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Direct and Residual Effects of Green Manure on Soil Chemical Fertility of Desert Plain Soil and Wheat (*Triticum aestivum* L.) Yield in New Hamdab Scheme, Northern State, Sudan

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Article history: Recieved: January 2019
Accepted: February 2019

Abstract

This study was conducted for three consecutive seasons 2014/15 (direct effect), 2015/16 (direct and residual effects) and 2016/17 (residual effect) on a desert soil with the aim to investigate direct and residual effects of green manure with three levels on soil fertility of desert soil and grain yield of wheat in the Northern State of Sudan. Four types of green manure *Vigna radiate* (Green gram), *Vigna sinensis* (Cowpea), *Dolichos Lablab* (Lablab bean) and S*esbania canabina* (Sesbania pea) were selected as green manure corps with three levels. The first level was a seed rate of 12 kg ha^{-1}, 18 kg ha^{-1}, 24 kg ha^{-1} , 12 kg ha^{-1} respectively. The second level was two times of the first level and third level was three times of the first level. The treatments were arranged in a randomized complete block design with three replications. Land preparation was done manually for the residual effects of green manure so as not to disturb the treatments which were fixed in the same plots of the first application of the manures. The results showed that the direct and residual effects of green manure were effective in improving the nitrogen and phosphorus uptake by plant and the chemical properties of the soil under investigation. The results showed that the green manure and its residues increased the organic carbon, nitrogen, available phosphorus, potassium, CEC and improved nitrogen and phosphorus uptake by wheat plant. The result also showed that the direct and residual effects of green manure obtained very high significant increase ($P\leq0.001$) in the grain yield of wheat on the desert plain soils.

Keywords: desert plain soil, green manure, wheat, direct and residual effects

Introduction

Soil fertility is especially affected by soil organic matter, which depends on biomass input to compensate mineralization. Higher biomass return to the soil can increase soil organic carbon and soil total N. N is the most studied nutrient, but P and K levels are also important. The soils of the Sudan where wheat is produced are almost poor in organic matter and as such they have inadequate supplies of many essential nutrients (Ageeb *et al.*, 1995). Regular addition of organic manures such as animal manures, green manures and crop residues is very important in maintaining the tilth, fertility and productivity of agricultural soils, and in protecting them from wind and water erosion, and preventing nutrient losses through runoff and leaching (Hornik and Parr, 1987).

Agdede *et al*. (2008) evaluated the effect of organic manure on soil physical and chemical properties, growth and grain yield of sorghum in Southwest, Nigeria. They found that manure increased significantly soil organic matter, nitrogen, available phosphorus and potassium.

Ahmed (2010) evaluated the effect of green and farmyard manures on properties of desert plain soil in Northern Sudan. His study showed that each of the tested manures was effective in improving the soil chemical properties. A minor increase in organic carbon, nitrogen, available phosphorus and potassium were observed with application of the manures, but the pH was not affected by the source of organic manure.

In a study on sandy clay loam soil in New Delhi, India, Ram *et al*.(2011) found that the direct and residual effect of green and farmyard manures had the highest increase in nutrient uptake.

Hababi *et al*. (2013) studied the effect of green manure on soil properties in east Azerbayjan province, Iran. They found that application of green manure had significant effects on organic carbon (OC) and calcium carbonate equivalent (CCE).

Elhadi *et al*. (2016) evaluated the effect of organic manure on the poor physical and chemical properties of sand dune soil in Elrawakeeb Dry Land Station, Khartoum State, Sudan. They reported that chicken manure and sewage sludge have very high significant ($P \leq 0.001$) increase on soil organic carbon by 224 %, available P by 139.9 %, total nitrogen by 142.9 %, and mineral nitrogen by 83.5 % and decreased soil pH by 5.6 %.

Hafifah *et al*. (2016) studied the effect of green manure and cow manure on soil properties and quality and yield of cauliflower in the village of Tegalgondo, Karangploso District of Malang Regency, Indonesia. Their study showed that application of green manure significantly changes the chemical properties of the soil. The increase of organic carbon was about 12.60%, of total N of about 53.87%, of available P of about 64.24 mg/kg, and exchangeable K of about 8.34 cmol/kg due to green manure treatment.

