IMPACT OF INTEGRATED USE OF INORGANIC, BIO- AND ORGANIC FERTILIZERS ON GROWTH TRAITS, FORAGE YIELD AND SEED QUALITY OF TWO EGYPTIAN CLOVER (FAHL) CULTIVARS

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ABSTRACT: *Two field trials were conducted at Giza Agricultural Research Station, ARC, during 2011/12 and 2012/13 winter seasons to study the impact of integrated use of inorganic, bio- and organic fertilizers on growth traits, forage yield and seed quality of two Egyptian clover (Trifolium alexandrinum, L.) cultivars (var. Fahl). Five treatments were applied i.e., T_1: (recommended NPK 100%), T_2: 50% NPK, T_3: 50% NPK + Rhizobium inoculation, T_4: 50% NPK + Rhizobium inoculation + 1.5 ton compost fed^{-1} and T_5: 50% NPK + Rhizobium inoculation + 2.5 ton compost fed^{-1}. The results indicated that the studied growth traits, forage yield and seed quality of the two cultivars were significantly affected by the fertilization treatments. Cultivar Kalupia showed more superiority of all traits than cultivar Local. All fertilization treatments were exceeded the treatment received half dose of mineral NPK. However, manuring soil with compost in combination with Rhizobium inoculation and 50% mineral NPK showed significant superiority over the other tested treatments and exerted considerable improvement in all growth traits, forage yield and seed quality. These enhancements were more obvious when compost applied at a rate of 2.5 ton fed^{-1}, relatively to the unamended plants or plants amended with 1.5 ton compost fed^{-1}. Significant positive correlations were detected between fresh forage yield ton fed^{-1} and each of plant height, number of branches plant^{-1}, leaf/stem ratio, dry forage yield, root length, root diameter, number of nodules plant^{-1} and nodules dry weight plant^{-1}, seed germination and dry seedling weight. Seed yield kg fed^{-1} was significantly positively correlated with each of number of heads plant^{-1}, number of seeds head^{-1}, 1000- seed weight, straw yield, crude protein and NPK content as well as with Fe, Zn, Mn and Cu content.*

It is evident that the applied compost together with 50% of inorganic NPK in the presence of Rhizobium may be acting as a good practice to maximize the return of clover yield and improving seed quality as well as saving chemical fertilizer use and reducing environmental pollution, particularly with implying legumes production under sustainable agriculture system.

Key words: *Fahl Egyptian clover, Trifolium alexandrinum L., Rhizobium inoculation, Compost, Inorganic NPK fertilizers.*

INTRODUCTION

Egyptian clover (*Trifolium alexandrinum*, L.) is the main forage crop grown in Egypt during the winter season. Nutrient availability is one the most important factors affected plant development. The drastic raising in chemical fertilizer prices and their adverse effects on environment greatly incited the serious endeavours of many researchers to seek the relevant alternatives of synthetic fertilizers. These may be involving the extension in the practice of sustainable agriculture system, which relies mainly on the legume-*Rhizobium* symbiosis (Jensen and Hauggaard, 2003) in addition to utilize the natural materials as sources of macro and micronutrients such as efficient inoculants and organic materials (Conacher and Conacher, 1998; Abdel-Wahab *et al*., 2003 and Mekhemar *et al*., 2007). There are evidences that yield in organic farming system is less than conventional production system, especially in areas with low soils organic matter content (Dawson *et al.,* 2008). There are scientific evidences supporting the idea that the application rate of chemical fertilizers could be reduced (to achieve optimum yield levels) if they apply along with organic fertilizers (Berecz *et al.,* 2005).

Application of legume-*Rhizobium* symbiosis system is important practice, particularly under the intensive cropping system as in Egypt to decrease chemical inputs and raise soil quality and sustainability (Jenkinson, 2001 and Jensen and Hauggaard, 2003). Rhizobia are widely used in agriculture for crop improvement because of their ability to fix the atmospheric nitrogen. The ability of symbiotic fixation (through symbiotic association with specific rhizobia) may offer an opportunity to improve nitrogen status of soil and legumes productivity (Mekhemar *et al*., 2005 and Ahmed *et al.,* 2008). Numerous publications have indicated the necessity of legume inoculation with efficient rhizobial strains, especially when the soil is void of the specific *Rhizobium*agents (Kandil *et al.,* 2008; Verma *et al.,* 2010 and Badawi *et al.,* 2011).

Using compost in agriculture is one of the practices for the sustainable soil management. Compost improves soil fertility by slow and longtime releasing of essential nutrients, improving soil physico-chemical properties and it's profoundly affects rhizospheric microorganisms that promote plant growth, allowing a sustainable land use (Gosling *et al.,* 2006 and Perez-piquerers *et al.,* 2006). Hence, the disintegration of the organic fertilizers in soil is very important in order to achieve its important roles. It adds organic matter, which improves soil structure, aggregate formation, drought protection, stopping erosion, buffering, reduces fertilizer requirements and gave nutrients when plants need them as well as inoculates the soil with vast numbers of beneficial microbes. Thus, compost can modify soil physical properties and strongly affects its chemical and biological ones (Fontaine *et al.,* 2003; Singh *et al.,* 2006 and Rashad *et al.,* 2011).

Keeping the views of the above aspects, the present research work is therefore, undertaken to identify the effect of integrated use of bio, inorganic and organic fertilizers on seed productivity and quality of two Fahl clover cultivars.

MATERIALS AND METHODS

Two field trials were conducted at Giza Agricultural Research Station, ARC, during 2011/12 and 2012/13 winter seasons to study the effect of integrated use of bio, organic and inorganic fertilizationon on productivity, seed quality and economic evaluation of Egyptian clover cv Fahl. A representative soil samples were collected from the top 20 cm layer in the experimental fields, air-dried and sieved through a 2 mm screen. The main physical and chemical properties were determined using the methods described by Piper (1950) and Jackson (1973), and shown in Table (1).

Matured compost was supplied by Soil, Water and Environ. Res. Inst. (SWERI), ARC, Giza, Egypt, and prepared from a mixture of plant and animal residues and inoculated with lignocellulolytic fungus, then it was composted in thermophilic and aerobic heap for three months (Abdel-Wahab, 2008). The main physical, chemical and biological traits of used compost were determined according to Page *et al.* (1982)

and Pare *et al.* (1997), and presented in Table (2).

Rhizobium leguminosarum biovar *trifolii* (mixture of two isolates ARC102 and ARC103) were supplied by Microbiology Dept., Soils, Water and Environ. Res. Instit., Agricultural Research Center (ARC), Giza, Egypt. Culture was injected into the sterile carrier materials (90% vermiculite + 10% Irish peat) to satisfy 60% of maximal water holding capacity. Seeds were inoculated with gamma irradiated vermiculite-based inoculant at rate of 300g inoculum (Okadin)/16 kg seeds, prior to sowing using 16% Arabic gum solution as adhesive agent.

