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The effect of yellow–brown and black soil on the germination of the peanut

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ABSTRACT

Yellow–brown soil, which is a type of soil most productive for peanuts (*Arachis hypogaea* L.), was compared with black soil which is typically not productive for peanuts. In this study, the effect of the two types of soil on the germination of peanuts was investigated. Pots filled with these two types of soil and different mixtures of them were used to test peanut germination. Both sterilized and unsterilized yellow–brown soil were compared to evaluate the effect of microorganisms on the germination. Twenty fungal strains and 19 bacterial strains isolated from yellow–brown soil were propagated to inoculate the black soil for germination testing. Yellow–brown soil, covered or mixed with black soil, was tested for its effect on germination. Microorganisms from the yellow–brown soil, separated into two parts by rinsing one part in water suspension and the other in rinsed soil sediment. Both parts were amended into the black soil for the germination test. The above-ground biomass of the peanut seedlings was weighed 20 days after sowing. Compared with the treatment of black soil only, the above-ground biomass of the peanut seedlings markedly improved when treated with yellow–brown soil covered with black soil. Sterilized or mixed treatment with yellow–brown soil resulted in a loss of improvement. Thirty-nine strains of microorganisms isolated from yellow–brown soil failed to promote peanut germination. Neither the rinsed yellow–brown soil amendments nor the rinsed soil suspension irrigation recovered the improvement of peanut germination in black soil. Black soil inhibited peanut germination. Peanut germination was rapid and uniform in black soil covered with 2 cm of yellow–brown soil. Yellow–brown soil steam sterilized or mixed with black soil makes the germination difficult. Inoculation with isolated microorganism formulations failed to promote the germination. Yellow–brown soil, including chemicals and microorganisms, is a system that benefits peanut germination.

1. Introduction

The peanut (*Arachis hypogaea* L.) is a staple crop in Hong'an county (30°56′-31°35′N, 114°23′-114°49′E), Hubei province, China. The production and quality of peanuts in that area are prominent. In 2012, the total output of peanuts was 7.72×10^4 tons, and the average output was 2.895×10^3 kg ha^{-1}, both of which ranked first in the province [12]. Yellow–brown soil could belong toTypical Pale Udalfs in USDA soil taxonomy systems and Luvisols or Eutric Planosols in FAO soil taxonomy systems. The bulk density is 1.39–1.62 $\times 10^3$ kg m^{-3}, and the pH is 5.5–6.7.

Peanut is an important oilseed crop that is rich in nutrients and be used in many other ways such as eaten raw, boiled or roasted [1]. Peanuts are a good source of niacin, folate, fiber, vitamin E, magnesium and phosphorus [6]. Peanuts contain antioxidants, phenolics and other phytochemicals that protect against cancer, coronary heart diseases, degenerative nerve disease, Alzheimer's disease, and viral/fungal infections [3,16,18,19].

The black soil region in Northeast China is an important region for cereal grain production in the country [20]. Maize and soybeans are the major crops in the arable fields in the region [5]. There are 4.825×10^6 ha of black soil in the Hei-long-jiang province, which occupy 75% of the total 5.956×10^6 ha of black soil in China, of which 3.606×10^6 ha are arable. In 2012, the total area of peanut planting was 1.924×10^3 ha in Harbin (44°04′-46°40′N, 125°42′-130°10′E), Hei-long-jiang province, China [12]. There is sporadic peanut crop planting in the hilly area but little in the black soil zone in the region.

However, the country's most important crop production area has been seriously affected by soil erosion [4]. Inoculation to legume crop plants with effective rhizobia strains provides an environmentally–friendly alternative to chemical fertilization, to increase productivity [13]. Aminopeptidases play an important role in the mobilization of storage proteins at the cotyledon during seed germination. It is often referred as an inducible component of defense against an herbivore attack. However the role of aminopeptidase in response to a pathogen attack in germinating seeds has remained to be unknown. AP1 activity was significantly induced in germinating seeds infected with *Fusarium oxysporum* f.sp. ciceri and *Aspergillus niger* var. niger. AP1 activity was significantly induced in germinating seeds infected with *Fusarium oxysporum* f.sp. ciceri and *Aspergillus niger* var. niger. These findings could be helpful to further dissect a defensive role of aminopeptidases in seed germination which is an important event in plant's life [11].

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Table 1
Pot experiments of peanut sowing in black soil and black soil covered with yellow–brown soil in Harbin, China.

Treatment	First repeat				Second repeat			
	A	B	C	D	E	F	G	H
Black soil	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds
Black soil covered by yellow-brown soil	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds	2 seeds

Stimulation with a magnetized arc plasma (MAP) can improve seed germination and seedling growth [17]. Kumar etal. [9] reported rhizobia promote seed germination, growth promotion and Fusarium wilt suppression of fenugreek (*Trigonella foenum-graecum* L.).

Germination is a complex process during which the seed must quickly recover physically from maturation drying, resume a sustained intensity of metabolism, complete essential cellular events to allow for the embryo to emerge, and prepare for subsequent seedling growth [14]. Germination provides non-conventional legume flours with higher nutritional quality and better physicochemical properties than raw flours [2]. While there is much information on the changes in gene expression during germination, no key event(s)has been identified that results in its completion. Hence, there are limited opportunities at present for improving germination through genetic manipulation [14].

