Research Article

Evaluating Green Manuring of Moringa and Jantar along with Inorganic Fertilizers to Enhance the Yield and Quality Attributes of Autumn Maize (*Zea mays* L.)

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Abstract | Addition of organic matter is considered one of the best approaches in crop production to improve soil fertility and productivity. Like jantar and moringa are rich in plant nutrients and becoming popular in farming community as a green manure. An experiment was conducted for evaluating green maunuring of moringa and jantar along with inorganic fertilizers to enhance the yield and quality attributes of autumn maize at Agronomic Research Farm, University of Agriculture, Faisalabad. There were two factors, green manuring (No green manuring, moringa green manuring and Jantar green manuring) and different levels of NPK fertilizers (no fertilizers, 50% of RDF, 100% of RDF). The experiment was laid out in Randomized Complete Block Design with split plot arrangement in triplicate run. Results from the experiment revealed that both the factors significantly affected all the parameters under study while their interactive effect was non-significant. Among green biomass incorporation treatments, maximum plant height (168.34 cm) cob length (16.32 cm), number of grains per cob (410), 1000-grain weight (200.22 g), biological yield (16.63 t ha^{-1}) grain yield (5.75 t ha^{-1}) harvest index (34.22 %) and grain protein content (8.56%) was obtained with (moringa green manuring).While Among fertilizer levels (100% of RDF) produced maximum plant height (189.02 cm) cob length (18.21 cm), number of grains per cob (438.7), 1000-grain weight (216.57 g), biological yield (17.79 t ha^{-1}) grain yield (6.99 t ha^{-1}) harvest index (39.37%) and grain protein content (8.78%). It can be concluded from above results that along with 100% of RDF, moringa can be used as green manure and incorporated into the soil to enhance the maize productivity.

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Introduction

Maize (*Zea mays* L.) stands as an imp ortant staple food of the world. It is ranked third after wheat and rice. Many products like starch, corn syrup, alcohol, acetic acid, lactic acid, corn oil, dextrose, corn flakes, cosmetics, waxes and tanning material are obtained from maize. Its whole grain contains

about 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 1.7% ash (Chaudhary, 1993). The yield of maize in Pakistan is very low as compared to other maize producing countries. The low production of maize in Pakistan is attributed to water shortage, improper selection of hybrids, less optimal plant population in the field, low organic matter and imbalanced use of fertilizers. Among these reasons the most important are low organic matter and injudicious use of inorganic fertilizers (Oad et al., 2004). Continuous application of chemical fertilizers alone deteriorates the soil health and environment through leaching, run off, emission and eutrophication (Oad et al., 2004). To increase the organic matter and soil nutrients green biomass is incorporated into the soil. Mostly there are two types of crops i.e leguminous and non-leguminous which can be incorporated as green biomass into the soil, (Deksissa et al., 2008).

In non-leguminous crops jantar (*Sesbania aculeate*) is used for biomass incorporation into the soil. Mostly legume green biomass adds more C into the cropping system as compared to inorganic fertilizers (Garrity, 1989). Moringa (*Moringa oleifera*) also belongs to non-leguminous family and is treated as a very beneficial tree with various benefits. It has a profile with maximum nutrients. Its stem, leaves, twigs, flowers, and roots all the parts are concentrated with different micro and macro nutrients. Being a rich source of nutrient and growth regulators, it is not only being used for plant growth enhancer but may also be used as a green manure crop, water purifier, fodder for animals, as human diet and to cure diseases (Foidle et al., 2001). Its application enhanced 1000 grain weight, biological yield and grain yield (Azra et al., 2012). Application of moringa also increased the maize yield from 60 to 120 sacks ha^{-1} (Price, 1985).

No similar study has been carried out to see the moringa effect when it is incorporated as green biomass. Considering the facts mentioned above of jantar and moringa biomass incorporation a field experiment was carried to see the effects of moringa and jantar incorporation on the maize yield.