It seems that limited research has been done on the effects of green manure on soil chemical fertility of these desert plain soils and their performance for wheat production. Therefore, this study was conducted with the aim to assess the effect of green manure on nitrogen and phosphors uptake by wheat crop and soil fertility of a desert plain soil as well as grain yield of wheat in the Northern State of Sudan.

Materials and Methods

The experiment was carried out during three consecutive seasons 2014/15 (direct effect), 2015/16 (direct and residual effects) and 2016/17 (residual effect) at the National Institute of Desert Studies Research Farm, New Hamdab Scheme, in the Northern State of Sudan. The study area lies at the intersection of latitude 17º 55' N, and longitude 31º 10' E in the desert climate.

The soil of the study area belongs to El Multaga soil series which classified as Typic Haplocambids, coarse loamy, mixed, supper active, hyperthermic. The soil structure is moderate subangular blocky. It is non-saline and non-sodic (see Table 1). Generally, the soil chemical fertility is low. These soils are deficient in nitrogen, phosphorus and organic carbon for optimum yield of different cultivated crops. Some physical and chemical properties of the soil are shown in Table 1 (LWRC, 1999).

Table (1): Some soil properties of the experimental site

Soil properties	Soil depth (cm)				
	0 – 23	23 – 65	65 – 80	80 – 105	105 - 125
FS (%)	40	23	22	21	24
CS (%)	37	33	43	42	40
Silt (%)	15	25	11	19	8
Clay (%)	8	19	24	18	28
Texture	SL	SL	SCL	SL	SCL
pH (paste)	7.5	7.3	8.1	7.8	7.5
ECe	0.35	0.37	0.42	1.1	3.2
ESP	3.0	3.0	4.0	5.0	8.0
CaCO3 (%)	0.8	2.6	10.4	0.2	27.5
O.C (%)	0.052	0.066	0.078	0.061	0.052
N (%)	0.013	0.015	0.017	0.013	0.011
K (cmol(+)/ kg soil)	0.25	0.38	0.35	0.43	0.28
Ava.P (mg/kg soil)	1.8	1.8	2.0	1.8	2.0
C/N ratio	4	4	5	5	5

LS =loamy sand, SL = sandy loam, SCL= sandy clay loam

Vigna radiate (Green gram), *Vigna sinensis* (Cowpea), *Dolichos Lablab* (Lablab bean) and *Sesbania canabina* (Sesbania pea) were selected as green manure crops. These crops were planted early in the summer season (20th July) on the designated experimental units in a seed rate of 12 ,18 , 24 and 12kg ha^{-1}, respectively. Also, these previous applied seed rates were doubled and tripled to find their effect on soil properties and yield of wheat. After two months from sowing and before flowering each crop was incorporated into the soil using disk plow. Then the soil was watered and the subsequent watering was carried out at ten-day interval for six weeks before the sowing of wheat (test crop).

Seeds of wheat (Wadi Elneel cultivar) were sown at the rate of 120 kg ha^{-1} on the 20th of November in all seasons at 0.2 m inter-row spacing. Nitrogen and phosphorus were added as recommended (86 kg N ha^{-1} plus 43 kg P_2O_5 ha^{-1}) by the Agricultural Research Corporation (ARC). Irrigation was carried out every ten days. During all experimental period observations on grain yield of wheat were taken.

Chemical properties:

Composite soil samples were collected from 0 – 30 cm soil depth using an auger from each experimental unit for some chemical analyses pH (paste) (McLean, 1982), total N (TN; Bremner and Mulvaney 1982), organic carbon (OC; Nelson and Sommers, 1982), available P (Olsen and Sommers, 1982), electrical conductivity ECe (Rhoades,1982) cation-exchange capacity (CEC; Thomas1982), soluble K, Na, Ca and Mg (Chapman and Pratt, 1961) after harvesting of the wheat crop (at the laboratories of LWRC of ARC).

Samples from each of the four green manure crops (green gram (G), cowpea (C), Lablab bean (L) and sesbania pea (S)) were taken before being incorporated into the soil for analysis of (N, P, K, O.C and C/N). Biomass production of different green manure crops was weighted (kgha^{-1}) before incorporation.

Plant analyses for N and P uptake:

Plant samples of wheat crop were taken at the booting stage from each of the experimental units to determine N and P uptake. The analyses were carried out in the Plant Nutrition Laboratory of ARC (Kjeldahl method, Jackson, 1958).