The peanut soil in Hong'an county is mostly gneiss developed from yellow–brown, which is sandy and shallow top-soil, with incompleteness of profile development, limited capacity of water, fertilizer, gas and heat, and lack of soil nutrients. Some of the chemical characters of the yellow–brown soil in Hong'an county are listed as follows: pH 4.8–6.3, average 5.6, total organic matter content 10–20 g kg^{-1}, available N 32.6–75.9 mg kg^{-1}, available K 35.5–102.8 mg kg^{-1}, and available P2.93–13.52 mg kg^{-1} [15]. The black soil planting soybean for decades in Harbin belongs to udicisohumisols suborder of isohumisols order, some of the chemical properties are listed as follows: pH 5.7–7.2, total organic matter content 14.45–34.69 g kg^{-1}, total N 1.16–3.76 g kg^{-1}, available N 112.7–258.2 mg kg^{-1}, available K 40.19–168.92 mg kg^{-1}, and available P22.8–136.5 mg kg^{-1} [21].

Soil factors, climatic factors, or both determine the difference between peanut planting in Hong'an county and Harbin. We intend to reveal the reasons for the differences between planting peanuts in black soil versus yellow–brown soil. Climatic factors cannot easily be controlled; however, chemical or microbial factor could be changed through fertilization or inoculation. Could yield and peanut quality be improved in the black soil areas of northeast China? If some microbial factors were discovered to play pivotal roles in improving yield and peanut quality, then new fertilizer or microbial inoculants could be developed as biological inoculation products for economic considerations. Trials of seed germination after peanut sowing may be elementary works. This work aims to investigate the effects of inoculation with yellow–brown soil on the seed germination of peanuts in black soil.

2. Materials and methods

2.1. Soil preparation

Yellow–brown soil for the pot experiment was collected from the surface (0–20 cm) of a peanut production field in the hilly area of Hong'an county, Hubei province, China. Black soil was collected from a soybean production field in Harbin, Hei-long-jiang province, China. The two types of soil were taken to a greenhouse after air-drying and passed through a 2-mm sieve on three different dates before the trials. The soil was steam sterilized at 121 °s for 60 min if needed.

2.2. Peanut sowing

Two peanut seeds were sowed 2 cm deep from the soil surface for each pot (6-cm diameter and 21-cm height, transparent), which was filled with a 20-cm height of soil, according to Tables 1–6 and Fig. 1. The experiment had a completely randomized block design with four replications that had the following treatments. Four copies of each treatment were repeated twice for each trial. The pots were incubated at room temperature (20–30 °0) and irrigated if necessary. The date of the seedlings' emergence and the date that root reached the bottom were noted, and the number of seedlings were counted. The seed germination rate for each treatment was calculated. T = the duration of the root growth that was taken from the sowing date to the date that the root reached the bottom of the pot; D = the distance of the seeds to the bottom. The root growth velocity = D / T. The germinated pots were counted 9 days after sowing, and the germination rate was then calculated. The peanut seedlings were cut and weighed 20 days after sowing.

2.3. Microorganism isolation and inoculation

Formulations of Yeast–Mannose–Agar (YMA): 0.02 g of Na_3MoO_4,0.02 g of H_3BO_3, 0.05 g of $CaCl_2$, 0.1 g of NaCl, 0.5 g of K_2HPO_4, 0.2 g of $MgSO_4 \cdot f_2O$, 1.0 g of yeast extract, 10.0 g of mannose, and 1000 ml of H_2O. Formulations of potato–dextrose–agar (PDA): 34.0 g of PDA powder, 6.0 g of agar, and 1000 ml of H_2O.

YMA and PDA culture media were used to isolate bacteria and fungi from the yellow–brown soil. Ten bacteria strains (B1,B2,2,cB10) were isolated by the conventional serial dilute and spread plate method [7], and another 10 bacteria strains (B11, B12,12, B20) were isolated from tissues of peanut seedlings sowing in the pot filled with yellow–brown soil. Fourteen fungi strains were isolated from yellow–brown soil by the conventional serial dilute and pour plate method [7], and five fungal strains were isolated from tissues of peanut seedlings mentioned above.

The 20 isolated strains of bacteria were propagated in the liquid culture medium for two days, and the bacteria suspension was inoculated directly into the soil (25-cm pot^{-1}).The 19 isolated strains of fungi were propagated on solid PDA plates for seven days, and the fungi biomass was collected by a sterilized spoon to inoculate the soil.

2.4. Soil rinse method

Yellow–brown soil was filled in the pot at a height of 3 cm, input tap water was added at a height of 10 cm, and the pot was shaken several times and left to rest. The upper suspension was transported to a new pot as the rinsed suspension. The down sediments were rinsed 10 times and used as rinsed sediments.

Table 2
Pot experiments for peanut germination in black soil covered by yellow–brown soil in Harbin, China.

Treatment	Germination rate (%)	Germination (d)	Root growth velocity (cm day^{-1})
Black soil	13.8 b	14.5 a	0.87 b
Black soil covered by yellow-brown soil	100.0 a	9.5 b	1.15 a

The values denoted by different letters within the same column represent a significant difference at 0.05 levels, and the user of a harmonic means a sample size = 8, which are the same as below.