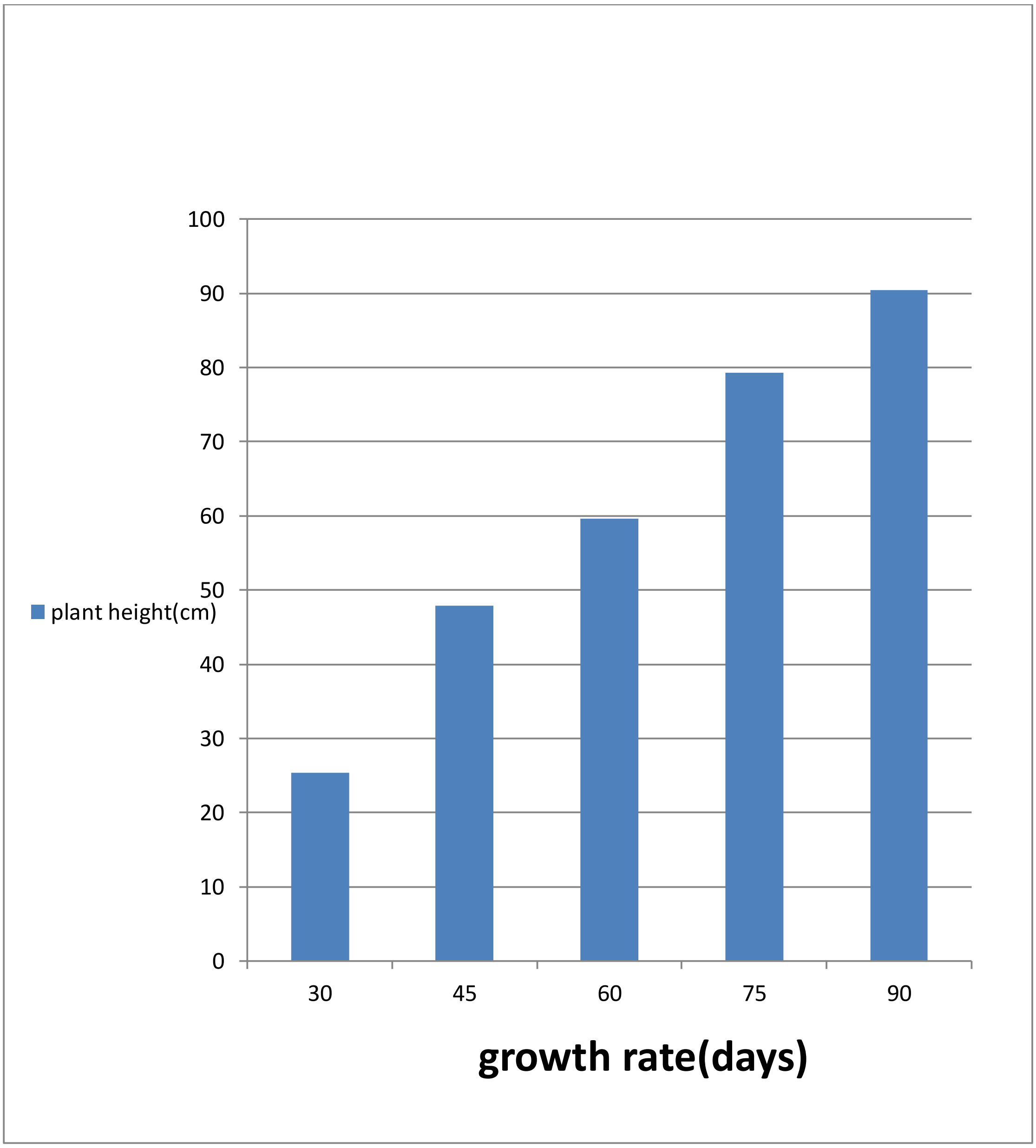

Figure (3) Effect of Urea on plant height and growth rate (days).

