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Triticale (X Triticosecale Wittmack) Forage Production with Solarized Sheep or Cattle Manure

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Abstract: In order to study the effect of solarization of cattle and sheep manure on dry matter production of triticale forage, a factorial experiment 2×2×4 was developed with two types of cattle and sheep manure, two treatments, nonsolarized and solarized and four levels of application 0, 80, 120 and 160 ton ha^{-1} with three replications for this purpose, plots of 1×1 m with a used plot of 0.5×0.05 m to be planted with triticale. Manure was solarized for a period of 90 days using manure from dairy cattle fed pasture, alfalfa and concentrate and manure of pasture-fed sheep. For solarization, a 1 mm thick transparent (polyethylene film) rubber covers was used for the manure. The results show that solarization has a positive effect on forage production, under the conditions of this study, a dry matter production of 6,173 kg ha^{-1} was obtained with sheep solarized manure at a rate of 120 kg ha^{-1} while the control only reached an average production of 2,049 kg ha^{-1}. Treatments with sheep solarized manure at equivalent rates of 120 kg ton^{-1} showed higher productions.

Key words: Organic fertilization, solarization, manure, ovine, bovine, triticale forage, Mexico

INTRODUCTION

In Northern Mexico an intensive production of forage is required to improve livestock production indices (Lozano del Rio *et al*., 2002). In many livestock, regions of Mexico as well as the Comarca Lagunera, there is a need to select the type of forage to help meet the needs of fodder for livestock both in stables and outdoor grazing. Triticale is a relatively new crop, result of crosses between wheat and rye to rescue, the best qualities of each of the two grains, resulting in a grain that has a high resistance to lodging, it adapts well in areas of poor soils, saline and acid soils in addition to have better tolerance than wheat to frost and now the genetic improvement is geared toward use in livestock.

Within the principles of organic agriculture is the use of farm products (Klonsky and Tourte, 1998). Cattle dung and compost are applied to the soil to add organic matter and nutrients and also to improve, the physical properties of soil by influencing in an important way on water infiltration and erosion control, this manure has also shown that some pathogens can be suppressed from the soil (Klonsky and Tourte, 1998). Therefore, a fertilization alternative are the manures, abundant material in the Laguna region but it is necessary to give it treatment so cannot be a source of contaminants such as weed seeds and pathogenic bacteria although, crop diseases can be controlled by previously planned application of pesticides and fumigants however, the use of these materials is often undesirable due to their toxicity to animals and people and their residual toxicity in plants and soils (Elmore *et al*., 1997; Lira-Saldivar *et al*., 2004).

Researchers and agricultural technicians are faced with one of the biggest challenges in recent years to find alternatives to these chemicals to control pests and plant diseases. As an alternative to chemical use arises solarization which is a process in which temperature rises using solar radiation as energy source (Khalid *et al*., 2006). The heat of solarization decreases pathogens and increases soil nitrates soil (Elmore *et al*., 1997).

Solarization is a hydrothermal process of disinfecting of soil to eliminate pests of plants, this is achieved by passive solar heating and solarization occurs by a combination of physical, chemical and biological

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mechanisms and it is compatible with many other disinfection methods to provide integrated pest management. Solarization is also financially compatible with other tactics of pest management so, it can be quickly integrated to standard systems of production and a valid alternative to fumigation (Chellemi *et al*., 1997).

Soil solarization is a widely studied and effective method to control many insects, diseases and weeds of soil since, the number of pathogens can be reduced from 89-100% (Sikora and ACES, 2009). Soil solarization combined with organic matter is a sustainable alternative to fumigation or use of herbicides for weed control and increase production of cantaloupe (Lira-Saldivar *et al*., 2004). Soil solarization, manured with chicken compost gives good results for the control of pathogens and high yield of lettuce and tomato than either treatment alone (Gamliel and Stapleton, 1997). Solarization consists of soil disinfection using solar energy, it is a non-chemical treatment that uses solar energy to heat the soil and its efficiency can be improved by the combination of organic products.

