International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 18, No. 5, p. 69-76, 2021

INNSPUB

RESEARCH PAPER OPEN ACCESS

Efficacy of different composts extracts for the management of *Rhizoctonia solani* of potato under the laboratory conditions

Iram Bilqees, Muhammad Usman Ghazanfar*, M. Imran Hamid

Department of Plant Pathology, College of Agriculture, University of Sargodha, Sargodha, 40100, Pakistan

Key words: Potato, Management, Sugarcane waste, Poultry waste compost.

http://dx.doi.org/10.12692/ijb/18.5.69-76 Article published on May 16, 2021

Abstract

Rhizoctonia solani is one of the destructive pathogens of the potato crop responsible for stem canker characteristics, root rot, and black sclerotia on tubers, which reduced the market quality of potato. Several management strategies have been adopted to overcome losses inflicted by this pathogen, such as chemical control, organic amendments, cultural practices and the development of resistant varieties. However, none of these management strategies work well to overcome this pathogen. Chemicals are causing severe environmental and health issues. Organic amendments and cultural practices are eco-friendly, however; the pathogen produces resistant sclerotia and can survive for a long time. The development of resistant varieties is laborious and the novel strains of the pathogen rapidly break the resistance of varieties. The present work was carried to evaluate compost extracts as an alternative to chemicals against *R. solani*. Two commercial composts, sugarcane waste compost and poultry waste were used at three concentrations 30%, 40%, and 50% respectively under laboratory conditions through food poisoning technique. Results revealed that poultry waste compost extract with 50% concentration was found best to manage *R. solani* as compared with other treatments. Based on our findings it is concluded that compost extract can be augmented for the sustainable management of *R. solani* for organic production of potato.

* **Corresponding Author:** Muhammad Usman Ghazanfar ✉ usman.ghazanfar@uos.edu.pk

Introduction

Potato (*Solanum tuberosum* L.) is the most popular and consumed vegetable worldwide and in Pakistan. Its origin is Bolivia, but now, it has cultivated over 100 countries (Haverkort *et al.,* 2009). China is the leading country in the production of potato with 99.2 million tons. In comparison, Pakistan is in 19^{th} position for potato production of 4.6 million tons cultivated on an area of 160 thousand hectares (FAO, 2019). Potato plays a vital role in fulfilling the hunger needs of the world. Almost $1/3^{rd}$ of the world population relies on potato (FAO, 2008). It has great nutritional and medicinal values due to a good source of carbohydrates, starch, proteins, vitamins B and C, antioxidants and anticancer agents (Akande *et al.*, 2000; Low *et al.*, 2007). In Pakistan, it is cultivated in three seasons; summer, autumn, and winter. It requires 25-27˚C temperature and well-drained sandy loam soil for germination (Hijmans and Spooner 2001). Certain factors can affect potato production in Pakistan, including low-quality seeds, insect attacks, diseases, and post-harvest losses (Shehroz *et al.*, 2018). Among these aspects, diseases caused by fungi, bacteria, nematode, and viruses pathogens resulted in considerable losses to potato crops (Majeed *et al.*, 2017). The fungal pathogen, *R. solani* Kuhn is the devastating one that causes root rot, black scurf, and stem canker diseases among fungal pathogens. This fungus is the soil inhabitant and belongs to the phylum *Basidiomycota* and class *Adelomycetes*. Initially, this fungus was reported on potato by Julius Kuhn in 1858 (Banville *et al.*, 1996). About 30-40% of losses were caused by *R. solani* in the world and continuously threatening potato production. Above ground and mostly the underground plant parts including roots and tubers are susceptible to this pathogen (Banville *et al.*, 1996). Moreover, it survives in the soil as black sclerotia and in certain environmental conditions, the fungi reproduce sexually and are called *Thanatephorus cucumeris* (Lehtonen *et al.*, 2008). This fungus is infecting a wide variety of host range over 200 plant species, including cereals, cotton, fruits, and vegetables. Symptoms include yellowing and wilting of plant, brown lesions on collar region, canker-like growth on stem and roots ultimately roots turned brown and rot. The most apparent symptom of *R. solani* is a production of black sclerotia on potato tubers (Tsror, 2010). Many strategies are used to minimize disease losses due to this pathogen. These practices include fungicides, resistant varieties, biological control, and organic amendments (Ahmed *et al.*, 2009). Among fungicide treatment Topsin M (Idrrees *et al.*, 2009) and Monterey (Rauf *et al.,* 2007) were best against *R. solani* on potato. Fungicides Tebuconazole + Trifloxystrobin, Captan + Hexaconazole, and Carbendazim were found best for *in-vitro* inhibition of *R. solani* (Rajendraprasad *et al.*, 2017). But these practices are not environmentally friendly.