Results and Discussion

Biomass production by green manure crops two months after sowing and before flowering (gm^{-2}): Table 2 shows the average biomass production by green manure crops two months after sowing and before being incorporated into the soil for both seasons.

The results showed that there were very high significant differences ($p \leq 0.001$) among the types of the green manure crops in the two seasons. But, there were no significant differences among the seed rate levels of the green manure crops. This may be due to the plant competition for light, moisture, and nutrients at a high seed rate. The highest biomass was obtained by sesbania pea (on the average 649 gm^{-2}) followed by green gram (on the average 480 gm^{-2}) and cowpea(on the average 432 gm^{-2}) and the lowest one by lablab bean (on the average 62 gm^{-2}) in season one, but in season two the highest biomass produced by green gram (on the average 570 gm^{-2}) followed by seasbania pea (on the average 541 gm^{-2}) and cowpea (on the average 454 gm^{-2}) and the lowest was obtained by lablab bean (on the average 96 gm^{-2}).The best types of green manure crop are green gram, sisbania pea and cowpea.

Table (2): Variation of biomass production by green manure crops two months after sowing and before flowering (g m^{-2}).

Seed rate Levels	Green manure types	First season	Second season
First level	Lablab bean (24 kgha-1)	68d	93d
	Green gram (12 kgha-1)	428c	533abc
	Cowpea (18 kgha-1)	449c	441bc
	Sesbania pea (12 kgha-1)	625a	489bc
Second level	Lablab bean (48 kgha-1)	62d	106d
	Green gram (24 kgha-1)	460c	557ab
	Cowpea (36 kgha-1)	406c	424c
	Sesbania pea (24 kgha-1)	647a	517abc
Third level	Lablab bean (72 kgha-1)	54d	89d
	Green gram (36 kgha-1)	551b	620a
	Cowpea (54 kgha-1)	439c	497bc
	Sesbania pea (36 kgha-1)	674a	617a
	C.V	7.08	14.68
	SE±	16.58	23.13

Means followed by different letters in the same column are significantly different at $P \leq 0.05$.

Chemical analysis of the green manure crops used:

Table (3) shows the chemical analysis of the green manure crops (*Vigna radiate* (Green gram), *Vigna sinensis* (Cowpea), *Dolichos Lablab* (Lablab bean), *Sesbania canabina* (Sesbania pea)) applied in this study. As seen, the nitrogen percentage in the green manure crops ranges from 3.5 to 3.9 %, total phosphorus ranges from 0.135 to 0.219 %, total potassium ranges from 1 to 1.1 and O.C ranges from11 to 13. The result revealed that carbon – nitrogen ratio (C/N) was 3.1 and 3.3.

Table (3): Chemical analysis of the biomass of green manure crops before incorporation

Green manure crops	N (%)	Total P (%)	Total K (%)	O.C (%)	C/N
Green gram	3.9	0.218	1.1	13	3.3
Cowpea	3.9	0.219	1.0	13	3.3
Lablab bean	3.9	0.151	1.0	12	3.1
Sesbania pea	3.5	0.135	1.0	11	3.1

Fertility status of the soil:

The fertility status of the soil under study was checked by determining N%, O.C%, available phosphorus, exchangeable potassium, CEC and pH.

Data in Table 4 and 5 show the direct effect of green manures on some chemical properties of the soil after harvesting for both seasons. The results show that the organic carbon (on the average 0.178%), nitrogen (on the average 0.022%), available phosphorus (on the average 1.3 ppm) and exchangeable potassium (on the average 0.33 meq/100g soil) for both seasons are relatively very low in the control which is the usual case of the desert plain soils (LWRC,1999). The O.C, total nitrogen, available phosphorus and exchangeable potassium recorded for the lablab bean treatments in both seasons ranges from 0.112 % to 0.172%, 0.015% to 0.025%, 0.6 ppm to 2 ppm and 0.24 meq/100g soil to 0.36 meq/100g soil, respectively. This is not far from that recorded for the control treatment. However, the results showed that the green gram, cowpea and sesbania pea treatments recorded some increase in O.C, total nitrogen, available phosphorus and exchangeable potassium ranges from 0.225% to 0.390%, 0.050% to 0.085%, 2.4 ppm to 4.8 ppm and 0.43 meq/100g to 0.91 meq/100g, , respectively in both seasons. The data showed that the application of green manure have positively increased the amount of soil organic carbon, nitrogen, available phosphorus and exchangeable potassium.