Table 1. Some physical and chemical properties of the experimental soil at Giza in 2011/12 and 2012/13 growing seasons.

Property	Values	
	Season 2011/12	Season 2012/13
Particle size distribution :		
Sand %	25.77	26.35
Silt %	35.90	34.97
Clay %	38.33	38.68
Texture grade	Clay loam	Clay loam
$CaCO_3$ (%)	2.14	2.10
Saturation percent (S.P %)	41.20	42.16
pH	7.80	7.76
E.C (dS m^{-1})	1.12	1.11
Soluble cations and anions (meq L^{-1}):		
Ca^{++}	4.22	4.10
Mg^{++}	2.88	3.05
Na^{+}	3.00	2.86
K^{+}	1.19	1.31
$CO^{=}_3$	0.00	0.00
HCO^{-}_3	3.28	3.81
Cl^{-}	4.33	4.12
$SO^{=}_4$	3.68	3.39
Organic matter (%)	0.81	0.85
Total soluble N (mg kg^{-1})	56.12	58.20
Available-P (mg kg^{-1})	7.89	7.65
Available-K (mg kg^{-1})	351.50	381.16
DTPA-extractable (mg kg^{-1}):		
Fe	5.88	6.12
Mn	3.22	3.41
Zn	1.01	1.21
Cu	0.68	0.58

DTPA: Di-ethylene tri-amine penta acetic acid.

Table 2. The main traits of used compost.

Property	Value
Bulk density (kg m^{-3})	514.00
Water holding capacity (%)	206.50
PH (1: 10 extract)	6.85
E.C (dS m^{-1})	4.41
Organic carbon (%)	25.16
Total-N (%)	1.31
C/N ratio	19.21
Total-P (%)	1.16
Total-K (%)	1.92
Total soluble-N (mg kg^{-1})	695.2
Available-P (mg kg^{-1})	265.6
Available-K (mg kg^{-1})	782.1
DTPA-extractable (mg kg^{-1}) :	
Fe	299.8
Mn	44.2
Zn	55.1
Cu	6.5
Total count (cfug^{-1}) :	
Bacteria	$3.2X10^7$
Fungi	$1.4x10^5$
Actinomycetes	$1.3x10^6$
Dehydrogenase activity (mg TPF*100g^{-1})	192.5
Germination test of cress seeds** (%)	88.0

*Tri-Phenyl-Formazan **Cress seeds incubated for 48 hr.

The experiment was laid out in a spilt plot design with three replicates and the experimental polt area was 24 m^2 (4 x 6 m). The two Fahl cultivars (a population collected from Kalupia and Local cultivar) were assigned to main plots, whereas fertilization treatments were assigned at random to sub-plots.

The following fertilization treatments were tested:

(T_1) The recommended treatment (full dose of inorganic NPK).

(T_2) Half dose of inorganic NPK.

(T_3) Half dose of inorganic NPK + Biofertilization (*Rhizobium* inoculation).

(T_4) Half dose of inorganic NPK+ Biofertilization+ Organic fertilization (1.5 ton compost fed^{-1}).

(T_5) Half dose of inorganic NPK+ Biofertilization+ Organic fertilization (2.5 ton compost fed^{-1}).

All treatments, except the recommended treatment (T_1), received 15 kg Nfed^{-1} in the form of ammonium nitrate (33.5% N) at sowing as an activator dose, while both phosphorus as calcium superphosphate (15% P_2O_5) and potassium as potassium sulphate (48 % K_2O) were broadcasted and incorporated into the soil before sowing at a rate of 75 and 25 Kg fed^{-1}, respectively. The recommended treatment received 30 kg N/fed, added before the second irrigation as well as 150kg superphosphate fed^{-1} and 50 kg potassium sulphate fed^{-1}. The mature compost at a rate of 1.5 and 2.5 tons fed^{-1} was applied to experimental soil 15 days before sowing.

Clover seeds were sown at the rate of 16 kg fed^{-1}. Sowing date was 17th and 25th November in 2011/12 and 2012/2013 seasons, respectively. Recommended cultural practices were followed throughout the growing season. The experimental plots were divided into two equal parts the first was for estimating forage yield and its component, while the second was left to the stage of flowering and seed formation to estimate seed yield fed^{-1}.

Data recorded:

- Growth traits: plant height (cm), number of branches $plant^{-1}$, leaf /stem ratio, fresh and dry forage yields (ton fed^{-1}) (fed = feddan = 4200 m^2).

-Seed yield and yield components: number of heads $plant^{-1}$, number of seeds $head^{-1}$, 1000- seed weight (g), seed yield (kg fed^{-1}) and straw yield (ton fed^{-1})

Determination of nodule numbers and dry weight: Plant samples were randomly taken from each plot at six weeks after planting, separated into shoots and roots. Root was carefully washed and diameter and length of root were determined. The nodules were counted in each plant and number of nodules $plant^{-1}$ was recored, roots and nodules were oven-dried at 70 ^{o}C for 12 hours and then nodules dry weight $plant^{-1}$ and roots dry weight $plant^{-1}$.

Seed quality characters:

Laboratory experiments were carried out at Seed Technology Research Department Lab, Field Crops Research Institute, ARC at Giza, to assess seed quality as affected by fertilization treatments in the field experiments.

Vigor test (seedling characters:

Germination capacity: germination capacity was determined according to the methods outlined in procedures for seed testing (ISTA, 1999). Three counts of 50 seeds each from each treatment in three replications were planted folded filter papers and then placed in an incubator at 20°C for 7days.

Shoot and radical length (cm): Ten seedlings were randomly selected and measured in cm according to Krishnasamy and Seshu (1990).

Fresh and dry weight of_seedlings (g): after measured shoot and radical length the seedlings were weighed to get fresh weight and then put into paper packet separately and placed into the preheated oven, and their weights were taken at 70 °C for 12 hours.

Chemical analysis:

The oven dried plant materials were wet digested using a mixture of pure $HClO_4$ and H_2SO_4 at a ratio of 1:1, according to Jackson (1973). Nitrogen was determined using the micro-Kjeldahel method, phosphorus was determined Spectrophotometrically using ammonium molybdate and stannus chloride reagents, while potassium was determined Flamephotometerically (Page *et al.,* 1982). Seed crude protein percentage was calculated by multiplying N% by 6.25 according to A.O.A.C (2000). Micronutrients concentration (Fe, Zn, Mn and Cu) was determined using the Atomic Absorption Spectrophotometer according to Cottenie *et al.* (1982). Carbohydrate percent in seeds was assayed according to the methods described by A.O.A.C. (2000).

