Research Article
doi:10.19071/jpc.2015.v43.i3.2850
Journal of Plantation Crops, 2015, 43(3): 171-177

Polypropylene woven fabric - A good mulch material for young rubber plants

Sherin George*, Sabu P. Idicula and Kochutresiamma Joseph

Rubber Research Institute of India, Kottayam-686009, Kerala, India

(Manuscript Received:19-06-2015, Revised:17-09-2015, Accepted:12-10-2015)

Abstract

In young rubber plantations, dry leaf, coco tree mat, polypropylene woven fabric and coir pith were evaluated as agricultural mulch materials for their influence on soil moisture conservation, weed control, soil temperature and microflora, plant growth and durability in two field experiments. The experiments were conducted in a drought susceptible clone (RRII 105) and a comparatively drought tolerant clone (RRII 430) at Chimoni Estate, Thrissur district, a drought-prone area in Kerala state, India. The effects of different treatments were similar in both the experiments irrespective of clones. Though dry leaf and coir pith were effective in soil moisture conservation, they remained in the field for one season only and failed to control weeds during rainy season. Coco tree mat conserved moisture and also smothered weeds in plant basins. However, it remained in the field for almost one year only before it was completely decomposed. Polypropylene woven fabric improved soil moisture retention, as well as suppressed weed growth and was found durable. Though mulching reduced the adverse effects of summer, significant impact on soil microflora and plant growth was not manifested. Polypropylene woven fabric appears to be a good alternative mulch material for *Hevea.*

Keywords: Coco tree mat, coir pith, *Hevea*, mulch, polypropylene, weed growth

Introduction

Water deficit is one of the most important environmental stresses affecting agricultural productivity and may result in considerable growth and yield reduction. Drought stress is a major constraint to rubber production in rain-fed areas associated with climate change. Therefore, good agro-management practices which can reduce the drought impacts through enhanced water conservation, retention and absorption assume importance in rubber farming. Weed management is yet another important and expensive agronomic input especially during the immature phase of rubber cultivation.

Mulching is a cropping practice that entails placing organic or synthetic materials on the soil close to plants to provide a more favourable environment for growth and development (Dickerson, 2002). Mulching has been advocated as an effective means for conserving soil moisture, improving soil fertility, suppressing weed growth, controlling erosion and modifying the thermal regime of soil (Maurya and Lal, 1981; Lakshmanan *et al*., 1995). Organic mulches include hay, straw, coir pith, grass and cover crop cuttings and compost, all of which provide nutrients to the soil during the decomposition process. Inorganic mulches on the other hand, include plastic mulches. Polyethylene plastic mulch is extensively used for crop production because it controls weeds, conserves soil moisture, increases soil temperature, increases crop yield, quality and is cheap and readily available (Miles *et al*., 2012; Sing and Kamal, 2012). Coco tree mat developed by Coirfed is an eco-friendly and fully biodegradable mulch material. Polypropylene woven fabric is also used as an agricultural mulch to prevent weed growth and conserve moisture and an advantage over black plastic mulch is that it is permeable to air and water. Coir pith, a by-product from coir industries, is a good source of mulch for improving the water

**Corresponding Author: sherin@rubberboard.org.in*

holding capacity and reducing the weed population (Solamalai *et al*., 2001) and is widely used in estate sector for mulching. In this context, an experiment investigating the effect of different mulches *viz.,* dry leaf, coco tree mat, polypropylene woven fabric and coir pith on growth of rubber, soil moisture conservation and weed control was taken up.

Materials and methods

Two field experiments, one with RRII 105 (Experiment 1), a drought susceptible clone and another with RRII 430 (Experiment 2), a comparatively drought tolerant clone were initiated in one-year-old field plants at Chimoni Estate, a drought-prone area in Thrissur district, Kerala state during 2012. The soil of the experimental site was sandy clay loam in texture, acidic in reaction (pH 5.15), medium in organic carbon (1.8%) and available K (116.5 mg kg^{-1}) and high in available P (41 mg kg^{-1}). *Mucuna bracteata* was established as cover crop and maintained during the immature phase. The treatments comprised of combinations of four different mulches *viz.,* dry leaf (DL), coco tree mat (CTM), polypropylene woven fabric (PPWF) and coir pith (CP, estate practice) and two irrigation treatments *ie.,* without irrigation and one basin irrigation during peak summer, the treatments being the same for both the experiments. The experiments were laid out in RBD with three replications. The plot size was 15 plants. Coco tree mat supplied by Coirfed and polypropylene woven fabric were of size 1x1 m. Coir pith was applied @ 8 kg per plant. Mulching was undertaken during the month of November and as the field was completely dry at the time of commencement of the trial, all the plants were given basin irrigation @ 30 L per plant irrespective of the treatment just before spreading the mulch. The plots with irrigation as per the treatments were given one more irrigation during the month of February with the same quantity of water during the first year and 50 L per plant during the second year. All the plots were under life- saving irrigation @ 2 L per plant once in 7 to 8 days during the summer of 2012-13.