Table 4: Direct effect of green manure on soil chemical properties after harvesting for 0 – 30 cm (Season1, 2014/015)

Seed rates levels	Types of Green manure	PH	O.C (%)	N (%)	K meq/100g	P Ppm	CEC cmol(+) kg-1 soil
	Control	7.2	0.172	0.025	0.27	0.6	12
First level	L (24 kgha-1)	7.4	0.172	0.025	0.38	0.8	15
	G (12 kgha-1)	7.6	0.272	0.080	0.56	2.0	26
	C (18 kgha-1)	7.1	0.278	0.085	0.45	2.6	27
	S (12 kgha-1)	7.3	0.265	0.075	0.45	2.0	20
Second level	L (48 kgha-1)	7.6	0.156	0.018	0.24	0.6	14
	G (24 kgha-1)	7.2	0.268	0.085	0.45	2.6	19
	C (36 kgha-1)	7.4	0.256	0.060	0.46	2.8	24
	S (24 kgha-1)	7.4	0.225	0.075	0.43	2.4	29
Third level	L (72 kgha-1)	7.1	0.164	0.020	0.30	1.0	15
	G (36 kgha-1)	7.5	0.312	0.050	0.43	2.4	26
	C (54 kgha-1)	8.2	0.374	0.085	0.46	2.4	25
	S (36 kgha-1)	7.0	0.290	0.085	0.44	2.6	23

L= Lablab bean, **G** = Green gram, **C** = Cowpea, **S** = Sesbania pea

The data also showed that green gram, cowpea and sesbania pea have a relative advantage over lablab bean in increasing soil organic carbon, nitrogen, available phosphorus and exchangeable potassium. This is probably acceptable because these three types of green manure crop (the best types of green manure crop) have a relatively higher biomass production (432 gm-2 to 649 gm-2) compared to that of lablab bean (62 gm-2 to 96 gm-2) (Table 2). The result revealed that there was an increase in CEC in response to the green manure (19 – 27 cmol(+) kg^{-1}soil) as compared with the control (10 – 12 cmol(+) kg^{-1}soil).

Table (5): Direct effect of green manure on soil chemical properties after harvesting for 0 – 30 cm (Season2, 2015/016)

Seed rates levels	Types of Green manure	PH	O.C (%)	N (%)	K meq/100g	P Ppm	CEC cmol(+) kg-1 soil
	Control	7.1	0.187	0.020	0.39	2.0	14
	L (24 kgha-1)	7.0	0.112	0.025	0.34	2.0	13
First level	G (12 kgha-1)	7.5	0.225	0.075	0.81	3.0	22
	C (18 kgha-1)	7.2	0.281	0.060	0.81	2.8	24
	S (12 kgha-1)	7.3	0.278	0.065	0.74	4.2	23
	L (48 kgha-1)	7.0	0.125	0.015	0.31	2.0	15
Second level	G (24 kgha-1)	7.3	0.265	0.075	0.91	3.4	21
	C (36 kgha-1)	7.5	0.231	0.078	0.90	3.6	23
	S (24 kgha-1)	7.4	0.312	0.075	0.83	3.6	26
	L (72 kgha-1)	7.2	0.165	0.025	0.36	1.9	16
	G (36 kgha-1)	7.0	0.312	0.075	0.81	4.8	26
Third level	C (54 kgha-1)	7.4	0.390	0.085	0.76	4.4	26
	S (36 kgha-1)	7.1	0.278	0.075	0.86	4.6	26

L= Lablab bean, **G** = Green gram, **C** = Cowpea, **S** = Sesbania pea

Tables 6 and 7 showed the residual effect of green manure on some soil chemical properties. The result revealed there was slight increase in O.C%, nitrogen, available phosphorus, potassium and CEC in the top soil (0 - 30 cm soil depth) as a result of the amendment treatments as compared with the control. This result is not far from that of the direct effect of green manure.