Data were statistically analyzed according to procedures outlined by Snedecor and Cochran (1980). Bartlett's test was done to test the homogeneity of error variances. The test was non significant for all traits, thus combined analysis for the two seasons was formed for all studied traits.

RESULTS AND DISCUSSION

1- Growth and forage yield

The means of plant height, number of branches plant^{-1}, leaf/stem ratio, fresh and dry forage yields as affected by the application of bio, inorganic and organic fertilizers of two Fahl Egyptian clover cultivarsare are presented in Table (3).

Data of the combined analysis showed that all mentioned characters were significantly affected by individual or mixed applications of bio, organic and mineral fertilization. The highest values of these characters for both cultivars were 100.10 and 99.00 cm for plant height, 9.50 and 9.12 for number of branches plant^{-1}, 0.33 and 0.35 for leaf/stem ratio, 16.94 and 15.28 for fresh forage yield and 3.14 and 2.82 for dry forage yield observed in treatment T_5 (Compost$_2$ + *Rhizobium* inoculation + 50% NPK) followed by treatments T_4 (Compost$_1$+ *Rhizobium*inoculation + 50% NPK), which recorded values of(99.67 and 98.89), (9.32 and 8.97), (0.34 and 0.36), (16.47 and 14.95) and (3.06 and 2.79) for plant height, number of branches plant^{-1}, leaf/stem ratio, fresh and dry forage yield, respectively.

The positive effect of bio- and organic fertilization on developing plant growth characters may be attributed to increase the availability and translocation of nutrients leading to boost the promotive effect on plant vigour. These results are in agreement with those obtained by Tilak *et al.* (2005) and Rashad *et al.* (2011) who reported that increasing plant growth characters may be due to application of bio-and organic fertilization, which enhance nutrient use efficiency.

The recommended treatment (full dose of inorganic NPK) gave the values (96.50 and 95.83), (8.26 and 7.74), (0.31 and 0.34), (15.22 and 14.00) and (2.84 and 2.63) for plant height, number of branches plant^{-1}, leaf/stem ratio, fresh and dry forage yield, respectively. Meanwhile, the lowest values were attained from T_2 treatment (50% NPK). Generally, the combination of 50% of inorganic NPK, *Rhizobium* inoculation and 2.5 ton compost/fed were significantly exceeded the other tested treatments. These results are in accordance with those reported by Rizk *et al* (2005) on faba bean and Shabani *et al.* (2011) on annual medics.

The effect of interaction between the two cultivars and the different fertilization treatments was significant on all traits. The effect of fertilizer was more pronounced with cultivar Kalupia compared with Local cultivar. The superiority of Kalupia cultivar over Local cultivar could be attributed to differences in the genetic make-up which reflect on growth habits.

2- Root traits

Root length and its diameter as affected by fertilization treatments of two Fahl Egyptian clover cultivarsare are shown in Figs. (1 and 2). Data of the combined analysis showed that root length and its diameter were significantly affected by individual or mixed applications of compost, biofertilizer and mineral fertilizer. The highest root length and its diameter were recorded in treatment T_5 (Compost$_2$ + *Rhizobium*inoculation+ 50% NPK) followed by treatments T_4 (Compost$_1$+ *Rhizobium*inoculation+ 50% NPK). These results may be attributed to the stimulatory effects of bio, organic and mineral fertilizers on root length and its diameter. Rizk *et al.* (2006) reported similar trend in lentil. Meanwhile the lowest values were obtained from treatment T_2 (50% NPK).

3- Nodule traits

Nodulation originated on Egyptian clover roots are presented in Figs. (3 and 4). Data revealed that the uninoculated plants (T_1 and T_2 treatments) had the lowest number of nodules and nodule dry weights. The results

Table 3

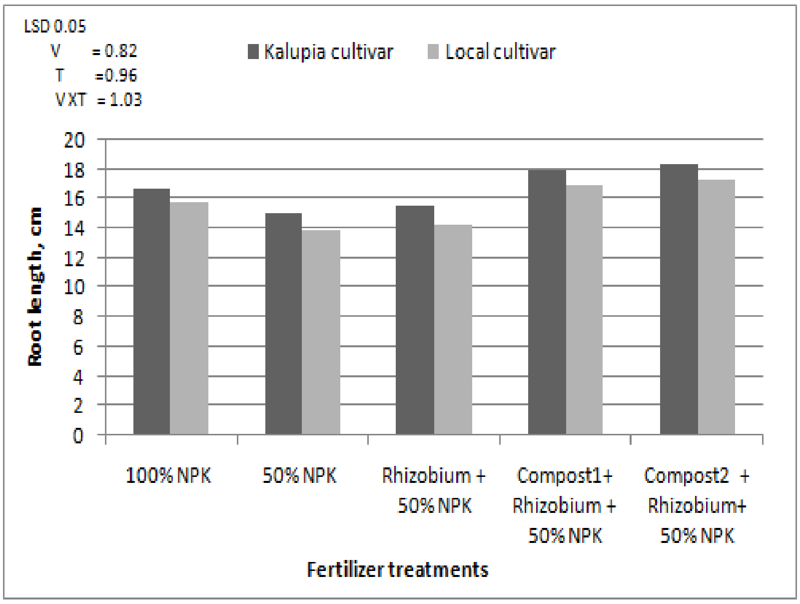

Fig. 1. Effect of fertilizer treatments on root length.

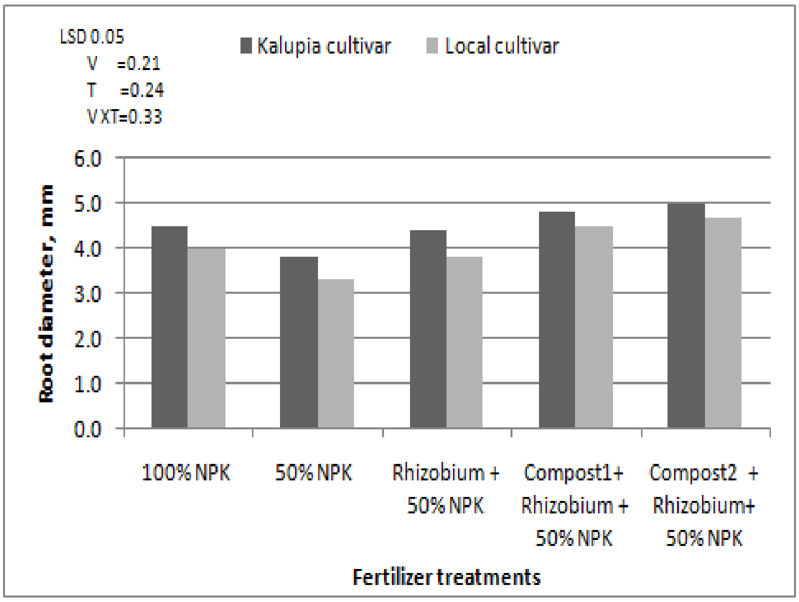

Fig. 2. Effect of fertilizer treatments on root diameter.