The rainfall received in the experimental area during course of study is presented in Figure 1. Soil moisture was estimated gravimetrically from samples collected at 0-15 cm depth during summer months. Observations on weed density and weed dry matter production were recorded from an area

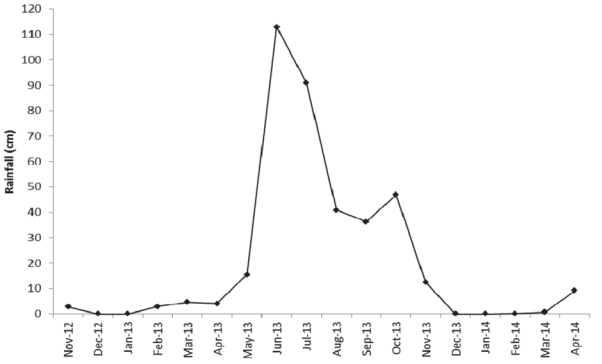

Fig. 1. Rainfall received in the experimental area (November 2012- April 2014)

of 1 m^2 around the plant basin periodically. Soil samples (0-15 cm depth) were collected just before the commencement of mulching and by the end of summer from the mulch applied area to determine the population of soil microflora. Rhizosphere microflora such as total bacteria, actinomycetes and fungi were enumerated following the serial dilution plate method using soil extract agar, Kenknights agar and Martin's Rose Bengal agar media respectively. Growth of rubber was recorded by measuring the diameter of the plants at a height of 30 cm above the bud union. The data were subjected to statistical analysis.

Results and discussion

Soil moisture

Soil water content of all treatments was similar at the beginning of the experiment (November 2012) as the plants were given uniform irrigation irrespective of the treatment and the moisture content varied with time in response to mulch, until the irrigation was applied as per the treatment in February. All the plants were under life-saving irrigation. In Experiment 1 (RRII 105), the soil moisture content at 0-15 cm depth during January and February was significantly higher under organic mulches, *viz.,* coir pith and dry leaves and the highest soil moisture content was associated with coir pith (Fig. 2). There was no significant difference in soil moisture retention between coco tree mat and polypropylene woven fabric. The moisture content determined after irrigating the plants (March 2012) also exhibited almost a similar trend. Though the soil moisture content under irrigated coir pith and dry leaves was positively influenced, the difference was not significant.