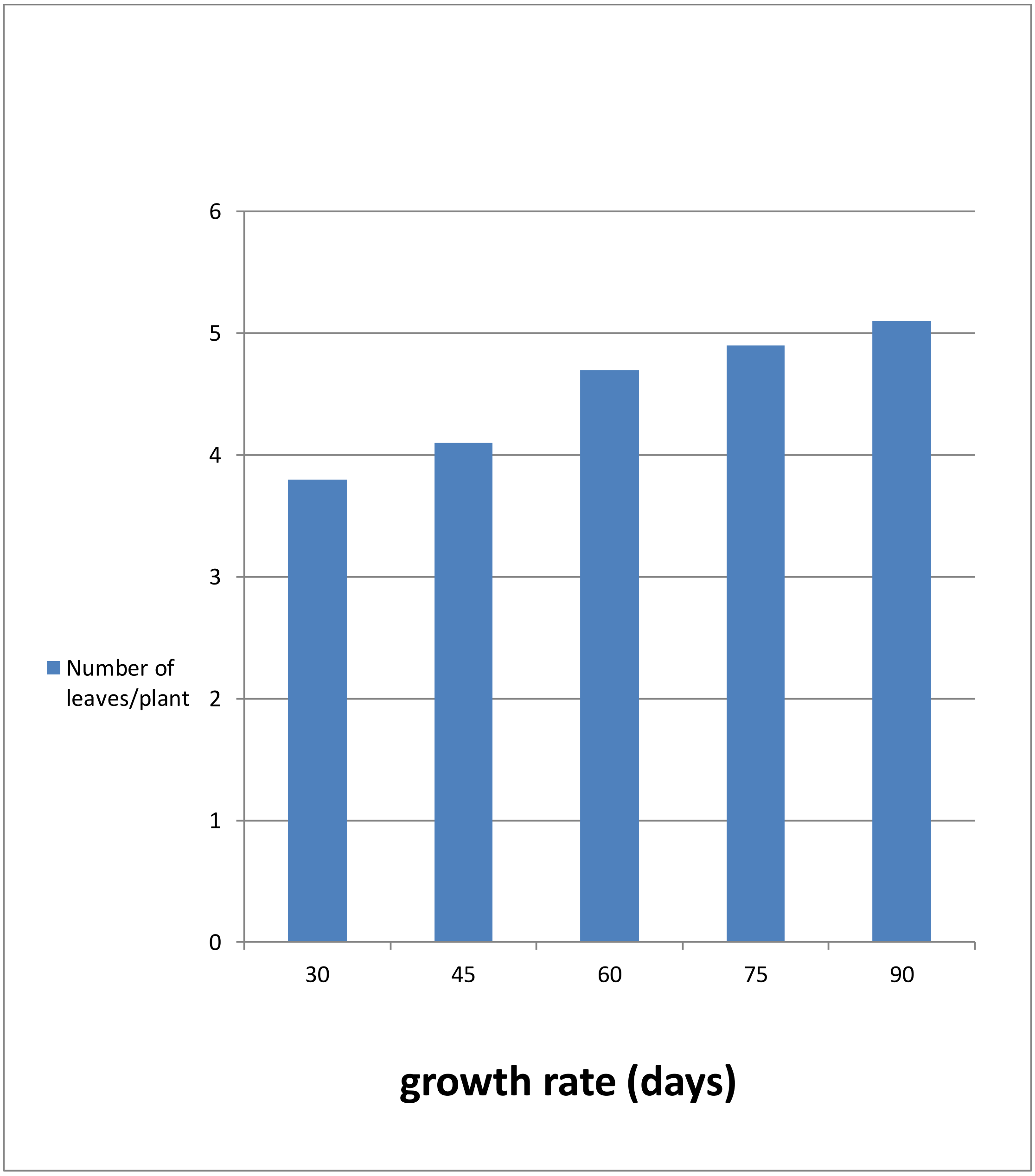

Figure (4) Effect of MAP on leaves per plant and growth rate (days) .