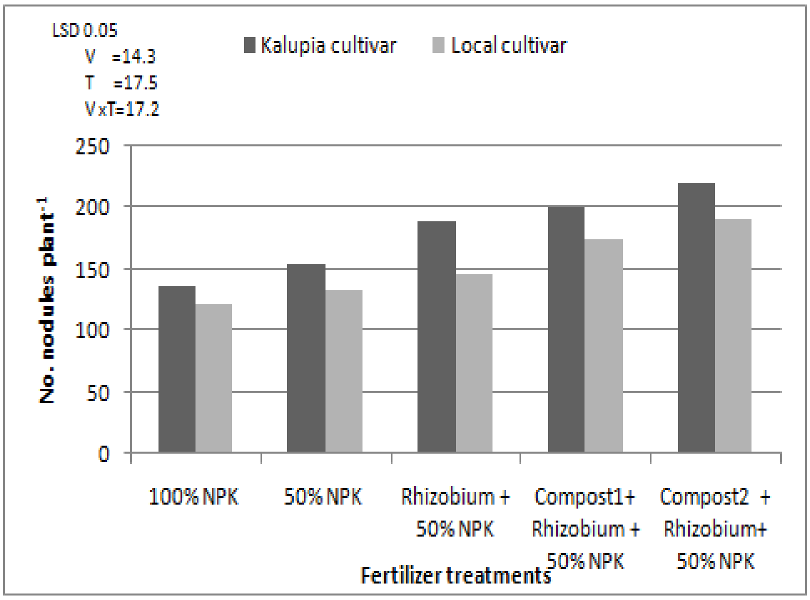

Fig. 3. Effect of fertilizer treatments on number of nodules plant $^{-1}$.

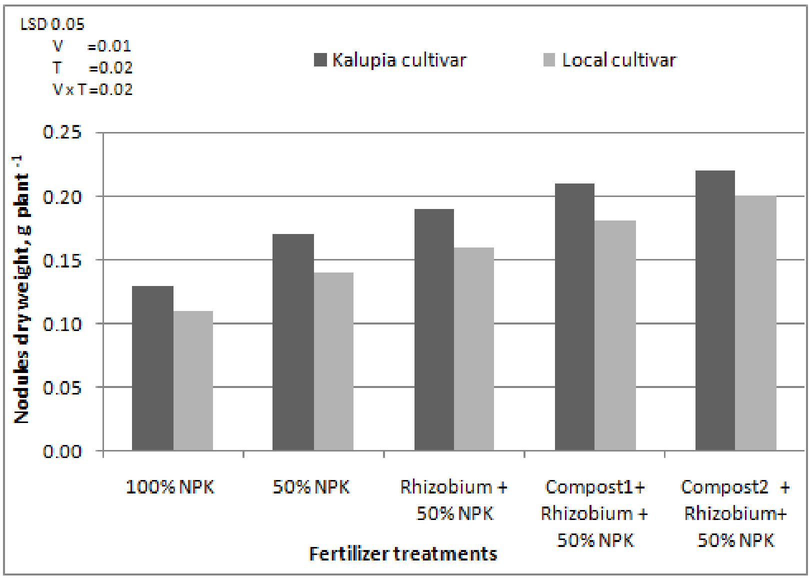

Fig. 4. Effect of fertilizer treatments on nodules dry weightg plant $^{-1}$.

suggest presence of native rhizobia of clover in the experimental soil but inadequate number, having a low efficiency of nitrogen fixation. Inoculating clover seeds with *Rhizobium* gave distinctly better nodulation status in both cultivars.This could be observed from the striking differences between the inoculated and uninoculated plants and emphasized the vital importance to continue inoculation of clover seeds successively with effective strains (Abotaleb *et al.,* 2008). It is evident that the parameters of nodulation status were highly responded to fertilization with 50% of the recommended NPK and inoculated with *Rhizobium* either solely or in combination with compost.In general, clover seeds inoculated with *Rhizobium* in combination with 50% inorganic NPK and amended with 2.5 ton compost fed^{-1} tended to remarkably improve the nodulation status over the other tested treatments. These results reflected the prominent role of organic amendments for enhancing the nodulation pattern originated on clover roots through the effect of organic substances in survival of rhizobia in the rhizosphere as well as improving the clover vegetative growth leading to establishing an intact nodulation pattern. These results are agreed with those recorded by (Abdel-Wahab *et al.,* 2006 and Basua *et al.,* 2008). Many investigators confirmed the stimulating effect of inoculation and organic materials in creating a favorable habitat for legume growth and biological nitrogen fixation (Basua *et al.,* 2008; Verma *et al.,* 2010; Rizk *et al.*, 2011 and Badawi and El-Sayed, 2015).

4- Seed yield and its components

Data presented in Table (4) showed that the two cultivars of Fahl Egyptian clover and the various organic and inorganic treatments combined with *Rhizobium* inoculation were significantly affected number of heads plant^{-1}, number of seeds head^{-1}, 1000-seed weight and seed and straw yields. Many studies have confirmed that inoculation with *Rhizobium* increased the productivity and quality of legumes (Badawi *et al.,* 2011 andRugheim and Abdelgani, 2012).These increases were more obvious when compost applied in combination with *Rhizobium*, with superiority of using 2.5 ton compost fed^{-1}, relatively to the unamended plants or plants amended with 1.5 ton fed^{-1}. Manuring soil with 2.5 ton compost fed^{-1} in combination with *Rhizobium* inoculation and 50% inorganic NPK (T_5) showed significant superiority over the other tested treatments and significantly increased number of heads plant^{-1}, number of seeds head^{-1}, 1000-seed weight, seed and straw yields by16.7, 4.2, 2.3, 3.2 and 8.5% over control treatment (100% NPK), respectively. Meanwhile, T_2 treatment (50% NPK) gave the lowest number of all above tested characters. These positive results could be ascribed to the promotive effects of bio-organic fertilization emphasized its essential role in establishment of fertile media for growing legumes leading to healthy growth and consequently sustains these plants to give high quality and quantity of clover yield.The result substantiates the findings of many researchers, who confirmed the beneficial effect of bio-organic materials in improving the productivity and quality of many legumes due to its directnutrients supplying and/or its microbial functions (Abdel-Wahab *et al.,* 2009;El-Sheikh *et al*., 2009; Das and Singh, 2014 and Badawi & El-Sayed, 2015).