There is a need to develop eco-friendly approaches to overcome this problem. Therefore, the present study was designed to determine the management of *R. solani* through compost extracts. Compost is the heterogeneous, decomposed organic material that nourishes the plant through nutrient availability and beneficial microbes. Compost has a remarkable ability to overcome plant diseases through antagonism, hyperparasitism, competition for nutrients and space (Nelson and Hoitnik, 1982; Voland and Epstain, 1994). A study also suggested poultry manure compost as the best treatment against *Phytophthora* spp. they are causing root rot (Aryantha *et al.*, 2000). Compost tea or extract is a diverse microbial community that protects from plant diseases (Islam *et al.*, 2013). This study's *in-vitro* efficacy of compost extracts against *R. solani* has been evaluated as an alternative to chemical control.

Materials and methods

This study was performed in the Department of Plant Pathology, College of Agriculture, University of Sargodha, Sargodha Pakistan.

Collection

Diseased samples were collected from potato fields, were kept in zipper bags and refrigerated at 4˚C. Samples were washed under tap water, disinfected through 2% sodium hypochlorite (NaOCl) and dried with blotter paper (Goswami *et al.*, 2010).

Isolation and Purification

Potato dextrose agar (PDA) media was found best for the growth of *R. solani*. PDA was prepared, autoclaved at 121˚C, and poured into Petri plates for solidification. After solidifying PDA, the diseased portion from the infected tuber was removed with the help of a scalpel and placed into PDA amended Petri plates and wrapped with paraffin. Petri plates were kept in an incubator at 25˚C for 3 days (Das *et al.*, 2014). *R. solani* culture was further purified on PDA and incubated at 25˚C.

Pathogenicity

The pathogenicity test of *R. solani,* was performed on potato tubers and slices. Healthy potato tubers and slices were washed under tap water and disinfected with 2% NaOCl and dried. Plugs from *R. solani* culture were placed on potato tubers and pieces with the help of inoculating needle (Zhang *et al.*, 2014). Potato tubers were placed in a plastic box, and potato slices were placed in Petri plates and kept in an incubator at 25˚C for 3 days.

In-vitro efficacy of compost extracts on R. solani

Two types of composts, sugar waste compost and poultry waste compost (Table 1) with three concentrations 30%, 40% and 50% were used by food poison technique to suppress *R. solani*. The composition of both composts is described below.

For extract preparation, 20g of each compost was ground through pestle and mortar and dissolved in 50ml distilled water to make compost water extract. Extracts were centrifuged at 8000rpm for 10 minutes and filtered through a muslin cloth (Sabet *et al.*, 2013). Filtered extract of each compost was used to make stock solutions of 30, 40, and 50%.

30% Stock solution:
30ml compost extract + 70ml water
40% Stock solution:
40ml compost extract + 60ml water
50% Stock solution:
50ml compost extract + 50ml water

PDA was prepared and autoclaved at 121˚C. The 30% formulations of both composts were prepared by adding 70ml PDA into 30ml of stock solution. The same procedure was adopted for 40% and 50% concentrations. PDA amended with each compost extract concentration was poured into Petri plates. When PDA was solidified, mycelial plug from the fresh culture of *R. solani* was taken and placed on PDA amended Petri plates, wrapped, and incubated at 25˚C. This experiment was performed through a complete randomized design (CRD) with three replications and four treatments, including control. According to the given formula, data of growth inhibition % (GIP) was taken after 3, 5 and 7 days of incubation (Jaiswal *et al.,* 2014). Data of GIP was analyzed through analysis of variance.

(GIP %) = [(C-T)/C] × 100

Results

Isolation and purification

After incubation, whitish growth of fungi was observed, which later turned brown. Barrel-shaped spores were found in cluster form, and hyphae were septate and right-angled (Fig. 1A & B). White cottony growth was obtained after the purification of culture.