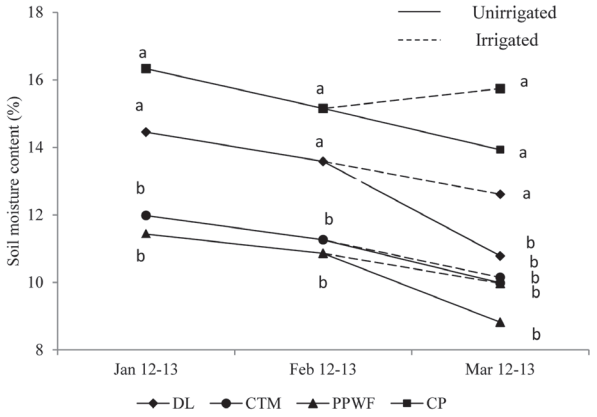

Fig. 2. Effect of mulches on soil moisture retention (2012-13) – Experiment I

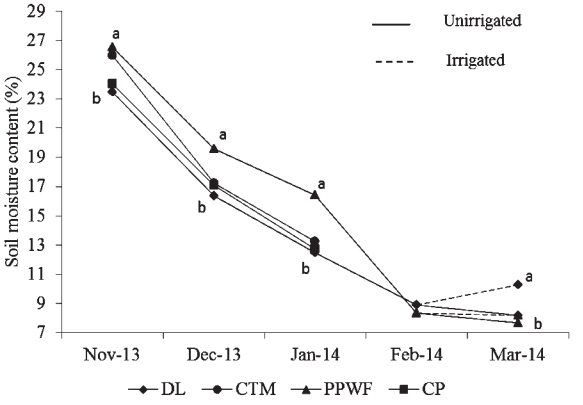

Fig. 4. Effect of mulches on soil moisture retention (2013-14) – Experiment I

The impact of irrigation was insignificant in the case of coco tree mat and polypropylene woven fabric.

The trend was almost similar in Experiment II also (RRII 430) *i.e*., coir pith and dry leaf retained a higher soil moisture than coco tree mat and polypropylene woven fabric, the surface moisture content under these being significantly less (Fig. 3). During January, the soil moisture content under coir pith was significantly greater compared to all other mulch materials. The variations in soil moisture regime after irrigation were also similar to that of Experiment 1 and the soil moisture content was lesser under polypropylene woven fabric.

A reverse trend was noticed during 2013-14. During November 2013, the soil moisture content was significantly higher under polypropylene woven fabric followed by coco tree mat which were comparable in Experiment I (Fig. 4). Soil moisture retention under dry leaf and coir pith was also on par and significantly inferior. In the second experiment also polypropylene woven fabric recorded the highest soil moisture followed by coir pith and coco tree mat which were comparable and the least soil moisture content was recorded for dry leaves during November (Fig. 5). Polypropylene woven fabric recorded significantly higher moisture content than all other mulches in both the experiments in December and January, the moisture content in others being comparable. However, with the soil temperature increasing gradually, the effect of mulch treatment became less apparent and little difference due to treatment was noticed in February and in March for unirrigated treatments whereas a significant difference was noticed in moisture

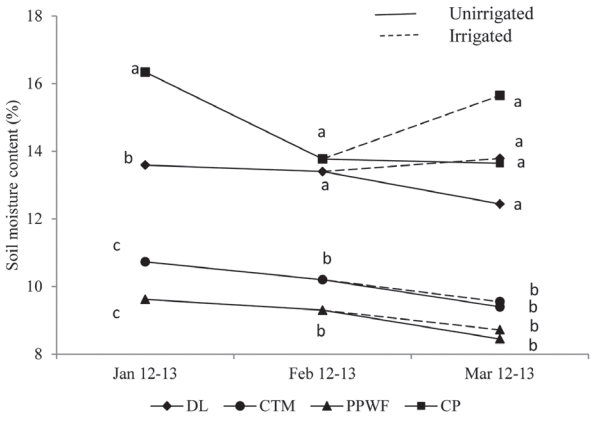

Fig. 3. Effect of mulches on soil moisture retention (2012-13) – Experiment II

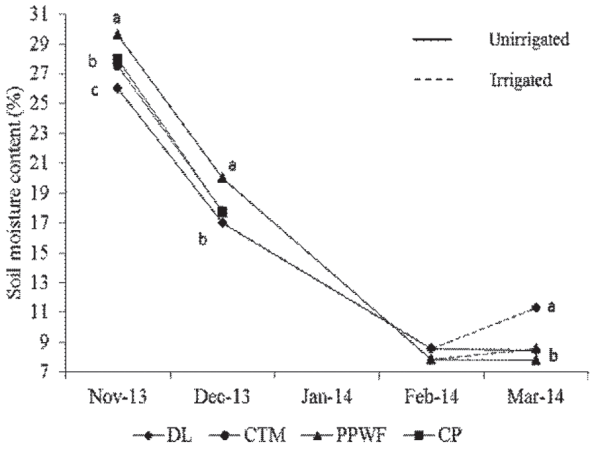

Fig. 5. Effect of mulches on soil moisture retention (2013-14) – Experiment II

retention pattern in the case of irrigated plants. From February onwards, the comparison was made between dry leaf and polypropylene woven fabric only as coco tree mat also was completely decomposed.