Materials and Methods

Experiment was conducted on sandy clay loam soil at Agronomic Research Farm, University of Agriculture, Faisalabad Pakistan. The treatments under study consisted of green manures i.e. No geen manure (G_1), Moringa green manuring (G2) and Jantar green manuring (G3) and different levels of fertilizers i.e no fertilizers (F1), 50% of RDF (F2), 100% of RDF (F3). Randomized Complete Block Design with split plot arrangement having a plot size of 3m x 8m was used with three replications. A composite soil samples collected at a depth of 30 cm was air dried, crushed, and tested for physical and chemical properties of soil. The research field had a sandy clay loam soil, having soil pH (7.8), O.M (0.45%), E.C (1.6dSm-1), N (0.05%), P (7.12 mg Kg^{-1}), K (175 mg Kg^{-1}), Mn (2.6mg Kg^{-1}), Zn (0.28mg.Kg^{-1}). Nitrogen, phosphorous and potassium were applied at the rate of 250, 125 and 125 kg ha^{-1} respectively. Jantar was incorporated *in-situ* and moringa was incorporated *ex-situ* in respective main plots. Both the green manures were incorporated six weeks before the time of sowing of maize for proper decomposition of green biomass. Fertilizers were applied according to the treatments in respective subplots. Potassium and phosphorus were applied at the time of sowing while nitrogen was applied in three splits: at sowing, knee height and tasseling.

Maize single cross hybrid (Hycorn-984) was sown in 75 cm apart rows with hand drill. Plant to plant distance of 25 cm was maintained at 3 to 4 leaves stage by thinning. Weeds were kept under control by manual hoeing. In addition to rainfall received during the growing period of the crop, a total of eight irrigations were applied as and when needed at different plant growth stages till the physiological maturity of the crop. Standard procedures were followed to collect the data for growth and yield parameters like plant height, cob length, No. of grains per cob, 1000 grain weight, grain yield and biological yield, while harvest index (HI) of each plot was calculated by using the formula:

$$H.I. = (Grain\ yield/Biological\ yield) \times 100$$

The data collected were analyzed statistically by using Fisher's analysis of variance technique and LSD at 5% probability was used to compare the differences among treatments' means (Steel et al., 1997). Benefit cost ratio was calculated for each treatment by the following formula:

$$BCR = Gross\ income/Total\ cost$$

The experimental data were economically analyzed by using the methodology described in CIMMYT

(1988). The purpose of this analysis was to estimate the economic returns of each productivity level.

Results and Discussion

Data regarding all the parameters under study showed that the interactive effect of green manures and different doses of fertilizers were not significant. However, individual effect of different doses of fertilizers and green manures incorporation was significant.

Results regarding plant height showed that maximum plant height was obtained when moringa was used as green biomass (G_2) but it was statistically similar to G_3 (jantar was used as green biomass) while lowest plant height was obtained in fallow or no green biomass application (G_1). Table 1 also indicated that in case of different fertilizer doses the highest plant height was noted where 100% of RDF (F_3) was applied while minimum plant height was observed where no fertilizer was applied (F_1).

The data regarding the effect of different levels of fertilizers and natural green manures on the cob length is presented in Table 1. Maximum cob length was observed in G_2 where moringa was incorporated as green biomass and it was statistically at par with jantar incorporation (G_3) on the other hand lowest cob length was measured in fallow or no green biomass (G_1). Similarly in case of different fertilizer application approaches, highest cob length was observed in 100% RDF (F_3) while in F_1 (where no fertilizers were applied) minimum cob length was observed.

Table 1 is showed that highest grains per cob were observed where moringa green biomass was incorporated (G_2) while lowest grains per cob were observed in fallow or no green biomass applicatied plots (G_1). Similarly results regarding different levels of fertilizers, F_3 (100% recommended fertilizers) showed maximum grains per cob while lowest grains per cob were observed in F_1 where no fertilizers were applied.

In the case of 1000-grain weight (Table 1) the highest 1000-grain weight value was recorded where moringa green biomass incorporated (G_2) while lowest 1000-grain weight was observed where no green biomass was incorporated. Table 1 also indicated that highest 1000-grain weight was observed in F_3 treatment (100% of RDF) while lowest 1000-grain weight was observed where no fertilizers were applied (F_1).