According to some researchers, solarization increases the current soil fertility by enhancing processes of mineralization of organic matter incorporated while decreasing pH and increases the total nitrogen and available phosphorus, an increase of soluble organic matter is produced in its composition, expressed by the considerable increase in the concentration of nitrate and ammonia by the decomposition of organic matter, thus increasing concentrations of Na, K, Ca, Mg and Cl.

However, there are few studies on the use of solarized manure in agriculture. So, the aim of this study is to study the application of cattle and sheep solarized manure on triticale forage production.

MATERIALS AND METHODS

Place of study: This study was carried out in Valley of Durango, Mexico, located on the geographical coordinates latitude 23°57' 09.26"N and longitude 104°33' 39.5"W at 1875 m above sea level. It was solarized manure of dairy cows fed *Lolium perenne* pasture and grain-based concentrate with 17% crude protein and sheep fed *Lolium perenne* pasture and concentrate of 17% protein freshly harvested. The manure was exposed to the sun, covered with special rubber to solarize during 90 days, sheep and cattle manure were applied at levels of 80, 120 and 160 ton ha^{-1} on plots of 1×1 m with a used plot 0.5×0.5 m after sowing triticale equivalent to 60 kg ha^{-1}, prior land preparation. All plots were irrigated with surface water every 10 days so, water was not limiting. Samples were taken when the grain of triticale plants were in milky, paste-like stage, plant samples were dried, ground and weighed. The results were analyzed using a randomized block design with factorial arrangement for four levels of manure, 0, 80, 120 and 160 ton ha^{-1} with two solarized and nonsolarized treatments, two sources of manure, cattle and sheep with three replications.

The statistical analysis was performed using ANOVA and using the procedure PROC GLM with the statistical package SAS, 9.1. Also, a regression analysis was conducted using the Hoerl model with the program CurvExpert 1.3.

Experimental design:

$$Y_{ijk} = \mu+A_i+B_j+C_K+A_i*B_j+A_i*C_K+B_j*C_k+A_i*B_j*C_K+\epsilon_{ijk}$$

Where:

Y_{ijk} = The observation of the treatment ijk
μ = The true effect of the general mean
A_i = The effect of k-ith type of manure, control of cattle and of sheep
B_j = The effect of j-ith treatment to manures, control, solarized and nonsolarized
C_k = The effect of i-ith levels of manure 0, 80, 120 160 ton ha^{-1}
A_i*B_j = The ij-ith effect of the interaction type of manure per type of treatment to manure
B_j*C_k = The jk-ith effect of the interaction type treatment per rate
$A_i*B_j*C_K$ = Effect of the ijk-ith effect of the interaction type of manure per type of treatment per rate
ϵ_{ijk} = The experimental error

RESULTS AND DISCUSSION

Dry matter yield of triticale seed: Seed yield per hactare as shown in Table 1 and Fig. 1 were significantly ($p\leq 0.05$) affected by the incorporation of manure, the type of manure that showed better results in the yield of seed per hectare was the sheep manure with mean values of 1,573 kg ha^{-1} of seed against 656 kg ha^{-1} of control which represents an increase of 917 kg ha^{-1} (240%) compared to the control. But also in cattle manure, productions of 1.379 kg ha^{-1} were found this value is not significantly different ($p>0.05$) of the value found with sheep manure. However when the cattle and sheep manure were solarized production of dry matter of seed was increased to 1,602 and 1,938 kg ha^{-1}, respectively, reflecting an increase of 423 kg ha^{-1} (1,602-179) 423 and 776 kg ha^{-1} (1,938-1162), respectively in response to solarization but when cattle and sheep manure is applied at rates of 120 ton ha^{-1} average values of 704 kg ha^{-1} (1,891-1,187)

Table 1: Triticale seed, stem and leaf yield and total in kg dry matter per hectare