There was distinct difference in soil moisture regime under different mulches during the first and second years. During 2012, all mulches were applied after an irrigation and the moisture retention was found to be higher under coir pith and dry leaves than coco tree mat and polypropylene woven fabric. A comparative study on the effect of different mulches on soil temperature, soil moisture and yield of paste tomato showed that organic mulches reduced afternoon soil temperature and maintained higher soil moisture levels than other treatments (Schonbeck and Gregory, 1998). In the second year, higher soil moisture content was associated with polypropylene woven fabric even after the application of dry leaf mulch by the end of December. It may be noted that coir pith and dry leaf mulch were retained in the field for one season only. Coco tree mat also started decomposing with the onset of monsoon and was fully decayed by November 2013 and polypropylene remained in the field without any damage throughout the study period. The soil moisture dynamics under different mulch materials during the two seasons clearly indicated that coir pith and dry leaf mulches retain higher moisture content in wet regime and therefore application of these mulches should be done along with the cessation of monsoon when there is enough soil moisture in the field. The advantage with polypropylene is that soil moisture conservation takes place during the entire rainy season and the effect is carried through the summer as evidenced by the higher soil moisture content under this mulch in both the experiments during the second year. The mulch layer on the soil surface can weaken the intensity of turbulent exchange between the atmosphere and soil water, which causes soil moisture to be prevented from evaporating, and thus reducing ineffective water consumption (Ramakrishna *et al*., 2006). Increased moisture retention capacity due to mulching with polythene could be attributed to less evaporation from the soil. The use of polyethylene mulch has been reported to conserve soil moisture (Anikwe *et al*., 2007; Kumar and Lal, 2012).

Weed infestation

Mulching brought about a significant reduction in weed infestation in rubber plantation. The weed growth was practically nil under polypropylene woven fabric and coco tree mat during May 2013 due to extreme dry weather and the weed count in coir pith and dry leaf mulch was very few. The weed count as well as weed dry biomass (Tables 1&2) was significantly reduced under poly polypropylene woven fabric and coco tree mat during August 2013 compared to coir pith and dry leaf mulch in both the experiments and the least weed infestation was found under polypropylene woven fabric. Ashrafuzzaman *et al*. (2011) recorded the lowest number of weeds in black plastic mulch and highest in clear plastic mulch. The weed smothering ability of mulches has been well established (Lal, 1995; Essien *et al.,* 2009).

Table 1. Effect of different mulches on weed count and dry matter production (DMP) in Experiment I

Treatment	Weed count (No. m^{-2})	Weed DMP (g m^{-2})
Dry leaf	39.8	26.0
Coco tree mat	20.3	8.9
Polypropylene woven fabric	14.7	7.6
Coir pith	40.8	22.7
SE	3.7	3.5
CD (P=0.05)	11.1	10.4

Table 2. Effect of different mulches on weed count and DMP in Experiment II

Treatment	Weed count (No. m^{-2})	Weed DMP (g m^{-2})
Dry leaf	58.2	33.9
Coco tree mat	30.3	18.7
Polypropylene woven fabric	24.3	11.7
Coir pith	62.5	34.2
SE	5.6	3.9
CD (P=0.05)	17.0	11.6

Soil microflora

The population density of different microorganisms like bacteria, fungi and actinomycetes in the rhizosphere of rubber just

Table 3. Effect of different mulches on soil microflora – Experiment I

Treatment	Bacteria (10^4 cfu g^{-1})		Fungi (10^3 cfu g^{-1})		Actinomycetes (10^4 cfu g^{-1})	
	Nov. 12	April 13	Nov. 12	April 13	Nov. 12	April 13
Dry mulch	31.7	3.8	5.9	1.3	8.3	0.5
Dry mulch + Irrigation	27.3	4.8	8.4	2.0	8.0	0.3
Coco tree mat	32.7	3.4	7.3	2.9	7.7	0.7
Coco tree mat + Irrigation	31.5	2.5	10.5	1.6	5.5	0.3
PPWF	28.0	2.2	11.0	2.1	6.7	0.4
PPWF+ Irrigation	31.7	4.2	7.0	2.0	6.7	1.0
Coir pith	25.7	3.9	10.3	3.2	6.7	0.6
Coir pith+ Irrigation	25.0	6.1	10.7	3.8	7.3	0.9
SE	11.4	1.3	2.3	0.8	1.3	0.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4. Effect of different mulches on soil micoflora- Experiment II