Table 1. Physiochemical properties of composts.

Features	Unit	Poultry waste compost	Sugar waste compost
Commercial name	-	Suraj	Kissan super
pH	-	8.2	5.1
Carbon	%	25	20
Nitrogen	%	1.15	0.92
C/N	%	19	17
Phosphorus $_5$	%	0.21	0.42
Potassium	%	0.10	0.92
Silicon	%	0.001	0.05
Color	-	Gray	Dark brown

Data for pathogenicity was recorded after 3 days of incubation. Results showed sunken brown lesions on potato tubers and slices, which ultimately confirmed the pathogenicity of *R. solani* on potato (Fig. 2A & B).

In-vitro suppression of *R. solani* through compost extracts

Both compost extracts inhibited the mycelial inhibition of *R. solani*. Still, poultry waste compost proved to be most effective. Maximum growth inhibition 79% was recorded in poultry waste compost extract at 50% concentration (Fig. 3A) while 40% and 30% showed GIP of 55% and 35%, respectively, as compared to control with 0% GIP. The second treatment, sugar waste compost extract, showed inhibition of 75% at 50% concentration and 45% and 26% inhibition at40% and 30% respectively, with 0% inhibition of control (Fig. 3B).

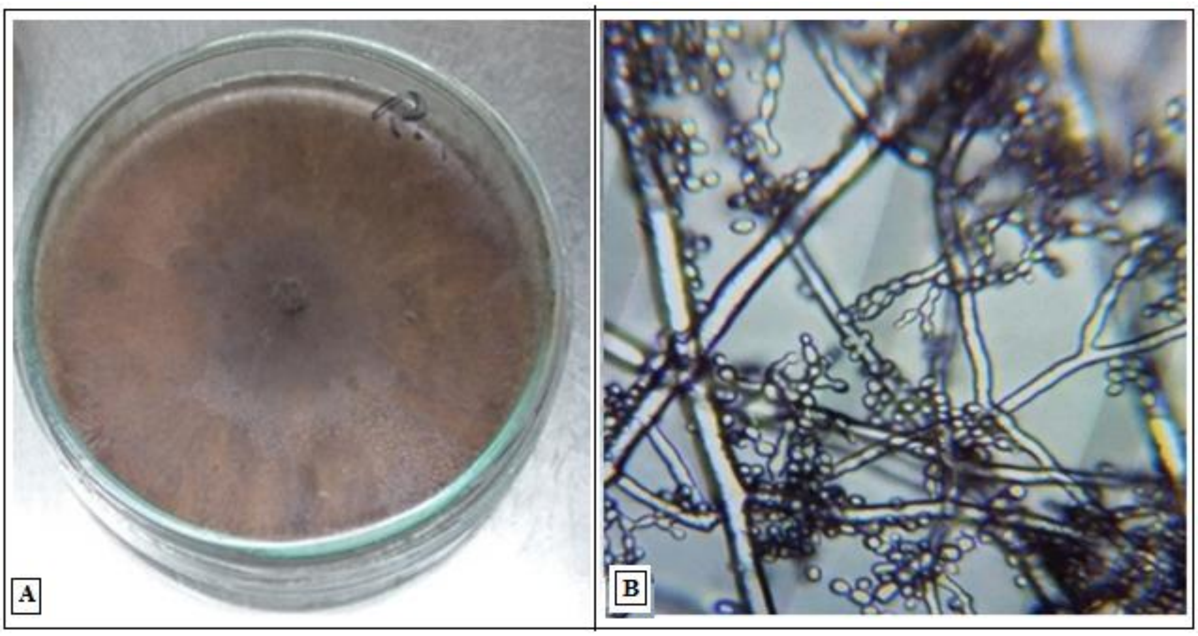

Fig. 1. *R. solani* growth on PDA (A) and a microscopic view of *R. solani* hyphae and spores (B).