5- Vigor test (seedting characters)

Results in Table (5) showed that germination percentage, shoot length, radical length; fresh and dry seedling weights were significantly affected by cultivars and fertilization treatments.It is noteworthy that all fertilization treatments were exceeded the treatment received 50% of the recommended NPK only.The recommended NPK treatment (T_1) gave values (82 and 81 %, 5.00 and 5.10 cm, 4.00 and 3.60 cm, 0.49 and 0.50g and 0.04 and 0.05g) for germination %, shoot length, radical length, fresh and dry seedling weight with two cultivars, respectively. While, radical length was superior at bacterium inoculation + application of 50% inorganic NPK, which recorded 4.80 and 4.70cm for two cultivars, respectively.It is clear that biofertilization enhances better root development and seed germination (Rajendran and Devarj, 2004;Chen, 2006 and Rugheim & Abdelgani, 2012).Addition of compost amendment exhibited synergistic effect onseedling characters of Fahl Egyptian clover. The existence of compost

Tabe 4

Table 5

in conjugation with *Rhizobium*inoculation tended to enhance all seedling characters as compared to the inoculated plants without compost manuring. Data confirmed again the superiority of using T_5 treatment (2.5 ton compost fed^{-1} + *Rhizobium* inoculation + 50% NPK) in achieving the highest values of all seedlingcharacters (86 and 84%, 5.30 and 5.80cm, 4.50 and 4.10cm, 0.56 and 0.52g and 0.07 and 0.06g)for germination %, shoot and radical length (cm), fresh and dry seedling weight (g) with two cultivars, respectively, followed by T_4 treatment (1.5 ton compost fed^{-1}+ *Rhizobium* inoculation + 50% NPK), which recorded (85 and 83 %, 4.70 and 4.60cm, 4.00 and 3.47cm, 0.40 and 0.54g and 0.06 and 0.05g), respectively.

This beneficial effect is more related to the important role of compost in establishment of rich media for healthy growth and develop the root system of plants, which originated from strengthened root architecture, whichformed due to promoting humic substances and other decomposed organic materials, which act to improve soil physico-chemical properties, and increase nutrients availability, either that its contain or those added as fertilizer (Tejada *et al.,* 2006 and Abdel-Wahab *et al.,* 2009).Also, compost contains beneficial microorganisms that stimulates root growth and provides it with more branching and larger surface area (Abdel-Wahab *et al.,* 2008). Many workers illustrated the positive effect of the combination between inoculation and compost for promotion plant growth (Abdel-Wahab *et al.,* 2006; Abdel-Wahab *et al.,* 2009; Wahdan *et al.,* 2009 and Das & Singh, 2014).

6- Chemical Analysis

Results in Table (6) show that N, P, K, protein and carbohydrate percentage were significantly affected by cultivars and fertilization treatments. The treatment T_5 gave the highest values of all characters. Meanwhile, T_2 treatment (50% NPK) gave the lowest values of all characters. Treatment (T_4) became in the second rank for all chracters, except K%. This could be due to the presence of applied compost, which may enhance the activity of nitrogen fixers in the rhizosphere, increasing nutrients availability and mobility towards plant roots and enhanced the mechanism of their uptake by plant roots. These results are agreed with those found by Abdel-Wahab *et al.* (2009), Wahdan *et al.* (2009), Awad *et al.* (2010), Rashad *et al.* (2011) and Badawi & El-Sayed (2015) who mentioned that the combined use of inorganic and organic fertilizers enhanced the inherent nutrient supplying capacity of the soil and also improved soil physical properties, which promoted better rooting and caused higher nutrient uptake by the plant.

Results in Table (7) show that seed content of Fe, Zn, Mn and Cu elements were significantly affected by cultivars and fertilization treatments. The results indicated that all fertilization treatments were exceeded the treatment received the half dose of mineral NPK fertilizers and behaved in similar manner as mentioned before. T_5 treatment gave the highest values of Fe, Zn, Mn and Cu elements, followed by T_4 treatment.

The results confirmed again the role of such decomposable organic materials in increasing the availability of micronutrients. This could be due to the beneficial effect of organic materials, which acts as chelating compounds that can bond to a metal by more than one bond and form a ring or cyclic structure and becomes more available to plants and general mobility in soils. These results are in accordance with those obtained by Abdel-Wahab *et al.* (2005) and Abdel-Wahab *et al.* (2009).

7- Correlation coefficients:

The simple correlation coefficients among forage yield and vigor test characters across the two years are presented in Table (8).

Table 6

Table 7

Table 8

Plant height showed positive and significant correlation with number of branches plant^{-1} (0.943*), fresh (0.921*) and dry forge yield (0.959**). Number of branches plant^{-1} was positively highly correlated with leaf/stem ratio (0.919*), fresh forage yield (0.992**), dry forage yield (0.993**), germination % (0.900*) and dry seedling weight (0.924*). Regarding fresh and dry forage yield, significant positive correlation with germination % (0.942* and 0.940*) and dry seedling weight (0.965** and 0.944*), was found respectively. Shoot length was significantly and positively correlated with each of fresh (0.967**) and dry (0.896*) seedling weights. Fresh seedling weight was significantly and positively correlated with dry seedling weight.

The results of simple correlation coefficients among seed yield and minerals content characters across the two years are presented in Table (9). Regarding number of heads plant^{-1}, significant positive correlations were found with number of seeds head^{-1}, 1000- seed weight, straw yield, seed yield, crude protein, carbohydrate, and NPK content, Fe, Zn, Mn and Cu content. Number of seeds head^{-1} showed a significant positive association with the above-mentioned characters except carbohydrate, Mn and Cu content of seeds. The 1000- seed weight showed positive and significant correlation with straw yield, seed yield and all minerals seed content. Straw yield was positively and significantly correlated with seed yield and all minerals content of seeds except carbohydrate content. Significant positive correlations were also detected between seed yield and all the minerals content of seeds except carbohydrate content. Regarding crude protein content, significant positive correlations were found with all the minerals content of seeds. Carbohydrate content showed positive and significant correlation with N, P, Mn and Cu. Nitrogen content was significantly and positively correlated with P, K, Fe, Zn, Mn and Cu. P content showed positive and significant correlation with K, Fe, Zn, Mn and Cu. Potassium content was significantly and positively correlated with Fe and Cu. Fe content was significantly and positively correlated with Zn and Cu. Zn content was significantly and positively correlated with Mn. Mn content was significantly and positively correlated with Cu.

These results clearly emphasized the vital role of legume inoculation with efficient strains of rhizobia to improve its productivity and quality. It is evident that the applied compost together with 50% of inorganic NPK fertilizers in the presence of *Rhizobium* inoculation may be acting as a good practice to maximize clover yield and improving seed quality as well as saving chemical fertilizer use and diminishing the risks of environmental pollution particularly with implying the legumes production under sustainable agriculture system.