Table 1: *Effect of green manures (moringa and jantar) and different levels of fertilizers on growth and yield contributing parameters of maize.*

Treatments	Plant height (cm)	Cob length(cm)	No. of grains per cob	1000-grain weight (g)
Green manures(G)				
G_1	141.72 b	14.31 b	381.0 b	182.68 c
G_2	168.34 a	16.32 a	410 a	200.22 a
G_3	164.00 a	15.34 ab	401.07 a	194.22 b
LSD value	15.91	1.23	7.11	8.06
Fertilizer levels(F)				
F_1	128.28 c	12.22 c	354.3 c	163.67 b
F_2	156. 77 b	15.54 b	399.0 b	192.61 b
F_3	189.02 a	18.21 a	438.7 a	216.57 a
LSD value	14.56	1.76	19.62	8.26
G x F	NS	NS	NS	NS

G_1: *No geen manure;* **G_2:** *Moringa green manuring;* **G_3:** *Jantar green manuring;* **F_1:** *No fertilizers;* **F_2:** *50% of RDF;* **F_3:** *100% of RDF.*

Table 2: *Effect of green manures (moringa and jantar) and different levels of fertilizers on growth, yield and quality parameters of maize.*

Treatments	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest index (%)	Protein Content (%)
Green manures (G)				
G_1	15.07 b	4.54 c	29.79 b	8.23 b
G_2	16.63 a	5.75 a	34.22 a	8.56 a
G_3	15.83 ab	5.17 b	32.13 b	8.50 a
LSD value	0.923	0.40	3.43	0.18
Fertilizer levels (F)				
F_1	13.49 c	3.61 c	26.90 b	7.97 b
F_2	16.26 b	4.86 b	29.87 b	8.53 a
F_3	17.79 a	6.99 a	39.36 a	8.78 a
LSD value	1.004	0.48	3.89	0.30
G x F	NS	NS	NS	NS

G_1: *No geen manure;* **G_2:** *Moringa green manuring;* **G_3:** *Jantar green manuring;* **F_1:** *No fertilizers;* **F_2:** *50% of RDF;* **F_3:** *100% of RDF.*

The results presented for grain yield (Table 2) showed that maximum biological yield was observed where moringa incorporated as green biomass (G_2) while G_1 showed lowest biological yield where no green biomass was incorporated. Similarly in case of different fertilizer application approaches highest biological yield was observed in F_3 (100% recommended dose of fertilizers) while lowest biological yield was observed where NPK was not applied.

It is indicated that maximum grain yield was observed in G_2 where moringa was incorporated as green biomass while G_1 showed minimum grain yield where no green biomass was incorporated. Regarding fertilizer levels impact, highest grain yield was observed in F_3 treatment (100% of RDF) while lowest grain yield was observed in F_1 where no NPK was applied.

Harvest index of maize linked with different types of green manuring (Table 2) showed that the highest harvest index was found in G_2 where moringa was incorporated as green biomass while G_1 showed minimum harvest index where no green biomass was incorporated. Meanwhile, in case of different doses of fertilizers F_3 (100% of RDF) treatment showed highest harvest index and lowest harvest index was observed where no NPK was applied.

Maximum grain protein content was noted in G_2 (moringa green biomass incorporation) that was statistically at par with G_3 treatment where jantar was incorporated as green biomass while lowest grain protein content was noted in G_1 (no green biomass). It was also showed by Table 2 that maximum grain protein content observed in F_3 treatment (100% of RDF NPK) that was statistically near to F_2 while lowest protein content was observed where no NPK was applied.

Table 3: *Effect of green manures (moringa and jantar) and different levels of fertilizers on benefit cost ratio of maize.*

Treatments		G.I. (Rs. ha^{-1})	T.C. (Rs. ha^{-1})	N.R (Rs. ha^{-1})	BCR
Fallow	No fertilizer	99960	69702	30258	1.43
	50% of RDF	129800	96866	32934	1.33
	100% of RDF	185268	124068	61200	1.49
Moringa	No fertilizer	126270	86402	39868	1.46
	50% of RDF	169775	113566	56209	1.49
	100% of RDF	220160	140768	79392	1.56
Jantar	No fertilizer	109250	87602	21648	1.24
	50% of RDF	144460	114766	29694	1.26
	100% of RDF	214140	141968	72172	1.51

G.I.: *Gross income;* **T.C.:** *Total Cost;* **N.R.:** *Net Return;* **BCR:** *Benefit cost ratio.*

Data regarding cost benefit ratio and net return (Table 3) showed that highest net return was observed in F_3G_2 (100% of RDF and moringa green biomass incorporation) on the other hand lowest net return was measured in G_3F_1 where jantar biomass was incorporated without fertilizer application. The highest cost benefit ratio value was also obtained in G_2F_3 treatment while lowest BCR value was obtained in G_3F_1 treatment.