Discussion

The present results showed that tested compost extracts inhibited *R. solani* 0-79% mycelial growth on PDA. These results agreed with previous findings that compost extracts prepared from animal manures were effective against soil-borne fungi (Eladand Shtienberg, 1994; Zhang *et al.*, 1998). Previous studies revealed that compost is an effective organic amendment to suppress soil-borne fungi. Poultry manure compost has significantly suppressed the *Pythium aphanidermatum* because poultry manure compost increased 68.4% of beneficial bacteria (Nelson and Boehm, 2002). Animal manure compost at 25% concentration suppresses incidence of *Phytophthora cinnamomi* on *Lupinus albus* seedlings and increased organic matter content and microbial population of actinomycetes, fungi and bacteria in soil (Aryantha *et al.*, 2000). Ingham (2002) reported that compost extracts or compost teas are best to minimize disease losses caused by phytopathogenic fungi. Elad and Shtienberg (1994) reported that compost extracts prepared from animal manures minimized disease incidence of leaf grey mold caused by *Botrytis cinerea* up to 56%. Another study showed that foliar application of compost extracts at 10% concentration reduced mycelial growth of *Fusarium oxysporum*, *R. solani*, *Botrytis cinerea*, *Alternaria solani* and *Septoria lycopersici* on plants (Tratch and Bettiol, 1997). Foliar spray of compost water extracts suppresses the bacterial population of *Pseudomonas syringae* in the *Arabidopsis thaliana* plant (Zhang *et al.*, 1998). Present results are related to the study of Znaidi *et al.* (2002), who reported that *in-vitro* and *in-vivo* experiments of compost extracts showed 50% inhibition of *Phytophthora* spp. and *F. solani* on potato tubers. Nelson and Boehm, (2002) showed that compost extract prepared from chicken manure and cow manure at a 50:50 ratio reduced root rot disease caused by *Pythium* spp. Another *in-vitro* finding of Said *et al.* (2017) elaborated that 40% compost (chicken manure + vine shoot) extract highly inhibited 97% mycelial growth of *F. oxysporum* f.sp. *albedinis* responsible for *Fusarium* wilt of a date palm. Likewise, Pane *et al.*, (2020) concluded that potato leaf extracts have antifungal properties and suppressed *R. solani* both *in vitro* and *in vivo*.

Fig. 2. Sunken brown lesions due to *R. solani* (A) and the brown concentric ring of sunken lesions (B).

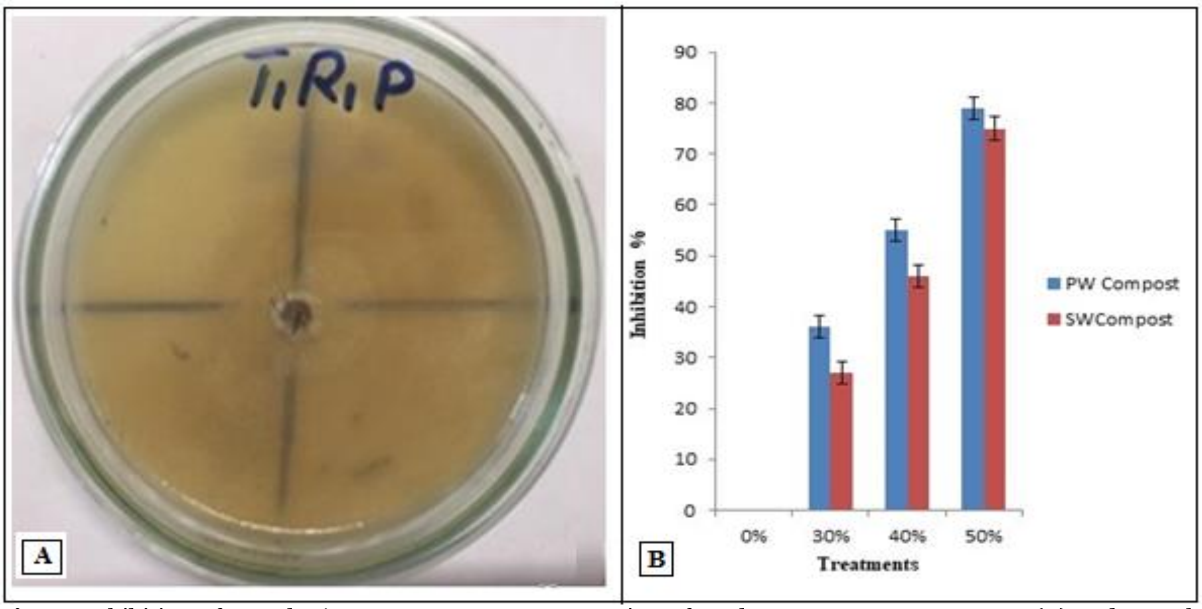

Fig. 3. Inhibition of *R. solani* on PDA at 50% concentration of poultry waste compost extract (A) and growth inhibition % (GIP) of *R. solani* through poultry waste compost extract and sugar waste compost extract along with concentrations of 30%, 40% and 50% (B).