Types manure	Process	Rates (ton ha^{-1})	N	Seed	Stem	Leaf	Total
				(kg ha^{-1})			
Control	None	0	3	656^{c}	740^{c}	653^{b}	2,049^{c}
Solarized	Cattle	80	3	1,546^{abc}	1,414^{abc}	1,043^{ab}	4,003^{abc}
Solarized	Cattle	120	3	1,891^{ab}	1,861^{ab}	1,306^{ab}	5,058^{ab}
Solarized	Cattle	160	3	1,368^{bc}	1,713^{abc}	1,501^{a}	4,582^{ab}
Nonsolarized	Cattle	80	4	1,211^{bc}	1,680^{abc}	985^{ab}	3,877^{abc}
Nonsolarized	Cattle	120	3	1,187^{bc}	1,760^{ab}	979^{ab}	3,926^{abc}
Nonsolarized	Cattle	160	3	1,127^{bc}	1,303^{bc}	1,245^{ab}	3,675^{bc}
Solarized	Sheep	80	3	1,560^{abc}	1,662^{abc}	1,108^{ab}	4,330^{abc}
Solarized	Sheep	120	3	2,404^{a}	2,386^{a}	1,382^{ab}	6,173^{a}
Solarized	Sheep	160	3	1,850^{ab}	2,215^{ba}	1,606^{a}	5,671^{ab}
Nonsolarized	Sheep	80	2	1,327^{bc}	1,778^{ab}	917^{ab}	4,021^{abc}
Nonsolarized	Sheep	120	3	1,148^{bc}	1,274^{bc}	1,425^{ab}	3,847^{bc}
Nonsolarized	Sheep	160	3	1,067^{bc}	1,420^{abc}	1,511^{a}	3,998^{abc}

^{abc}Means in the same column with same letter are not significantly different ($p \leq 0.05$)

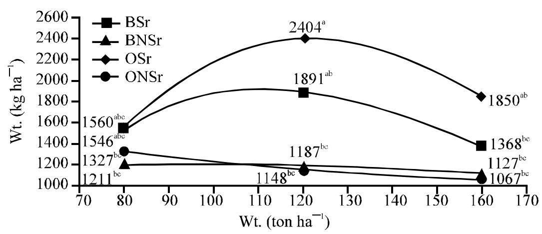

Fig. 1: Seed yield in triticale dry matter in relation to manure rate

and 1,256 kg ha^{-1} (2,404-1,148) are obtained, respectively. (Table 1, 2). Therefore, it can be concluded that solarization increases dry matter production up to 704 kg ha^{-1} when solarized cattle manure is applied at equivalent rates of 120 ton ha^{-1} and up to 1.256 kg ha^{-1} when solarized sheep manure is applied at a rate equivalent of 120 ton ha^{-1}.

Dry matter yield of triticale stems: Similarly, the yields of stems per hectare were affected significantly ($p \leq 0.05$) by the different treatments as they show significant differences compared to the control since the control only produced 740 kg ha^{-1} while the treatments with cattle manure 1625 kg ha^{-1} were obtained and with sheep manure 1790 kg ha^{-1} while if solarized, these stem productions are increased to average values of 1,662 and 2,087 kg ha^{-1} for solarized cattle manure and solarized sheep manure, respectively however if these solarized manures are applied at equivalent rates of 120 ton ha^{-1}, the stem production is increased to 1,861 and 2,386 kg ha^{-1} for treatments with solarized cattle manure at equivalent rates of 120 ton ha^{-1} and solarized sheep manure at a rate of 120 ton ha^{-1}, respectively (Fig. 2). The net effect of solarization is 101 kg ha^{-1} (1,861- 1,760) for treatments with solarized cattle manure at rates of 120 and 1,112 kg ha^{-1} (2,386-1,274) for treatments with solarized sheep manure at equivalent rates of 120 kg ha^{-1} (Table 1).