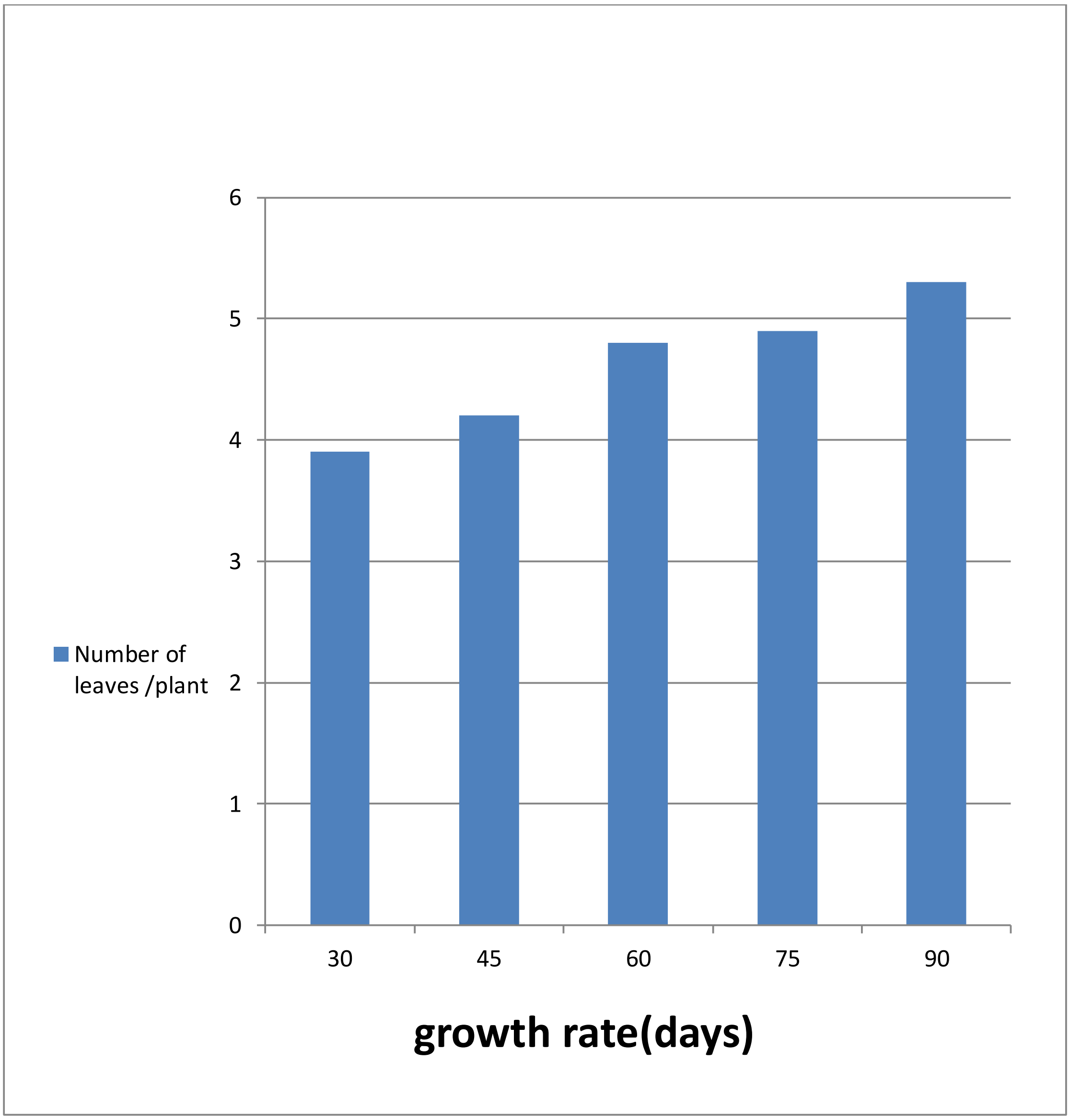

Figure (5) Effect of NPK on number of leaves per plant and growth rate (days) .