The reason for maximum plant height with green biomass incorporation and inorganic fertilizers might be due to the reason that moringa is a tender plant and decompose rapidly which made the nutrients in available form. Moringa also contain zeatin in large amounts which enhanced the cell division in plants. The higher plant height might have been at the expense of nitrogen that could have been fixed by the jantar crop. Nitrogen in combination with P and K significantly influenced the vegetative growth and plant height. Nitrogen plays an important role in enhancing the vegetative growth and gives plant a lush green color and enhance the photosynthetic ability of plants. So plant height was increased in regard to increase in NPK levels. Our results are in agreement with those of Fuglie (2000), Maqsood et al. (2001), Ayub et al. (2002), Sharar et al. (2003) and Anjorin et al. (2010) who reported that green biomass incorporationa and fertilizers increased the plant height.

In case of cob length green biomass incorporation might have supplied the nutrients for a longer time due to continuous decomposition. Nitrogen in the soil is built up and availability of phosphorous is also enhanced due to which vegetative growth was enhanced. Due to enhanced vegetative growth cob length also influenced greatly. Application of NPK fertilizers might have provided the essential nutrients to the plants when these were needed at vegetative growth stage which ultimately increased the cob length. Our results are in agreement with Kaul et al. (1994), Maqsood et al. (2000), Munda et al. (2007) and Khan et al. (2008), who reported that green biomass incorporation and increased amount of NPK fertilizers increased the cob length significantly.

The reason for increase in number of grains per cob with green biomass incorporation (either of moringa or jantar) and inorganic fertilizers application might be due to the in time availability of mineralized nutrients. Rapid decomposition of moringa and its rich nutrients profile might be the reason for higher number of grains per cob where moringa was incorporated. Inorganic fertilizers applied at different amounts might have enhanced the vegetative growth which ultimately effected the fruit development. During

grain development nutrients are required essentially. Inorganic fertilizer fulfilled the requirement at grain formation stage so number of grains was higher. Our results are in agreement with Sreelatha and Padma (2009), Rasheed et al. (2004) and Oktem et al. (2005).

Among various parameters contributing to the economic yield of a crop, 1000-grain weight is of prime importance. It directly relates with the yield of the crop. Moringa is said to have rich nutrient profile and ability to decompose rapidly. Zeatin is a growth hormone in moringa which enhances the cell division and help in fast growth and development in early stages and in accumulation of photosynthates in large amounts. This ultimately resulted in better development of grains with higher weight. Application of NPK fertilizers has positive effect on 1000 grain weight. It might be due to the easily available nutrients through inorganic sources. Plants can easily uptake the required nutrients from these sources. Maize showed a positive response to the increasing level of NPK fertilizers regarding 1000 grain weight. Our results are in accordance with Itnal and Palled (2001), Mahmood et al. (2001), Foidle et al. (2001) and Jayprakash et al. (2005), who reported that incorporation of green biomass and application of inorganic fertilizers has positive effect on 1000 grain weight.

The reason for maximum biological yield is due to the rapid decomposition of moringa. Organic acid produced by decomposition process released the nutrients which are taken up by the plants for better growth. Nitrogen also plays very important role in vegetative growth. As moringa is rich with all essential nutrients and growth hormones like zeatin so has positive effect on biological yield. Our results are in agreement with Mehboob (2011) and Kamran (2011) who also reported that green biomass incorporation enhanced the availability and uptake of nutrients and in this way increased the biological yield. Similarly application of recommended dose of NPK fertilizers played their pivotal role in enhancing biological yield. Hanif (1990) also disclosed same observations regarding fertilizers application.

The maximum grain yield was might be due to the continuous and ample supply of nutrients throughout the cropping season especially in grain formation and grain filling stages. These results are also in agreement with Codjia (1996), Asghar et al. (2010) and Azra et al. (2012), who reported that incorporation of green biomass and application of NPK fertilizers increased the grain yield in maize.

Harvest index increased with incorporation of green biomass which indicated that green manures developed a positive source to sink relationship. Better biological yield gave better economical yield. Similar effect was with increased amount of inorganic fertilizers. Our results are in agreement with Mkhabela et al. (2001), Khaliq et al. (2004), Sharar et al. (2003) and Memon et al. (2007) who reported the same findings regarding harvest index.