Conclusion

In conclusion, both compost extracts were beneficial at their perspective concentrations. Still, poultry waste compost extract at 50% concentration was most effective for the *in-vitro* suppression of *R. solani*. This could be used as a substitute for fungicides.

Acknowledgement

The authors are highly Acknowledge to the Department of Plant Pathology, College of Agriculture, University of Sargodha, Sargodha Pakistan for providing research space.

Author's contribution

Iram Bilqees experimented and wrote the manuscript. Muhammad Usman Ghazanfar designed and supervised the experiment.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

There is no finding from any agency or department for this project.

References

Ahmed ZM, Dawar S, Tariq M. 2009. Fungicidal potential of some local tree seeds for controlling root rot disease. Pakistan Journal of Botany **41,** 1439-1444.

Akande A, van Wyk CD, Osagie JE. 2000. Importance of exercise and nutrition in the prevention of illness and the enhancement of health. Education **120(4),** 758-772.

Aryantha IP, Cross R, Guest DI. 2000. Suppression of Phytophthora cinnamomi in potting mixes amended with uncomposted and composted animal manures. Phytopathology **90(7),** 775-782. https://doi.org/10.1094/PHYTO.2000.90.7.775

Banville GJ, Carling DE, Otrysko BE. 1996. Rhizoctonia disease on potato, In: *Rhizoctonia species*: *Taxonomy, molecular biology, ecology, pathology and disease control.* Springer, Dordrecht, p 321-330.

Das S, Shah FA, Butler RC, Falloon RE, Stewart A, Raikar S, Pitman AR. 2014. Genetic variability and pathogenicity of Rhizoctonia solani associated with black scurf of potato in New Zealand. Plant Pathology **63,** 651-666. https://doi.org/10.1111/ppa.12139.

Elad Y, Shtienberg D. 1994. Effect of compost water extracts on grey mold mould (Botryitis cinerea). Crop protection **13(2),** 109-114.

FAO. 2008. New light on a hidden treasure. An End-of-Year Review (International Year of the Potato-2008). Food and Agriculture Organization of the United Nations, Rome, 148.

FAO. Statistical programmer of work 2019.

Goswami BK, Bhuiyan KA, Mian IH. 2010. Morphological and pathogenic variations in the isolates of Rhizoctonia solani in Bangladesh. Bangladesh Journal of Agriculture Research **35(3),** 375-380. https://doi.org/10.3329/bjar.v35i3.6443.

Haverkort AJ, Struik PC, Visser RGF. 2009. Applied biotechnology to combat late blight in potato caused by Phytophthora infestans. Potato Research, **52(3),** 249-264. https://doi.org/10.1007/s11540-009-9136-3.

Hijmans RJ, Spooner DM. 2001. Geographic distribution of wild potato species. American Journal of Botany **88(11),** 2101-2112.

Idrees M, Ali S, Ayub M, Niaz M, Ali Q. 2009. Impact of seed dressing on soil borne potato tubers diseases. Pakistan Journal of Phytopathology **21(1),** 89-91.

Ingham ER. 2002. Compost tea brewing manual. 3rd Edn., p 78.

Islam MR, Mondal C, Hossain I, Meah MB. 2013. Compost tea and poultry litter extract: alternative organic management approaches for stem canker of potato caused by Rhizoctonia solani. Journal of Agriculture Science, **5(10),** 261-272.

https://doi.org/10.5539/jas.v5n10p261.

Jaiswal AK, Elad Y, Graber E. 2014. Non-monotonic influence of biochar dose on bean seedling growth and susceptibility to Rhizoctonia solani: the "shifted R_{max}-Effect". Plant and Soil **69,** 110-118.