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تأثير الاستخدام المتكامل للأسمدة المعدنية، الحيوية والعضوية على صفات النمو والإنتاجية وجودة البذور لصنفين من البرسيم المصري (الفحل)

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الملخص العربي

أجريت تجربتان حقليتان بمحطة البحوث الزراعية– مركز البحوث الزراعية بالجيزة خلال الموسمين الشتويين ٢٠١٢/٢٠١١ و٢٠١٣/٢٠١٢ وذلك لدراسة تأثير استخدام التسميد المعدني والحيوي والعضوي على صفات النمو ومحصول العلف وجودة البذور لصنفين من البرسيم الفحل (عشيرة القليوبية والصنف المحلى). وقد تم اختبار خمسة معاملات في هذه الدراسة وهى معاملة التسميد المعدني الكاملة (١٠٠% تسميد معدني)، معاملة نصف الجرعة من

التسميد المعدني (٥٠% تسميد معدني)، معاملة نصف جرعة التسميد المعدني مع التسميد الحيوي (٥٠% تسميد معدني + التلقيح بالريزوبيا) ، معاملةنصف جرعة التسميد المعدني مع التسميد الحيوي والعضوي (٥٠% تسميد معدني + التلقيح بالريزوبيا + ١,٥ طن كمبوست للفدان) والمعاملة الأخيرة (٥٠% تسميد معدني + التلقيح بالريزوبيا + ٢,٥ طن كمبوست للفدان). وكان تصميم التجربة هو قطع منشقة مرة واحدة في ثلاثة مكررات، حيث تم وضع الاصناف في القطع الرئيسية ومعاملات التسميد في القطع الفرعية.

أشارت النتائج الى أن صفات النمو المدروسة ومحصول العلف وجودة البذور للصنفين قد تأثرت معنويا بمعاملات التسميد المختلفة. كما وجد أن عشيرة القليوبية قد تفوقت على الصنف المحلى في جميع الصفات المدروسة. واظهرت النتائج وجود تفوق ملحوظ لجميع معاملات التسميد المختبرة مقارنة بمعاملة التسميد بنصف الجرعة من التسميدالمعدني. وقد اشارت النتائج الى ان استخدم الكمبوست كإضافة أرضية مع التلقيح البكتيري واضافة نصف الجرعة من التسميد المعدني قد أدت الى تفوق ملحوظ في جميع صفات النمو ومحصول العلف الأخضرومحصول البذور والصفات الخاصة بجودة البذور مقارنة بباقي المعاملات، وكان هذا التأثير اكثر وضوحا مع استخدام المعدل العالي من الكمبوست (٢,٥ طن للفدان) مقارنة بالنباتات الغير معاملة او المعاملة بالمعدل المنخفض من الكمبوست (١,٥ طن للفدان). كما وجد أن هناك ارتباط موجب معنوي بين محصول العلف الاخضر وكل من الصفات التالية (ارتفاع النبات، عدد الافرع بالنبات، نسبة الورق للسيقان، محصول المادة الجافة للعلف، طول وقطر الجذر و عدد العقد ووزنها الجاف, نسبة الانبات للبذور، الوزن الجاف للبادرة). كما وجد ان هناك ارتباط موجب معنوي بين محصول البذوروالصفات التالية (عدد الرؤوس/نبات ، عدد البذور/الرأس ، محصول القش، وزن ١٠٠٠ بذرة). وكما تشير النتائج وجود ارتباط موجب معنوي بين محصول البذور والصفات التالية (نسبة البروتين في البذور ومحتواها من تركيزات العناصر الصغرى والكبرى).

وتشير النتائج الى أهمية التلقيح بسلالات فعالة ومتخصصة من الريزوبيم مما يحسن من الإنتاجية وجودة البذور. ومن الواضح ان اضافة الكمبوست مع نصف الجرعة من التسميد المعدني في وجود التلقيح بالريزوبيم يؤدى الى تعظيم العائد من محصول البرسيم وتحسين نوعية البذور وكذلك تقليل استخدام الأسمدة الكيماوية مما يقلل من مخاطر التلوث البيئي خاصة مع إنتاج البقوليات تحت نظم الزراعة المستدامة.

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Table 3. Growth traits and Forage yield of Fahl Egyptian clover as affected by cultivars and fertilizer treatments in 2011/ 2012 and 2012/2013 seasons.

Treatment		Plant height (cm)			Number of branches plant^{-1}			Leaf/stem ratio			Fresh forage yield (ton fed^{-1})			Dry forage yield (ton fed^{-1})		
		Season		Combined	Season		Combined	Season		Combined	Season		Combined	Season		Combined
		2011/12	2012/13		2011/12	2012/13		2011/12	2012/13		2011/12	2012/13		2011/12	2012/13	
T_1	V_1	95.40	97.60	96.50	7.92	8.60	8.26	0.30	0.32	0.31	14.51	15.93	15.22	2.78	2.90	2.84
	V_2	95.27	96.39	95.83	7.60	7.88	7.74	0.33	0.35	0.34	13.78	14.22	14.00	2.55	2.71	2.63
T_2	V_1	82.80	83.54	83.17	6.54	7.10	6.82	0.29	0.31	0.30	13.23	13.67	13.45	2.32	2.64	2.48
	V_2	81.90	82.10	82.00	6.12	6.70	6.41	0.32	0.34	0.33	12.00	12.52	12.26	2.00	2.42	2.21
T_3	V_1	84.60	85.40	85.00	7.31	7.90	7.61	0.31	0.33	0.32	14.20	14.80	14.50	2.58	2.72	2.65
	V_2	84.44	84.90	84.67	7.10	7.36	7.23	0.34	0.34	0.34	13.67	13.91	13.79	2.36	2.62	2.49
T_4	V_1	99.42	99.91	99.67	9.11	9.52	9.32	0.33	0.35	0.34	16.22	16.72	16.47	3.00	3.12	3.06
	V_2	98.84	98.94	98.89	8.94	9.00	8.97	0.35	0.37	0.36	14.90	15.00	14.95	2.63	2.95	2.79
T_5	V_1	99.98	100.22	100.10	9.20	9.80	9.50	0.32	0.34	0.33	16.76	17.12	16.94	3.02	3.26	3.14
	V_2	98.77	99.23	99.00	9.00	9.24	9.12	0.34	0.36	0.35	15.11	15.45	15.28	2.66	2.98	2.82
LSD 0.05																
Cultivars (V)		٠.٧٢	٠.٦٤	0.59	SN	٠.١٢	NS	٠.٠١	٠.٠٢	0.01	١.٢١	١.١٧	1.15	٠.١٣	٠.١٤	0.12
Treatment (T)		٢.٥١	٢.٣٧	1.86	٠.٨٧	٠.٦٨	0.65	SN	SN	NS	١.٦٥	١.٥٩	1.63	٠.٣٣	٠.٢٩	0.24
V x T		٢.٦٣	٢.٤٩	2.11	١.٠٩	١.٠٣	0.98	٠.٠٥	٠.٠٦	0.05	١.٩٥	١.٩٣	1.92	٠.٤٢	٠.٣٥	0.30

T_1=100% NPK, T_2=50% NPK, T_3= Rhizobium + 50% NPK, T_4= Compost$_1$+ Rhizobium + 50% NPK, T_5= Compost$_2$ + Rhizobium+ 50% NPK, V_1= a population from Kalupia, V_2= local cultivar, Compost1= compost at a rate of 1.5 ton fed^{-1} and compost 2= compost at a rate of 2.5 ton fed^{-1}. 100%NPK treatment: received 30 kg N/fed, 150 kg superphosphate/fed and 50 kg potassium sulphate/fed. 50% NPK treatment: received 15 kg N/fed, 75 kg superphosphate/fed and 25 kg potassium sulphate/fed.