Treatment	Bacteria (10^4 cfu g^{-1})		Fungi (10^3 cfu g^{-1})		Actinomycetes (10^4 cfu g^{-1})	
	Nov. 12	April 13	Nov. 12	April 13	Nov. 12	April 13
Dry mulch	27.3	2.2	7.4	2.0	8.5	0.3
Dry mulch + Irrigation	26.0	3.1	5.1	3.3	9.0	0.2
Coco tree mat	23.3	2.0	4.7	3.5	8.3	0.7
Coco tree mat + Irrigation	20.7	2.4	5.9	2.4	9.5	0.5
PPWF	29.0	3.8	3.7	1.8	8.0	0.3
PPWF+ Irrigation	26.3	1.8	5.0	3.2	4.9	0.4
Coir pith	23.3	3.1	6.3	5.6	5.3	0.5
Coir pith+ Irrigation	24.7	5.7	4.0	3.2	7.3	0.4
SE	5.0	0.8	1.4	1.1	2.7	0.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 5. Effect of different mulches on growth of rubber

Treatment	Diameter increment at 30 cm from the bud union (Nov. 12 - Nov. 13)	
	RRII 105 (mm)	RRII 430 (mm)
Dry mulch	23.5	27.7
Dry mulch + Irrigation	22.5	25.7
Coco tree mat	23.0	29.5
Coco tree mat + Irrigation	22.5	26.5
Poly propylene woven fabric (PPWF)	22.7	28.7
Poly propylene woven fabric + Irrigation	24.0	29.5
Coir pith	22.4	27.8
Coir pith+ Irrigation	24.1	26.8
SE	0.9	0.9
CD (P=0.05)	NS	NS

before the application of mulches (November 2012) and five months after, by the end of summer (April 2012) is presented in Tables 3 and 4. A drastic reduction was observed in the population of all microorganisms from November to April irrespective of the treatments. However, no significant difference was observed among treatments in either case. Microbial growth in soils typically is resource limited and growth increases rapidly in response to added carbon sources (Johnson, 1992; Wardle, 1992). Soil moisture and temperature increase due to plastic mulching change soil biological characteristics, enhance soil microbial biomass and provide a more stable soil micro-environment (Li *et al*., 2004). However, such an improvement in microbial count was not indicated in this study.

Table 6. Economics of mulching

Mulch	Material cost per plant (₹)	Application cost per ha per year (₹)	Total cost per plant for 3 years (₹)
Coco tree mat	140.00	1500.00 (3)*	429.00
PPWF	99.00	1500.00 (3)*	102.00
Dry mulch	-	6250.00 (12.5)	37.50
Coir pith	16.00 **	4500.00 (9)	75.00

* No. of workers @ ₹ 500 per worker, ** 8 kg plant^{-1} @ ₹ 2 kg^{-1}

Growth of plants

Mulching, irrespective of its type, did not exhibit any significant influence on growth of plants for a period up to one year after application in Experiment I and II and the girth increment during this period did not differ significantly among treatments in both experiments (Table 5). Earlier researchers reported an improvement in growth characters as a result of mulching due to the enhancement in photosynthesis and other metabolic activities (Bhatt *et al*., 2011; Parmar *et al*., 2013), especially in annual crops as a consequence of improved moisture availability, better weed control and regulation of soil temperature. Such an effect is not manifested in the present study. *Hevea* being a perennial crop, it is too early to expect such a favourable effect on growth.

Cost analysis

The cost of mulching per plant for a period of three years was ₹ 102/- for polypropylene woven fabric which is comparatively higher than coir pith (₹ 75/-) and dry leaves (₹ 37.5/-) (Table 6). However, the advantage of polypropylene mulch over other mulches is that on one time application, it remained intact in the field for three years resulting in soil moisture conservation and weed control in the plant basin throughout the immaturity period, whereas, coir pith and dry leaves remained in the field only for one season. The cost savings in weeding is not accounted here. Since the material is UV-stabilized and remained intact there is possibility for re-using the material during the next planting season, especially in the estate sector.

Conclusion

The study has shown that polypropylene woven fabric has the potential of improving the soil moisture retention as well as suppressing weed growth, thereby providing a conducive environment for crop growth. Though coco tree mat also conserved moisture and smothered weeds, it remained in the field for one year only. The air and water permeability of polypropylene woven fabric makes it more sustainable over plastic mulch. Rubber being a perennial crop its durability is yet another advantage. Further studies are being needed to investigate the effect of different mulch materials on soil physico-chemical properties and soil sustainability.