Table 2: Total production of triticale dry matter

	Cattle		Sheep	
Constants	Solarized	Nonsolarized	Solarized	Nonsolarized
a	0.104	348.546	0.00348	53976.529
b	0.977	0.993	0.97146	1.006
c	2.825	0.668	3.73090	-0.702

Manure type, Hoerl model y = a*(b^x)*(x^c)

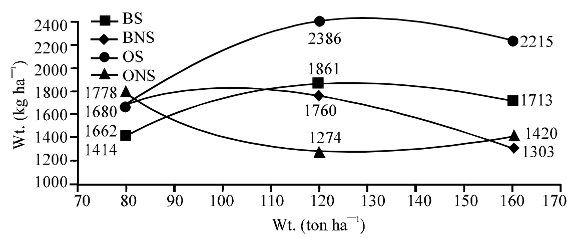

Fig. 2: Stem yield in triticale dry matter in relation to manure rate

It is confirmed that solarized sheep manure at rates equivalent to 120 ton ha^{-1} produces 1.112 kg ha^{-1} of dry matter of extra stems.

Total yield of dry matter of triticale leaves: Production of leaves in triticale forage was affected significantly ($p \leq 0.05$) and positively by the addition of manure, since the control only produced 653 kg ha^{-1} of leaves against 1,167 kg ha^{-1} for cattle manure and 1,349 kg ha^{-1} for sheep manure but when manure is solarized the production of leaf dry matter is increased at levels of 1,324 kg ha^{-1} against 1,181 kg ha^{-1} for not solarized manure representing a gain attributable to solarization of 143 kg ha^{-1} (1,324-1,181) (Fig. 3). But when the manure is applied at levels of 120 kg ha^{-1}, production of leaf dry matter increases at levels of 1.344-1.202 kg ha^{-1}, representing a net gain attributable to solarization of 142 kg ha^{-1} (1.344-1.202). While the application of solarized cattle manure at rates equivalent to 120 kg ha^{-1}, a production of 1.306 kg ha^{-1} is obtained whereas the

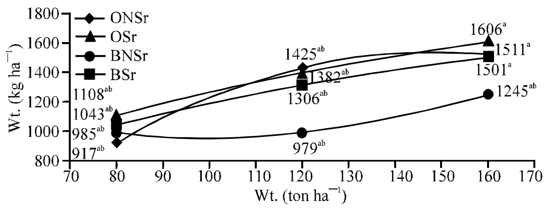

Fig. 3: Leaf yield in triticale dry matter in relation to manure rates

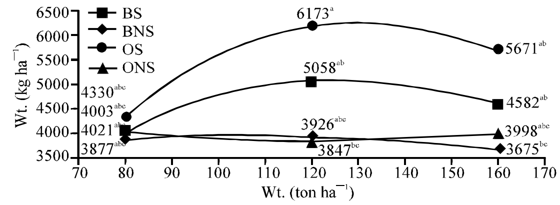

Fig. 4: Total yield of triticale dry matter in relation to the rate of manure

application of manure without solarization at the same rate only obtained 979 kg ha^{-1} so, the net gain attributable to solarization is 327 kg ha^{-1} (1,306-979).

Total yield of dry matter of triticale forage: Similarly as in the case of the dry matter of seed, stem and leaf, the manure application affects significantly ($p<0.05$) and positively total forage production of triticale as from the control only 2.049 kg ha^{-1} of forage were obtained against 4.170 and 4.712 kg ha^{-1} when cattle and sheep manure was applied, respectively but if manures are solarized this increases to 4,969 against 3.882 kg ha^{-1}, representing a net gain of 1.087 kg ha^{-1} (4,969-3,882). But if manure is applied at rates equivalent to 120 ton ha^{-1} then the triticale forage production increases to 5.615 kg ha^{-1}, representing a net overall increase due to solarization of 1.729 kg ha^{-1} (5.615-3.886). In relation to the manure type by species, the solarized cattle manure and at rates equivalent of 120 ton ha^{-1} produced 5,058 kg ha^{-1} with a net gain of 1,132 kg ha^{-1} (5,058-3,926), attributable to solarization while sheep manure reached productions of 6,173 kg ha^{-1} with a net gain of 2330 kg ha^{-1} (6,173-3,843) attributable to solarization.