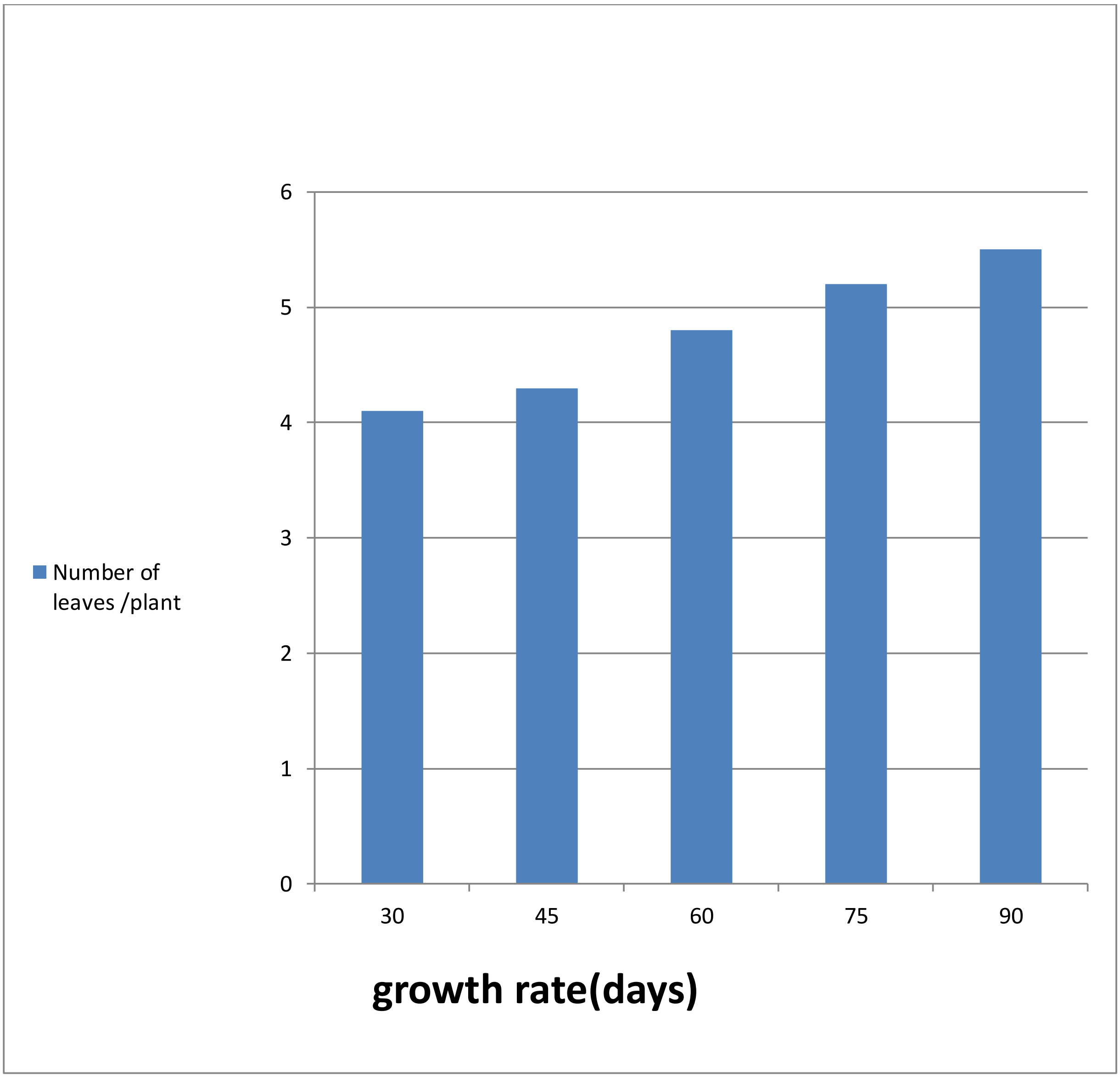

Figure (6) Effect of Urea on number of leaves per plant and growth rate (days) .