Lehtonen MJ, Ahvenniemi P, Wilson PS, German-Kinnari M, Valkonnen JPT. 2008. Biological diversity of Rhizoctonia solani (AG-3) in a northern potato-cultivation environment in Finland. Plant Pathology **57**, 141-151.

Low JW, Arimond M, Osman N, Cunguara B, Zano F, Tschirley D. 2007. A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. The Journal of Nutrition **137(5),** 1320-1327.
https://doi.org/10.1093/jn/137.5.1320.

Majeed A, Muhammad Z, Ullah Z, Ullah R, Ahmad H. 2017. Late blight of potato (Phytophthora infestans) I: Fungicides application and associated challenges. Turkish Journal of Agriculture-Food Science and Technology **5(3),** 261-266.
https://doi.org/10.24925/turjaf.v5i3.261-266.1038.

Nelson EB, Boehm MJ. 2002. Microbial mechanics of composts-induced disease suppression. Biocycle **43(7),** 45-47.

Nelson EB, Hoitnik HAJ. 1982. Factors effecting suppression of Rhizoctonia solani in container media. Phytopathology **72(3),** 275-279.

Pane C, Caputo M, Francese G, Manganiello G, Scalzo R, Mennela G, Zaccardelli M. 2020. Managing Rhizoctonia damping-off of rocket (Eruca sativa) seedlings by drench application of bioactive potato leaf phytochemical leaf extracts. Biology, **9(270),** 1-17.
https://doi.org/10.3390/biology9090270.

Rajendraprasad M, Vidyasagar B, Devi GU, Rao SRK. 2017. In vitro evaluation of fungicides and biocontrol agents against Rhizoctonia solani in tomato. International Journal of Plant & Soil Science, **17(5),** 1-9.
https://doi.org/10.9734/IJPSS/2017/35307.

Rauf CA, Ashraf M, Ahmad I. 2007. Management of black scurf disease of potato. Pakistan Journal of Botany **39(4),** 1353-1357.

Sabet KK, Saber MM, El-Naggar MA, El-Mougy NS, El- Shahawy I. 2013. Using commercial compost as control measures against cucumber root-rot disease. Journal of Mycology **2013,** 1-13.
https://doi.org/10.1155/2013/324570.

Said EK, El-Hassan A, Abdellatif H, Jamal I, Saadia B, Fouad R, Ghizlane E, Rachid B. 2017. In vitro evaluation of compost extracts efficiency as biocontrol agent of date palm Fusarium wilt. African Journal of Microbiology Research **11(29),** 1155-1161.
https://doi.org/10.5897/AJMR2017.8567.
https://doi.org/10.5897/ajmr2017.8567.

Shehroz A, Hussain MM, Ramzan I, Ali MA. 2018. Evaluation of exotic potato germplasm for high yield and disease resistance under local conditions. The Journal of Animal & Plant Sciences **28(5),** 1413-1417.

Tratch R, Bettiol W. 1997. Effect of biofertilizer on mycelial growth and spores germination of plant pathogenic fungi. Pesquisa Agropecuaria Brasileira (Brazil) **32(11),** 1132-1139.

Tsror L. 2010. Biology, epidemiology and management of *Rhizoctonia solani* on Potato. Journal of Phytopathology **158,** 649-658.
https://doi.org/10.1111/j.1439-0434.2010.01671.x.

Voland RP, Epstein AH. 1994. Development of suppressiveness to diseases caused by Rhizoctonia solani in soils amended with composted and non composted manure. Plant Disease **78(5),** 461-466.

Zhang W, Han DY, Dick WA, Davis R, Hoitink HAJ. 1998. Compost and compost water extract-induced systemic acquired resistance in Cucumber and Arabidopsis. Phytopathology **88(5),** 450-455.

Zhang XY, Yu XX, Yu Z, Xue YF, Qi LP. 2014. A simple method based on laboratory inoculum and field inoculum for evaluating potato resistance to black scurf caused by Rhizoctonia solani. Breeding Science **64,** 156-163. https://doi.org/10.1270/jsbbs.64.156.

Znaidi A, Daami M, Khedar MB, Mahjoub M. 2002. Study and assessment of different organic mixtures and effect of organic compost teas on plant diseases. Working paper, Technical Center of Organic Agriculture. [Unpublished]. Archived at http://orgprints.org/00003079