The role of organic manures in increasing the soil organic carbon, nitrogen, available phosphorus, exchangeable potassium and CEC has been reported by many researchers (Mahmuod *et al*., 2009; Ahmed, 2010; Hababi *et al*., 2013; Elhadi *et al*., 2016 and Hafifah *et al*., 2.016). They found that organic manures increased O.C, N, available P, exchangeable K and. This is simply due to their contents of these materials in addition to their capability to improve CEC.

The pH was almost not affected by the treatments in all seasons and this presumably due to the high buffering capacity of the soil. This result is in conformity with that of Ahmed (2010) who reported that the soil pH was not affected by organic manure treatments.

Table (6): Residual effect of green manures on soil chemical properties after harvesting for 0 – 30 cm (Season1, 2015/016)

Seed rates levels	Types of Green manure	PH	O.C (%)	N (%)	K meq/100g	P Ppm	CEC cmol(+) kg-1 soil
	Control	7.1	0.016	0.015	0.26	1.6	11
First level	L (24 kgha-1)	7.1	0.016	0.015	0.26	1.6	12
	G (12 kgha-1)	7.4	0.372	0.075	0.44	4.4	16
	C (18 kgha-1)	7.3	0.343	0.065	0.45	4.6	16
	S (12 kgha-1)	7.3	0.378	0.061	0.41	4.2	16
Second level	L (48 kgha-1)	7.3	0.112	0.025	0.29	2.4	11
	G (24 kgha-1)	7.0	0.318	0.095	0.42	3.8	19
	C (36 kgha-1)	7.3	0.312	0.095	0.42	7.4	28
	S (24 kgha-1)	7.3	0.312	0.095	0.40	4.2	16
Third level	L (72 kgha-1)	7.3	0.062	0.01	0.22	2.6	13
	G (36 kgha-1)	7.3	0.312	0.091	0.47	4.6	18
	C (54 kgha-1)	7.3	0.288	0.075	0.42	6.6	16
	S (36 kgha-1)	7.4	0.278	0.065	0.41	5.6	16

L= Lablab bean, **G** = Green gram, **C** = Cowpea, **S** = Sesbania pea

Table (7): Residual effect of green manures on soil chemical properties after harvesting for 0 – 30 cm (Season2, 2016/017)

Seed rates levels	Types of Green manure	PH	O.C (%)	N (%)	K meq/100g	P Ppm	CEC cmol(+) kg-1 soil
	Control	7.4	0.156	0.020	0.20	2.1	7
First level	L (24 kgha-1)	7.8	0.117	0.065	0.22	2.1	8
	G (12 kgha-1)	7.2	0.264	0.070	0.30	4.1	11
	C (18 kgha-1)	7.4	0.236	0.070	0.30	4.1	11
	S (12 kgha-1)	7.5	0.253	0.070	0.30	4.8	12
Second level	L (48 kgha-1)	7.5	0.156	0.015	0.26	3.1	7
	G (24 kgha-1)	7.4	0.267	0.069	0.30	4.1	12
	C (36 kgha-1)	7.4	0.251	0.065	0.37	6.6	10
	S (24 kgha-1)	7.6	0.271	0.065	0.30	6.1	12
Third level	L (72 kgha-1)	7.4	0.115	0.020	0.20	2.1	7
	G (36 kgha-1)	7.4	0.231	0.060	0.30	6.8	10
	C (54 kgha-1)	7.4	0.256	0.075	0.30	8.0	10
	S (36 kgha-1)	7.5	0.239	0.070	0.30	4.1	12

L = Lablab bean, **G** = Green gram, **C** = Cowpea, **S** = Sesbania pea

Wheat uptake of nitrogen and phosphorus:

The data on N and P uptake by wheat crop as influenced by green manure are presented in Table (8). In all seasons, positively higher N and P percentage was recorded by green manure over the control except lablab bean treatments. The nitrogen uptake by the plant from the control and lablab bean treatments ranges from 1.2 to 1.7 % in all seasons. The data of plant uptake of nitrogen showed that nitrogen uptake in the direct effect of green gram, cowpea and sesbania pea treatments ranges from 2 to 3.3 % while in their residual effect range from 2.4 to 4.2 %.