From the pervious study, it is concluded that solarization significantly and positively affects ($p<0.05$) the total dry matter production of triticale forage, sheep manure is the one that brings out best results and the best rate is the equivalent of 120 ton ha^{-1} of the above, extra increases are achieved of 2.330 kg ha^{-1} of dry matter as triticale forage (Table 1). But according to equations to Hoerl model (Table 2), it is calculated that the best rates are 124 ton ha^{-1} for solarized cattle manure and 129 ton ha^{-1} for solarized sheep manure (Fig. 4).

The values found in this experiment for the solarized cattle manure at equivalent rates of 120 kg ha^{-1} of 5,058 kg ha^{-1}, solarized sheep manure at equivalent rates of 160 kg ha^{-1} with mean values of 5,671 kg ha^{-1} and solarized sheep manure at a rate of 120 kg ha^{-1} with mean values of 6,173 kg ha^{-1} are above those mentioned by Sagrasseed in Argentina, they report as mean 5,000 kg ha^{-1} with conventional systems of production while Scianca reported values of triticale forage production of 6,034 kg MS ha^{-1} with conventional production systems, these values are very close to those found in this experiment with the solarized sheep manure treatment at rates equivalent to 120 kg ha^{-1}. Likewise, the found results agree with those reported by Grassi who found values of 1470.1±693.6 kg ha^{-1} of dry weight for triticale in the 1st cut in Argentina, grown in a typical Haplustol soil with 18% of organic matter. As well as those found by who reported values of 3270-5131 kg ha^{-1} with mean values of 4425 kg ha^{-1} grown in soils with good level of fertility and moisture, a level of NO_3 >100 ppm and phosphorus close to 30 ppm.

The best results of total production of DM are found at a rate of 120 ton ha^{-1} of manure, data that agree with those reported by for forage maize with cattle manure. With regard to the values found by with the application of 125 kg ha^{-1} of P_2O_5 and K_2O, report productions of triticale forage values ranging from 6.0-8.1 ton ha^{-1} in these conditions, the values found in this experiment show that they are at the lower limit. However, season of the year when planting and seed variety have a great influence as reported by for twelve varieties of triticale (X Triticosecale Wittmack) sown in winter and fall in A Coruna (Lugo), they found production values within a range from 4718 kg DM ha^{-1} for Noé varieties as minimum value to values of 8715 kg DM ha^{-1} as maximum value for the Tritano variety in winter while in the summer crop the minimum values reported for the Senatrit varieties with 6711 kg DM ha^{-1} and and the maximum values in the Trijan varieties with values of 9796 kg DM ha^{-1}.

As also reported by Ye Ceh in the evaluation of 90 genotypes of triticale forage, applying 468 kg ha^{-1} ammonium sulfate (20.5-00-00), they found values of 5050, 6750, 6310 and 7290 kg DM ha^{-1} for groups A-D, respectively defining the groups A with those of winter habit with slow growth, the group B of spring habit with rapid growth, the group C of habits similar to B but with greater tillering and group D of slightly higher tillering than the spring type and medium regrowth capacity.

CONCLUSION

Solarized manure application to produce triticale forage is of great benefit as a good production of both cattle and sheep manure is achieved and that extra productions of 1132 and 2330 kg ha^{-1} are also achieved, attributed to solarization for cattle and sheep manure, respectively thus, it is founded that solarization positively affected dry matter production of triticale forage similarly, it is concluded that lower results are obtained with rates of 120 ton ha^{-1} in the same way the best response is obtained from solarized sheep manure at rates of 120 ton ha^{-1} with productions of 6173 kg ha^{-1}, compared to cattle manure production which only reached productions of 5058 kg ha^{-1} although, they are acceptable levels so, the recommendation is to apply manure preferably solarized sheep manure at rates of 120 ton ha^{-1} for the production of triticale forage.

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