Table 4. Seed yield and its components of Fahl Egyptian clover as affected by cultivars and fertilizer treatments in 2011/ 2012 and 2012/2013 seasons.

Treatment		Number of heads plant^{-1}			Number of seeds head^{-1}			1000- seed weight (g)			Seed yield (kg fed^{-1})			Straw yield (ton fed^{-1})		
		Season		Combined	Season		Combined	Season		Combined	Season		Combined	Season		Combined
		2011/12	2012/13		2011/12	2012/13		2011/12	2012/13		2011/12	2012/13		2011/12	2012/13	
T_1	V_1	7.57	8.19	7.88	77.11	77.57	77.34	3.40	3.62	3.51	443.44	447.68	445.56	2.45	2.51	2.48
	V_2	6.80	7.20	7.00	70.86	71.00	70.93	3.27	3.39	3.33	423.54	427.72	425.63	2.2	2.26	2.23
T_2	V_1	6.38	6.70	6.54	69.00	69.22	69.11	3.21	3.43	3.32	390.66	399.80	395.23	2.17	2.25	2.21
	V_2	5.57	5.87	5.72	63.11	63.72	63.42	3.11	3.25	3.18	377.11	379.39	378.25	1.84	1.9	1.87
T_3	V_1	7.25	7.73	7.49	70.10	70.34	70.22	3.33	3.59	3.46	418.42	423.20	420.81	2.35	2.39	2.37
	V_2	7.00	7.32	7.16	66.79	66.95	66.87	3.20	3.38	3.29	395.57	405.91	400.74	1.98	2.06	2.02
T_4	V_1	8.78	9.16	8.97	79.69	79.87	79.78	3.45	3.69	3.57	452.76	458.80	455.78	2.6	2.64	2.62
	V_2	8.02	8.23	8.13	73.78	73.94	73.86	3.34	3.42	3.38	432.12	443.00	437.56	2.32	2.4	2.36
T_5	V_1	8.97	9.25	9.11	80.12	80.36	80.24	3.48	3.72	3.60	458.93	461.11	460.02	2.68	2.7	2.69
	V_2	8.11	8.38	8.25	74.22	74.46	74.34	3.37	3.43	3.40	434.10	444.12	439.11	2.41	2.45	2.43
LSD 0.05																
Cultivars(V)		0.35	0.33	0.32	1.17	1.29	1.23	0.09	0.11	0.10	20.68	16.22	15.11	0.13	0.12	0.11
Treatment(T)		0.89	0.88	0.89	1.45	1.37	1.40	0.12	0.11	0.12	21.63	22.03	21.43	0.15	0.13	0.14
V x T		0.93	0.90	0.89	2.36	2.31	2.15	0.21	0.23	0.18	25.11	26.34	24.27	0.27	0.25	0.21

T_1=100% NPK, T_2=50% NPK, T_3= Rhizobium + 50% NPK, T_4= $Compost_1$+ Rhizobium + 50% NPK, T_5= $Compost_2$ + Rhizobium+ 50% NPK, V_1= a population from Kalupia, V_2= local cultivar, Compost1= compost at a rate of 1.5 ton fed^{-1} and compost 2= compost at a rate of 2.5 ton fed^{-1}. 100%NPK treatment: received 30 kg N/fed, 150 kg superphosphate/fed and 50 kg potassium sulphate/fed. 50% NPK treatment: received 15 kg N/fed, 75 kg superphosphate/fed and 25 kg potassium sulphate/fed.

Table 5. Seedling characters (vigor test) of Fahl Egyptian clover as affected by cultivars and fertilizer treatments (mean of two seasons).

Treatments	Germination (%)			Shoot length (cm)			Radical length (cm)			Fresh seedling weight (g)			Dry seedling weight (g)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T_1	82.00	81.00	81.50	5.00	5.10	5.05	4.00	3.60	3.80	0.49	0.50	0.50	0.04	0.05	0.05
T_2	70.00	68.00	69.00	4.00	3.80	3.90	3.20	2.50	2.85	0.30	0.38	0.34	0.02	0.02	0.02
T_3	81.00	79.00	80.00	4.80	4.68	4.74	4.80	4.70	4.75	0.48	0.48	0.48	0.05	0.04	0.05
T_4	85.00	83.00	84.00	4.70	4.60	4.65	4.00	3.47	3.74	0.40	0.54	0.47	0.06	0.05	0.06
T_5	86.00	84.00	85.00	5.3	5.8	5.55	4.5	4.1	4.30	0.56	0.52	0.54	0.07	0.06	0.07
Mean	80.80	79.00	79.90	.76	.80	4.78	4.10	.67	3.89	0.45	.48	0.47	0.05	0.04	0.05
LSD 0.05															
Cultivars(V)	0.73			0.52			0.43			0.12			0.02		
Treatments (T)	0.80			0.75			0.61			0.19			0.03		
V x T	1.03			NS			NS			NS			NS		

T_1=100% NPK, T_2=50% NPK, T_3= Rhizobium + 50% NPK, T_4= $Compost_1$+ Rhizobium + 50% NPK, T_5= $Compost_2$ + Rhizobium+ 50% NPK,
V_1= a population from Kalupia, V_2= local cultivar, $Compost_1$= compost at a rate of 1.5 ton fed^{-1} and $compost_2$= compost at a rate of 2.5 ton fed^{-1}.
100%NPK treatment: received 30 kg N/fed, 150 kg superphosphate/fed and 50 kg potassium sulphate/fed.
50% NPK treatment: received 15 kg N/fed, 75 kg superphosphate/fed and 25 kg potassium sulphate/fed.

Table 6. Seed quality affected by Fahl Egyptian clover as cultivars and fertilizer treatments (mean of two seasons).