The phosphorus percentage removed from the soil by wheat crop for the control and lablab bean treatments ranges from 0.09 to 0.12 % in all seasons. However, P uptake by wheat plants of the direct effect of green gram, cowpea and sesbania pea treatments ranges from 0.15 to 0.313 % while their residual effect range from 0.183 to 0.404 %. The residual effect of organic manure recorded higher N and P uptake than that of the direct effect as more time was allowed for mineralization of the residual organic amendments.

These results are positively correlated with the yield and yield of wheat. The increase of N and P uptake appeared to be more obvious when the green manure was applied. This could be attributed to higher mineralization of organic manures that increased plant availability of macro – and micronutrients which led to high vegetative growth and more absorption of nitrogen.

The present finding of increase in N and P uptake from the soil by wheat crop in response to organic manures application is in agreement with that reported by Agbede *et al*. (2008) and Ram *et al*. (2011). They found that organic manures increased the N and P percentage.

Table (8): Direct and residual effect of green manure on N and P uptake by wheat plant in the Northern State, Sudan

Seed rates levels	Types of Green manure	Direct effect season1 (2014/2015)		Residual effect season1 (2015/2016)	
		N (%)	P (%)	N (%)	P (%)
	Control	1.5	0.090	1.2	0.120
First level	L (24 kgha-1)	1.5	0.093	1.5	0.105
	G (12 kgha-1)	2.3	0.159	3.2	0.240
	C (18 kgha-1)	2.1	0.150	3.3	0.291
	S (12 kgha-1)	2.2	0.168	2.4	0.242
Second level	L (48 kgha-1)	1.4	0.071	1.7	0.090
	G (24 kgha-1)	2.1	0.162	3.8	0.203
	C (36 kgha-1)	2.2	0.153	3.7	0.404
	S (24 kgha-1)	2.0	0.237	2.7	0.183
Third level	L (72 kgha-1)	1.6	0.097	1.7	0.097
	G (36 kgha-1)	2.0	0.175	4.2	0.224
	C (54 kgha-1)	2.1	0.182	3.9	0.278
	S (36 kgha-1)	2.2	0.162	2.5	0.200

L= Lablab bean, **G** = Green gram, **C** = Cowpea, **S** = Sesbania pea

Grain yield of wheat crop: The results in Table (9) showed that there were no significant differences for the grain yield of wheat among the seed rate levels of green manure in all seasons. However there were very high significant differences ($P \leq 0.001$) in grain yield among the control and the types of green manure except lablab bean treatments. The control recorded the lowest grain yield that ranges from 0.52 to 2.04 ton ha^{-1} in all seasons. Lablab bean treatments ranged from 0.92 to 3.29 ton ha^{-1} in all seasons, which is not far from that of the control while the other types of green manure ranged between 2.29 to 5.86 ton ha^{-1}.

Generally, the residual effect of green manure gave higher grain yield than that of the direct effect in all seasons. This supports the general concept that green manure has more beneficial residual effect when compared to its direct effect.

The data in all Tables showed that green gram, cowpea and sesbania pea have a relative advantage over lablab bean in improving the soil chemical properties, plant uptake and increased grain yield of wheat . This is probably acceptable because these three types of green manure crops (the best types of green manure crop) have a relatively higher biomass production (432 gm^{-2} to 649 gm^{-2}) compared to that of lablab bean (62 gm^{-2} to 96 gm^{-2}, Table 2).

High wheat grain yield due to application of organic fertilizers is reported by Ahmed *et al*. (2011) who found that green manure significantly increased grain yield of wheat crop.

Table (9): Direct and residual effects of green manure on grain yield (ton ha^{-1})