Grain protein contents are directly related to the amount of available nitrogen. Green biomass incorporation enhanced the availability of nitrogen for plant uptake which ultimately increased the protein content. Similarly increased amount of inorganic nitrogen enhanced the grain protein content. Our results are in accordance to Talgre et al. (2009).

Conclusions

The study suggested that moringa being rich in nutrients and plant growth hormones can be used as a green manure along with 100% of RDF, to increase the maize productivity and net economic return.

Author's Contributions

Muhammad Aqeel Sarwar conceived the idea, collected data and wrote abstract, Muhammad Tahir did overall management and supervised the experiment. Abid ali and Manzoor Hussain provided technical input at every step. Muhammad Waheed Anwar, Muhammad Khubaib Abuzar and Ijaz Ahmad did statistical analysis and wrote the article.

References

Anjorin, T.S., P. Ikokoh and S. Okolo. 2010. Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. Int. J. Agric Biol. 12: 431-434.

Asghar, A., A. Ali, W.H. Syed, M. Asif, T. Khaliq and A.A. Abid. 2010. Growth and yield of maize cultivars affected by NPK application in different proportion. Pak. J. of Sci. 62: 211-216.

Ayub, M., M.A. Nadeem, M.S. Sharar and N. Mahmood. 2002. Response of maize (*Zea mays* L.) fodder to different levels of nitrogen and

phosphorus. Asian J. PI. Sci. 9: 352-354.

Azra, Y., S.M.A. Basra, R. Ahmad and A. Wahid. 2012. Performance of late sown wheat in esponse to foliar application of *Moringa oleifera* L. leaf extract (MLE). Chilean J. Agric. Res. 72:92-97. https://doi.org/10.4067/S0718-58392012000100015

Basra, S.M.A., M.N. Irfan, I. Afzal and M. Ashfaq. 2011. Potential of moringa leaf extract as seed priming agent in hybrid maize. Int. J. Agric. Biol. 13: 1006-1010.

Chaudhary, A.R. 1993. Maize in Pakistan. Punjab Agric. Res. Cord. Board, Uni. Agric. Faisalabad, Pakistan.

CIMMYT. 1988. From agronomic data to farmer recommendation: An economic training manual. Mexico. D.F: 25-33.

Codjia, X.C. 1996. Study of fertilising on earth bar black Mucuna (Mucuna *pruriens* var. cochinchinensis) and their interaction with fertilizer. Ag Eng thesis, University National du Benin, Cotonou, Benin.

Deksissa T., I. Short and J. Allen. 2008. Effect of soil amendment with compost on growth and water use efficiency of Amaranth. In: Proc. of the UCOWR/NIWR Annual Conf. Int. Water Res. Challenges for the 21st Century and Water Resources Education, Durham, NC.

Foidle, N., H.P.S. Makkar and K. Becker. 2001. The potential of *Moringa oleifera* for agricultural and industrial uses. In: Fugile, L.J. (ed.), the Miracle Tree: The Multiple Attribute of Moringa. pp. 45–76.

Fuglie, L.J. 2000. New uses of moringa studied in nicaragua. ECHO Development Notes8, June, 2000.

Garrity, D.P. 1989. Agronomic research on biofertilizers at IRRI: Overcoming systemlevel constraints. Paper presented at the symposium on "Bio- and Organic Fertilizers", U.P. at Los Bafios, College, Laguna, Philippines. Oct. 9-12, 1989.

Hanif, M. 1990. Growth and yield of maize genotypes as influenced by NPK application. M.Sc. (Hons) Agronomy Thesis, Deptt. of Agronomy, Univ.of agri. Faisalabad.

Itnal, C.J. and Y.B. Palled. 2001, Studies on inter cropping of sunhemp green manuring in hybrid maize. Karnataka J. of Agric. Sci. 14: 586-596

Jayaprakash, T.C., V.P. Nagalikar, B.T. Pujari and R.A. Shetty. 2005. Effect of organics and inorganics on growth and yield of maize under irrigation. Karnataka J. Agric. Sci. 18: 798-800.

Kamran, M. 2011. Improving the rice wheat system productivity by seed priming. M.Sc. hesis, Department of Crop Physiology, University of Agriculture, Faisalabad.