CONCLUSIONS

5.1- The present study indicated that :-

1- fertilizer types and dosing significantly affected the dual purpose of wheat micro-dosing.

2- Urea applied with 4g doses increased grain yield per hectare (kg/ha).

3- It is economically sound for small household farmers to use microdosing.

4- Microdosing is an easy technique and reduces labor such as fertilizer application equipment for small areas.

5- it could be recommended that more research is needed to evaluate the effect of microdosing.

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A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	2101.105	700.368	2.7665	0.1336
2	Factor A	2	5135.822	2567.911	10.1434	0.0119
-3	Error	6	1518.957	253.160		
4	Factor B	4	2108.507	527.127	6.5336	0.0005
6	AB	8	1246.944	155.868	1.9319	0.0851
-7	Error	36	2904.477	80.680		
	Total	59	15015.813			

Coefficient of Variation: 11.60%

s_ for means group 1: 4.1082 Number of Observations: 15
y

s_ for means group 2: 3.5578 Number of Observations: 20
y

s_ for means group 4: 2.5929 Number of Observations: 12
y

s_ for means group 6: 4.4911 Number of Observations: 4

y

Appendix(1) ANOVA OF plant height(cm)

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	0.333	0.111	0.6250	
2	Factor A	2	1.600	0.800	4.5000	0.0640
-3	Error	6	1.067	0.178		
4	Factor B	4	4.933	1.233	2.5965	0.0525
6	AB	8	3.567	0.446	0.9386	
-7	Error	36	17.100	0.475		
	Total	59	28.600			

Coefficient of Variation: 13.00%

s_ for means group 1: 0.1089 Number of Observations: 15

y

s_ for means group 2: 0.0943 Number of Observations: 20

y

s_ for means group 4: 0.1990 Number of Observations: 12

y

s_ for means group 6:   0.3446   Number of Observations: 4

y

Appendix(2) ANOVA OF leaves/plant

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	11.653.8846.518	0.0257		
2	Factor A	2	9.7724.8868.2010	0.0192		
-3	Error	6	3.5750.596			
4	Factor B4	20.875.2184.1781	0.0070			
6	AB	8	2.601	0.2500.2003		
-7	Error	36	44.959	1.249		
	Total	59	92.838			

Coefficient of Variation: 13.07%

s_ for means group 1:   0.1993   Number of Observations: 15

y

s_ for means group 2:   0.1726   Number of Observations: 20

y

s_ for means group 4:   0.3226   Number of Observations: 12

y

s_ for means group 6: 0.5588 Number of Observations: 4

y

Appendix(3) ANOVA OF spike length(cm)

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	6.983	2.328	0.6476	
2	Factor A	2	81.900	40.950	11.3926	0.0091
-3	Error	6	21.567	3.594		
4	Factor B	4	46.767	11.692	3.4444	0.0175
6	AB	8	23.433	2.929	0.8629	
-7	Error	36	122.200	3.394		
	Total	59	302.850			

Coefficient of Variation: 5.93%

s_ for means group 1: 0.4895 Number of Observations: 15

y

s_ for means group 2: 0.4239 Number of Observations: 20

y

s_ for means group 4: 0.5319 Number of Observations: 12

y

s_ for means group 6:   0.9212   Number of Observations: 4

y

Appendix(4) ANOVA of grain/spike

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	3930.330	1310.110	3.3936	0.0947
2	Factor A	2	12309.157	6154.578	15.9422	0.0040
-3	Error	6	2316.339	386.057		
4	Factor B	4	26323.271	6580.818	12.7731	0.0000
6	AB	8	1108.032	138.504	0.2688	
-7	Error	36	18547.593	515.211		
	Total	59	64534.722			