Seed rates levels	Types of Green manure	First season		Second season	
		Direct effect	Residual effect	Direct effect	Residual effect
	Control	0.51^{c}	1.69^{d}	0.92^{b}	2.04^{c}
First level	**L** (24 $kgha^{-1}$)	0.92^{bc}	3.29^{c}	1.34^{b}	3.02^{b}
	G (12 $kgha^{-1}$)	2.35^{a}	5.86^{a}	4.10^{a}	5.64^{a}
	C (18 $kgha^{-1}$)	2.40^{a}	5.64^{ab}	3.94^{a}	5.67^{a}
	S (12 $kgha^{-1}$)	2.51^{a}	5.65^{ab}	3.81^{a}	5.72^{a}
Second level	**L** (48 $kgha^{-1}$)	0.91^{bc}	3.34^{c}	1.38^{b}	3.11^{b}
	G (24 $kgha^{-1}$)	2.29^{a}	5.71^{ab}	4.00^{a}	5.74^{a}
	C (36 $kgha^{-1}$)	2.45^{a}	5.65^{ab}	4.10^{a}	5.65^{a}
	S (24 $kgha^{-1}$)	2.44^{a}	4.96^{b}	3.96^{a}	5.78^{a}
Third level	**L** (72 $kgha^{-1}$)	1.04^{bc}	3.25^{c}	1.10^{b}	3.17^{b}
	G (36 $kgha^{-1}$)	2.43^{a}	5.86^{a}	4.20^{a}	5.72^{a}
	C (54 $kgha^{-1}$)	2.33^{a}	5.83^{a}	4.20^{a}	5.74^{a}
	S (36 $kgha^{-1}$)	2.35^{a}	5.55^{a}	4.00^{a}	5.69^{a}
	Grand mean	**1.91**	**4.79**	**3.15**	**4.82**
	C.V	12.12	8.3	19.65	10.35
	SE±	0.134	0.229	0.357	0.288

L= Lablab bean, **G** = Green gram, **C** = Cowpea, **S** = Sesbania pea

Means followed by different letters in the same column are significantly different at $P \leq 0.05$.

Conclusions

The results showed that direct and residual effect of applying green manure has improved soil fertility and wheat yield. Green manure, therefore, may be used in vast desert plain soils areas, as it may pose a solution to the problems of the infertility and unavailability of organic manure. Green manure has continuing positive effects on desert plain soil to produce higher grain yield of wheat at least for the duration of this experiment. it is recommended that Green gram (Seed rate 12 kg ha^{-1}), Cowpea (Seed rate 18 kg ha^{-1}) and Sesbania pea (Seed rate 12 kg ha^{-1}) which are available and cheaper are suitable types of green manure crops for reclamation of the desert plain soils.

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الأثر المباشر والباقي للسماد الأخضر على خصوبة ترب السهل الصحراوي و إنتاجية القمح بمشروع الحامداب الجديدة بالولاية الشمالية, السودان

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المستخلص:

تضمنت الدراسة تجربة نفذت خلال ثلاثة مواسم متتالية 15/2014 (الأثر المباشر), 16/2015 (الأثر المباشر والباقي) و17/2016 (الأثر الباقي) بتربة صحراوية بهدف معرفة الأثر المباشر والباقي للسماد الأخضر بثلاثة مستويات معدل بذور على خصوبة تربة السهل الصحراوي وإنتاجية القمح بالولاية الشمالية بالسودان. شملت التجربة أربعة أنواع من السماد ألأخضر حيث تم اختيار كل من اللوبيا الذهبية, اللوبيا الحلوة, اللوبيا العفن والسيسبانيا كمحاصيل للسماد الأخضر بمعدل بذر 12كم/هكتار, 18كم/هكتار, 24كم/هكتار و12كم/هكتار على التوالي. ويمثل ذلك المستوى الأول للمحسنات العضوية والمستوى الثاني عبارة عن ضعفين المستوى الأول والثالث عبارة عن ثلاثة أضعاف المستوى الأول. نفذت التجربة على نظام القطع العشوائية الكاملة بثلاثة مكررات. تم تحضير ارض التجربة يدويا حتى تحتفظ وحدات التجربة بنفس معاملات السنة الأولى وذلك لمعرفة الأثر الباقي للسماد الأخضر. أوضحت النتائج أن الأثر المباشر والباقي للسماد الأخضر فعال في تحسين امتصاص نبات القمح للنيتروجين والفسفور والخواص الكيميائية للتربة تحت الدراسة. أظهرت النتائج أن هنالك زيادة في النسبة المئوية للكربون العضوي في التربة، النيتروجين، الفسفور المتاح والبوتاسيوم والسعة التبادلية الكايتونية عند إضافة السماد الأخضر. عمل السماد الأخضر وأثره الباقي على تحسين امتصاص نبات القمح للنتروجين والفسفور. كما أظهرت نتائج البحث أن للسماد الأخضر وأثره الباقي أثر معنوي عال جدا ($P \leq 0.001$) في زيادة إنتاجية القمح بترب السهل الصحراوي.