References

Anikwe, M.A.N., Mbah, C.N., Ezeaku P.I. and Onyia, V.N. 2007. Tillage and plastic mulch effects on soil properties and growth and yield of coco yam (*Colocasia esculenta*) on an ultisol in South-eastern Nigeria. *Soil Tillage Research* **93**: 264-272.

Ashrafuzzaman, M.M., Abdul hamid, M., Ismail, M.R. and Sahidullah, S.M. (2011). Effect of plastic mulch on growth and yield of chilli. *Brazilian Archives of Biology and Technology* **54**(2): 321-330.

Bhatt, L., Rana, R., Uniyal, S.P. and Singh, V.P. 2011. Effect of mulch materials on vegetative characters, yield and economics of summer squash (*Cucurbita pepo*) under rainfed mid-hill condition of Uttarakhand. *Vegetable Science* **38**: 165-168.

Dickerson, G.W. 2002. *Commercial Vegetable Production with Plastic Mulches*. Guide H 245 Cooperative Extension Service, New Mexico State University, Las Cruces, U.S.A.

Essien, B.A., Essien, J.B., Nwite, J.C., Eke, K.A., Anaele, U.M. and Ogbu J.U. 2009. Effect of organic mulch materials on maize performance and weed growth in the derived savanna of southeastern Nigeria. *Nigeria Agricultural Journal* **40**(1): 255-262.

Johnson, D.W. 1992. Nitrogen retention in forest soils. *Journal of Environmental Quality* **21**: 1-12.

Kumar, S.D. and Lal, B.R. 2012. Effect of mulching on crop production under rainfed condition: A review. *International Journal of Research in Chemistry and Environment* **2**: 8-20.

Lakshmanan, R., Punnoose, K.I., Mathew, M., Mani, J. and Pothen, J. 1995. Polythene mulching in rubber seedling nursery. *Indian Journal of Natural Rubber Research* **8**(1): 13-20.

Lal, R. 1995. Tillage and mulching effects on maize yield for seventeen consecutive seasons on a tropical alfisol. *Journal of Sustainable Agriculture* **5**: 79-93.

Li, F., Song, Q., Jjemba, P. and Shy, Y. 2004. Dynamics of soil microbial biomass C and soil fertility in crop land mulched with plastic film in a semi-arid agro-ecosystem. *Soil Biology and Biochemistry* **36**: 1893-1902.

Maurya, P.R. and Lal, R.1981. Effects of different mulch materials on soil properties and on the root growth and yield of maize (*Zea mays*) and cowpea (*Vigna unguiculata*). *Field Crops Research* **4**: 33-45.

Miles, C., Wallace, R., Wszelaki, A., Martin, J., Cowan, J., Walters, T. and Inglis, D. 2012. Durability of potentially biodegradable alternatives to plastic mulch in three tomato production regions. *HortScience* **47**(9): 1270-1277.

Parmar, H.N., Polara, N.D. and Viradiya, R.R. 2013. Effect of mulching material on growth, yield and quality of watermelon (*Citrullus lanatus* Thunb). *Journal of Agricultural Research* **1**: 30-37.

Ramakrishna, A., Hoang, M.T. Suhas, P.W. and Tranh, D.L. 2006. Effect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam. *Field Crops Research* **95**: 115-125.

Schonbeck, M.W. and Evanylo, G.K. 1998. Effects of mulches on soil properties and tomato production I. Soil temperature, soil moisture and marketable yield. *Journal of Sustainable Agriculture* **13**(1): 51-81.

Singh, A.K. and Kamal, S. 2012. Effect of black plastic mulch on soil temperature and tomato yield in mid hills of Garhwal Himalayas. *Journal of Horticulture and Forestry* **4**(4): 78-80.

Solamalai, A., Ramesh, P.T. and Ravisankar, R. 2001. Utilization of raw coir pith in crop production: A review. *Indian Journal of Agronomy* **22**(2): 285-290.

Wardle, D.A. 1992. A comparative assessment of factors which influence microbial biomass carbon and nitrogen levels in soil. *Biological Reveiws* **67**: 321-358.