Coefficient of Variation: 12.33%

s_ for means group 1:   5.0732   Number of Observations: 15

y

s_ for means group 2:   4.3935   Number of Observations: 20

y

s_ for means group 4:   6.5524   Number of Observations: 12

y

s_ for means group 6: 11.3491 Number of Observations: 4

y

Appendix(5) ANOVA of fresh weight(g)

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	4.625	1.542	0.2158	
2	Factor A	2	313.131	156.565	21.9192	0.0017
-3	Error	6	42.857	7.143		
4	Factor B	4	935.058	233.764	7.6590	0.0001
6	AB	8	238.067	29.758	0.9750	
-7	Error	36	1098.771	30.521		
	Total	59	2632.508			

Coefficient of Variation: 11.79%

s_ for means group 1: 0.6901 Number of Observations: 15

y

s_ for means group 2: 0.5976 Number of Observations: 20

y

s_ for means group 4: 1.5948 Number of Observations: 12

y

s_ for means group 6: 2.7623 Number of Observations: 4

y

Appendix(6) ANOVA OF Dry weight(g)

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	1304.654	434.885	0.2620	
2	Factor A	2	43453.287	21726.644	13.0894	0.0065
-3	Error	6	9959.208	1659.868		
4	Factor B	4	1144.471	286.118	0.2792	
6	AB	8	3055.031	381.879	0.3727	
-7	Error	36	36890.146	1024.726		
	Total	59	95806.797			

Coefficient of Variation: 17.79%

s_ for means group 1: 10.5194 Number of Observations: 15

y

s_ for means group 2: 9.1101 Number of Observations: 20

y

s_ for means group 4: 9.2409 Number of Observations: 12

y

s_ for means group 6: 16.0057 Number of Observations: 4

y

Appendix(7) ANOVA of tillers/row meter

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	2.889	0.963	0.4517	
2	Factor A	2	397.361	198.681	93.1953	0.0000
-3	Error	6	12.791	2.132		
4	Factor B	4	527.779	131.945	16.4537	0.0000
6	AB	8	190.178	23.772	2.9644	0.0118
-7	Error	36	288.689	8.019		
	Total	59	1419.688			

Coefficient of Variation: 6.97%

s_ for means group 1: 0.3770 Number of Observations: 15

y

s_ for means group 2: 0.3265 Number of Observations: 20

y

s_ for means group 4: 0.8175 Number of Observations: 12

y

s_ for means group 6: 1.4159 Number of Observations: 4

y

Appendix(8) ANOVA of Thousand grain weight(g)

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	0.119	0.040	0.5590	
2	Factor A	2	4.287	2.144	30.1665	0.0007
-3	Error	6	0.426	0.071		
4	Factor B	4	2.661	0.665	10.0121	0.0000
6	AB	8	0.963	0.120	1.8117	0.1070
-7	Error	36	2.392	0.066		
	Total	59	10.849			

Coefficient of Variation: 10.09%

s_ for means group 1: 0.0688 Number of Observations: 15

y

s_ for means group 2: 0.0596 Number of Observations: 20

y

s_ for means group 4: 0.0744 Number of Observations: 12

y

s_ for means group 6: 0.1289 Number of Observations: 4

y

Appendix(9) ANOVA of yield/plant(g)

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	34485.173	11495.058	1.6366	0.2778
2	Factor A	2	735904.326	367952.163	52.3872	0.0002
-3	Error	6	42142.230	7023.705		
4	Factor B	4	1981268.006	495317.001	110.7557	0.0000
6	AB	8	243553.666	30444.208	6.8075	0.0000
-7	Error	36	160997.644	4472.157		
	Total	59	3198351.046			

Coefficient of Variation: 7.66%

s_ for means group 1: 21.6390 Number of Observations: 15

y

s_ for means group 2: 18.7399 Number of Observations: 20

y

s_ for means group 4: 19.3049 Number of Observations: 12

y

```
s_ for means group 6:    33.4371       Number of Observations: 4
y
```

Appendix(10) ANOVA of yield/hectare(kg/ha)