Kaul, T.N., Kumar, M. and Brar, Z.S. 1994. A physiological analysis of growth, dry matter partitioning and grain yield of transplanted winter maize (*Zea mays* L.) in relation to N-management. J. Res. Punjab Agricultural University. 31: 9-14.

Khaliq, T., T. Mahmood, J. Kamal and A. Masood. 2004. Effectiveness of farmyard manure, poultry manure and nitrogen for corn (*Zea mays* L.). Productivity. Int. J. Agric. Biol. 2: 260-263

Khan, H.Z., M.A Malik and M.F. Saleem. 2008. Effect of rate and source of organic material on the production potential of spring maize (*Zea mays* L.). Pak. J. Agric. Sci. 45 40-43.

Mahmood, M.T., M. Maqsood, T.H. Awan, S. Rashid and R. Sarwar. 2001. Effect of different levelsof nitrogen and intra-row plant spacing on yield and yield components of maize. Pak. J. Agric. Sci. 38: 48-49.

Makkar, H.P.S., G. Francis and K. Becker. 2007. Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture productionsystems. Animal 1:1371-1391. https://doi.org/10.1017/S1751731107000298

Maqsood, M., A.M. Abid, A. Iqbal M.I. Hussain. 2001. Effect of variable rate of nitrogen and phosphorus on growth and yield of maize (golden). Online J. Biol. Sci. 1: 19-20. https://doi.org/10.3923/jbs.2001.19.20

Maqsood, M., A.M. Abid, A. Iqbal and M.I. Hussain. 2001. Effect of variable rate of nitrogen and phosphorus on growth and yield of maize (golden). Online J. Biol. Sci. 1: 19-20. https://doi.org/10.3923/jbs.2001.19.20

Mehboob, W. 2011. Physiological evaluation of prime maize seed under late sown conditions. M.Sc. Thesis, Department of Crop Physiology, University of Agriculture, Faisalabad.

Memon, S.Q., M.B. Baig and G.R. Mari. 2007. Tillage practices and effect of sowing methods ongrowth and yield of maize crop. Agricultura Tropica ET Subtropica. 40: 89-100.

Mkhabela, M.S., M.S. Mkhabela and J. Pali-Shikhulu. 2001. Response of maize (*Zea mays* L.)

cultivars to different levels of nitrogen application in Swaziland.In Seventh Eastern and Southern Africa Regional Maize Conference. pp. 377–381.

Munda, G.C. and Islam, M. 2007. Effect of IPNS on productivity, profitability and economic feasibility of maizebased cropping system on farmers' field. Indian J. Agric. Res. 41(3):200-204.

Oad, F.C., U.A. Buriro and S.K. Agha. 2004. Effect of organic and inorganic fertilizer applicationon maize fodder production. Asian J. Plant Sci. 3: 375-377. https://doi.org/10.3923/ajps.2004.375.377

Oktem, A.G. and A. Oktem. 2005. Effect of nitrogen and intra spaces on sweetcorn characteristics. Asian J. Plant Sci. 4: 361-364. https://doi.org/10.3923/ajps.2005.361.364

Price, M.L. 1985. The benzolive tree, *moringa oliefera*, is called mother's best friend. ECHO development notes, issue no.101.

Price, M.L. 2007. The moringa tree. ECHO Technical Note. 19 p. Educational Concerns ForHunger Organization ECHO, North Fort Myers, Florida, USA

Rasheed, M., W.M. Bhutta, M. Anwar-ul–Haq and A Ghaffar. 2004. Genotypic response of maize hybrids to NP applications. Int. J. Agric. Biol. 4: 721-722.

Sharar, M. S., M. Ayub, M.A. Nadeem and N. Ahmad. 2003. Effect of different rates of nitrogen and phosphorus on growth and grain yield of maize. Asian Plant Sci. 2: 347-349.

Sreelatha and Padma. 2009. Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. Plant Foods Human Nutr. 64: 303-311. https://doi.org/10.1007/s11130-009-0141-0

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and procedures of statistics.

Taiz, L. and E. Zeiger. 2006. Plant physiology. 4th ed. Sinauer Associates, Sunderland, MA, USA.

Talgre, L., E. Lauringson, H. Roostalu, A. Astover,V. Eremeev and A. Selge. 2009. The effects of pure and undersowing green manures on yields of succeeding spring cereals, Acta Agriculturae Scandinavica, Section B. Soil Plant Sci. 59:1: 70–76.