Treatments	N (%)		Mean	P (%)		Mean	K (%)		Mean	Crude protein (%)		Mean	Carbohydrate (%)		Mean
	V1	V2		V1	V2		V1	V2		V1	V2		V1	V2	
T_1	2.56	2.72	2.64	0.33	0.36	0.35	1.40	1.80	1.60	16.00	17.00	16.50	73.00	72.25	72.63
T_2	2.40	2.48	2.44	0.30	0.33	0.32	1.10	1.20	1.15	15.00	15.5	15.25	71.00	70.00	70.50
T_3	2.54	2.60	2.57	0.32	0.35	0.34	1.28	1.53	1.41	15.88	16.30	16.09	73.50	73.30	73.40
T_4	2.64	2.72	2.68	0.33	0.36	0.35	1.30	1.60	1.45	16.50	17.00	16.75	74.00	74.00	74.00
T_5	2.72	2.8	2.76	0.35	0.37	0.36	1.50	1.80	1.65	17.00	17.50	17.25	74.20	74.30	74.25
Mean	2.57	2.66	2.62	0.33	0.35	0.34	1.32	1.59	1.45	16.08	16.66	16.37	73.14	72.77	72.96
LSD 0.05															
Cultivars (V)	0.11			0.04			0.04			0.58			0.21		
Treatments(T)	0.21			NS			0.08			0.49			0.48		
V x T	0.31			NS			0.12			0.44			0.68		

T_1=100% NPK, T_2=50% NPK, T_3= Rhizobium + 50% NPK, T4= $Compost_1$+ Rhizobium + 50% NPK, T_5= $Compost_2$ + Rhizobium+ 50% NPK,
V_1= a population from Kalupia, V_2= local cultivar, $Compost_1$= compost at a rate of 1.5 ton fed^{-1} and $compost_2$= compost at a rate of 2.5 ton fed^{-1}.
100%NPK treatment: received 30 kg N/fed, 150 kg superphosphate/fed and 50 kg potassium sulphate/fed.
50% NPK treatment: received 15 kg N/fed, 75 kg superphosphate/fed and 25 kg potassium sulphate/fed.

Table 7. Seed content of some microelements (Fe, Zn, Mn, and Cu) contents of seed of Fahl Egyptian clover as affected by cultivars and fertilizer treatments (mean of two seasons).

Treatments	Fe (ppm)		Mean	Zn (ppm)		Mean	Mn (ppm)		Mean	Cu (ppm)		Mean
	V1	V2		V1	V2		V1	V2		V1	V2	
T_1	90.00	91.00	90.50	32.60	31.20	31.90	61.00	60.00	60.50	5.30	5.20	5.25
T_2	70.30	75.00	72.65	30.10	30.50	30.30	58.00	53.40	55.70	3.00	3.10	3.05
T_3	81.40	81.80	81.60	33.10	28.50	30.80	62.30	60.50	61.40	5.50	4.70	5.10
T_4	90.30	92.00	91.15	33.8	31.50	32.65	64.4	63.00	63.70	5.50	5.50	5.50
T_5	91.40	93.70	92.55	34.10	32.50	33.30	67.00	65.00	66.00	6.00	5.50	5.75
Mean	84.68	86.70	85.69	32.74	30.84	31.79	62.54	60.38	61.46	5.06	4.80	4.93
LSD 0.05												
Cultivars (V)	0.98			0.20			0.24			0.23		
Treatments (T)	0.54			0.19			0.66			0.39		
V x T	0.76			0.28			0.94			0.55		

T_1= 100% NPK, T_2=50% NPK, T_3= Rhizobium + 50% NPK, T_4= $Compost_1$+ Rhizobium + 50% NPK, T_5= $Compost_2$ + Rhizobium+ 50% NPK,
V_1= a population from Kalupia, V_2= local cultivar, $Compost_1$= compost at a rate of 1.5 ton fed^{-1} and $compost_2$= compost at a rate of 2.5 ton fed^{-1}.
100%NPK treatment: received 30 kg N/fed, 150 kg superphosphate/fed and 50 kg potassium sulphate/fed.
50% NPK treatment: received 15 kg N/fed, 75 kg superphosphate/fed and 25 kg potassium sulphate/fed.

Table 8. Simple correlation coefficients among growth traits, forage yield and vigor test.

Traits	X2	X3	X4	X5	X6	X7	X8	X9	X10
Plant height, cm (X1)	0.943*	0.821	0.921*	0.959**	0.846	0.739	0.227	0.738	0.829
Number of branches plant^{-1} (X2)		0.919*	0.992**	0.993**	0.900*	0.760	0.401	0.775	0.924*
Leaf/stem ratio (X3)			0.897*	0.894*	0.828	0.506	0.356	0.605	0.820
Fresh forage yield, ton fed^{-1} (X4)				0.993**	0.942*	0.822	0.510	0.844	0.965**
Dry forage yield, ton fed^{-1} (X5)					0.940*	0.810	0.444	0.831	0.944*
Germination, % (X6)						0.867	0.700	0.944*	0.980**
Shoot length, cm (X7)							0.694	0.967**	0.896*
Radical length, cm (X8)								0.792	0.713
Fresh seedling weight, g (X9)									0.940*
Dry seedling weight, g (X10)									

*, ** denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 9. Simple correlation coefficients among seed yield and chemical composition of seeds.

Traits	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
Number of heads plant^{-1} (X1)	0.931*	0.982**	0.970**	0.950*	0.962**	0.946*	0.961**	0.926*	0.888*	0.911*	0.941*	0.975**	0.912*
Number of seeds head^{-1} (X2)		0.946*	0.987**	0.986**	0.946*	0.792	0.950*	0.922*	0.898*	0.962**	0.981**	0.859	0.837
1000- seed weight, g (X3)			0.977**	0.980**	0.984**	0.944*	0.983**	0.975**	0.881*	0.967**	0.938*	0.963**	0.961**
Straw yield, ton fed^{-1} (X4)				0.987**	0.982**	0.866	0.984**	0.955*	0.896*	0.961**	0.989**	0.930*	0.886*
Seed yield, kg fed^{-1} (X5)					0.971**	0.861	0.973**	0.965**	0.885*	0.990**	0.961**	0.900*	0.915*
Crude protein, % (X6)						0.907*	0.999**	0.988**	0.918*	0.960**	0.962**	0.961**	0.934*
Carbohydrate ,% (X7)							0.901*	0.898*	0.785	0.846	0.802	0.971**	0.959*
N, % (X8)								0.987**	0.917*	0.961**	0.966**	0.958*	0.929*
P, % (X9)									0.963**	0.975**	0.921*	0.933*	0.960**
K, % (X10)										0.928*	0.822	0.822	0.907*
Fe, mg (X11)											0.924*	0.872	0.932*
Zn, mg (X12)												0.898*	0.816
Mn, mg (X13)													0.929*
Cu, mg (X14)													

*, ** denote significant at 0.05 and 0.01 levels of probability, respectively.