POSSIBILITY OF THE NEW SOIL FUMIGATION TECHNIQUE WITH ETHANOL SOLUTION

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Introduction

Methyl bromide (CH_3Br) was a major fumigant used in Japan to control soil-borne diseases in crops such as cucumbers, gingers, tomatoes, melons, green peppers, etc. The use of CH_3Br as a soil fumigant was phased out in 2005, but no new chemical or non-chemical alternative has yet been commonly used as its substitute. Therefore, areas under cultivation of these crops are decreasing steadily year by year. For now, chloropicrin, 1,3-dichloropropene (1,3-D) and methyl isothiocyanate (MITC) and its generators (dazomet *etc.*) are seen as the best alternatives to CH_3Br. Economically feasible new soil fumigation techniques are desired eagerly by growers. Furthermore, recently production volumes of bioethanol increase substantially, so the effective utilization of crude ethanol (ca. 95 % v/v) such as the raw material and the by-product from distillation purification process is required. The purposes of our study were to develop the new fumigation technique with crude bioethanol, and to evaluate possibility of this technique by inhibiting germination effect of seeds of crop plants and weeds.

Materials and methods

Laboratory experiments were conducted to fill up cylindrical glass vessels (9 cm inside diameter and 6 cm depth) with air-dried soils (Hydric Hapludand soil at the NIAES, Tsukuba and Loamy Sand at Tateyama, Chiba), and to sow each 100 seeds of crop plants and weeds to depth of 1 cm from the soil surface. These seeds were wheat (N61, *Triticum aestivum* L.), lettuce (Great lakes 366, *Lactuca sativa*), rice (Koshihikari, *Oryza sativa* subsp. *japonica*), crabgrass (*Digitaria ciliaris* (Retz.) Koel), lambsquarters (*Chenopodium album*), annual bluegrass (*Poa annua* L.), ladysthumb (*Polygonum persicaria* L.), and so on. Given amounts of crude bioethanol and soil fumigants such as chloropicrin, 1,3-D and MITC were injected into soils 4 cm in depth with gas tight syringes, and top edges of glass vessels were covered with gas-barrier films immediately. These glass vessels were maintained at 25 ^{o}C for 7days in the incubator. After having removed covering films, these vessels were left in the incubator for 7 days while adding adequate amounts of water, and inhibiting germination effects by these chemicals were evaluated.

For sequential changes of physicochemical properties of soils by applying diluted ethanol as a soil fumigant, we focused on soil pH, oxidation-reduction potentials (ORP) and oxygen concentrations in soil or soil waters. Polypropylene containers (15.4 cm in height, 16.0 cm in width and length with an inner dimension, and ca.

3.94 L with an internal volume) were filled up with air-dried soils and then applied with diluted ethanol (to several % v/v). Then, soil pH and oxidation-reduction potential (ORP) were measured with multiple electrodes (Orion 3-Star Portable pH/ORP/Temperature Meter, Thermo Fisher Scientific, Inc.) and oxygen concentrations in soils or soil waters were measured with the Oxygen Sensor Spectrometer (USB4000-FL-450 Spectrofluorometer and FOXY-T1000-RTD, Ocean Optics, Inc.) consecutively every 30 minutes.

Results and discussion

Water contents of air-dried Hydric Hapludand soil and Loamy Sand were 26.4 and 4.4 %, respectively. With the dosage of 0.06 ml almost equivalent to usual dosage (ca. 30 g/m^2, and 20 cm in soil depth) of fumigants, enough inhibiting germination effects were provided. However, by applying crude bioethanol directly to into dry soils, enough effects were not provided to amount of 6 times of fumigants and the effects varied widely. These are attributed to lower diffusion rates of ethanol in soils than fumigants.

Diluted ethanol (to several % v/v) was applied to air-dried soils to get wet or submerged conditions. Then, vessels were covered with gas-barrier films immediately and maintained at 25 ^{o}C for 7days in the incubator. After having removed covering films, these vessels were left in the incubator for 7 days. Under these conditions, inhibiting germination effects more than equivalence with fumigants was provided. This prevention mechanism seems to depend on anaerobic soil disinfestation (ASD), not direct influence of the ethanol. The ethanol seems to act as an initiator to the reduction condition of soils and several phase reaction steps take place (Fig. 1). In addition, it is important to intercept oxygen gas by covering soil surface with a gas-barrier film to get good fumigation effect. These fumigation techniques with crude bioethanol are promising economically feasible.

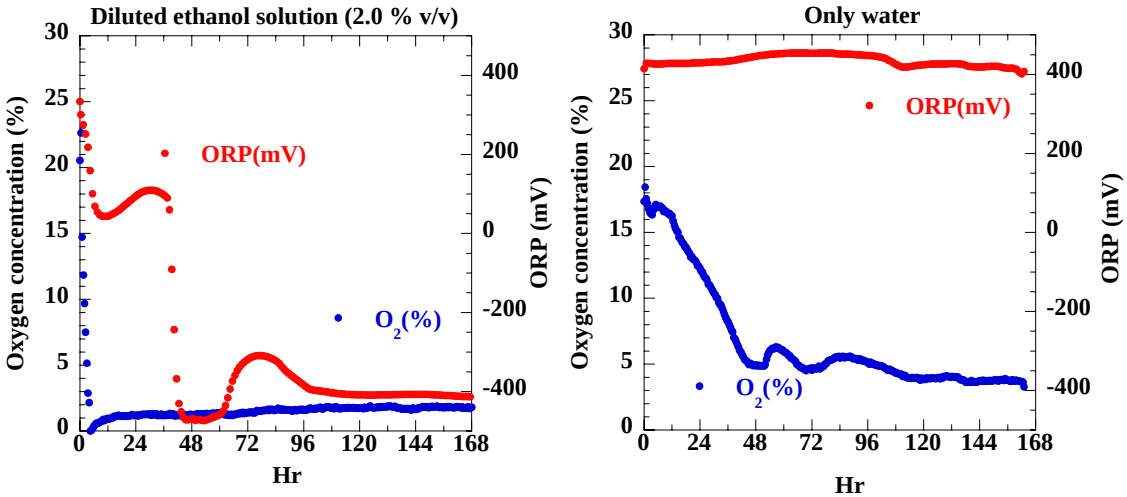

Fig. 1 Oxygen concentration and oxidation-reduction potential applied with diluted ethanol solution (2.0 % v/v) or only water into air-dried Hydric Hapludand soil