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**Research Article**

# Effects of Zeolite on Seed Quality of Organic Upland Rice

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**Abstract:** The production of high quality seeds is an important strategy for organic seed producers. In particular, organic farming is a production system which avoids the use of synthetic fertilizers, insecticides and plant growth regulators. Alternative management organic farming system is reducing nutrient loss and improving soil quality. Zeolite is organic matter and alternative for organic upland rice production. Our objective was to determine the effects of zeolite on seed quality of organic upland rice varieties: Dokkam and Nangchuan. The study involved using Randomized Complete Block design (RCB) with four replications and four treatments: 1) Chemicals method by using fertilizer (15N-15P-15K) rated 4.80 kg/ha for control (T1) 2) Cattle manure rated 160 kg/ha (T2) 3) Zeolite rated 16 kg/ha (T3) 4) Zeolite rated 32 kg/ha (T4). The fertilizer was applied at the rate of 160 kg/ha of cow manure (T1 to T4) and were applied at the rated of 16 and 32 kg/ha of zeolite (T3 and T4), respectively, (mixing into the soil before growing). The experiment was done at the experimental plots of King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Thailand during July to November, 2012. The results showed that both varieties of organic upland rice seed quality, all four treatments had high quality, which were not significantly different among the treatments. The 1,000-seed weight ranged from of 22.30 to 25.24 mg, standard germination of 91.50 to9 5. 50%, soil emergence of 90.00 to 94.00%, speed of germination index of 6.79 to 11.30, seedling dry weight of 4.38 to 5.88 mg/seeding, conductivity of 5.49 to 9.07 µmo/cm/gm and age acceleration of 92.00 to 99.00%. These results confirm that a zeolite could replace the application of chemical fertilizers which could be used to produce agricultural products to satisfy the needs of the consumers who want to consume safe food, besides minimizing pollution of agricultural environment and economic costs.

**Keywords:** Organic farming, organic upland rice, seed quality, zeolite

## INTRODUCTION

Rice is consumed by about 3 billion people and is the most common staple food of a large number of people on earth. In fact, it feeds more people than any other crop (Maclean *et al*., 2002). Upland rice is cultivated on nearly 20 million hectares in different countries of the world. It has a growing area of about 60% in Asia, 30% in Latin America and 10% in Africa. More than 50% of Asian upland rice is grown in south Asia (Pande *et al*., 1994). In Thailand, most upland rice is grown in the north and in the south, where it represents about 10% of total rice area. It has been grown almost exclusively by small households for food security. The southern part of Thailand is lowland and has less area than other regions and cannot produce enough rice for domestic consumption. Upland rice is planted as an alternative crop of farmers for household consumption or for sale in local market. However, one of the major problems of organic upland rice production in southern Thailand is low seed quality. Thus, production of high quality seeds is an important strategy for seed producers. In particular, organic farming is a production system which avoids the use of synthetic fertilizers, insecticides and plant growth regulators. The use of high quality seed can increase yields by 5.00 to 20.00% (Nokkoul and Wichitparp, 2013). Increased productivity under organic systems can reduce risk. It also makes it possible to calculate the growth rate accurately. The seedlings are strong with consistent and quick growth rates (Santipracha, 1997).

The use of zeolite is an alternative in the organic farming system because zeolite is made from nature and can be used instead of chemical fertilizers as plant growth regulators and can be used for disease and pest prevention and elimination. Zeolite produced from coal ash is a beneficial soil amendment because it enhances the absorption and retention of plant nutrients and water and supplemented micronutrients (Burriesci *et al*., 1984). It is microporous, crystalline aluminosilicates of alkali and alkaline materials that have a high internal surface area (Silberbush *et al*., 1993). It's having prompted slow release of fertilizers and other materials (Artiola, 1991). The chemical composition of the

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natural zeolites contained silicon 55.80%, sodium 3.90%, potassium 2.35%, calcium ions 5.75% and manganese 0.70% (Curkovic *et al*., 1997). Zeolite is organic matter and an alternative for organic upland rice production. Our objective was to determine the effects of zeolite on seed quality of two organic upland rice varieties: Dokkam and Nangchuan.

## MATERIALS AND METHODS

Two varieties of organic upland rice: Dokkam and Nangchuan, were grown in the field at King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Chumphon Province, Thailand in 2012 growing season. It is located at the southern of Thailand situated at Latitude 10º 00' 30.05" N Longitude 99º 25' 45" E Altitude 17.84 m above the sea level. The study involved using Randomized Complete Block design (RCB) with four replications and four treatments:

- Chemicals method by using fertilizer (15N-15P-15K) rated 4.80 kg/ha for control
- Cattle manure rated 160 kg/ha (T2)
- Zeolite rated 16 kg/ha (T3)
- Zeolite rated 32 kg/ha (T4)

The land was ploughed and disc harrowed and leveled before sowing the seeds. The fertilizer was applied at the rate of 160 kg/ha of cow manure (T1 to T4) and were applied at the rated of 16 and 32 kg/ha of zeolite (T3 and T4), respectively, (mixing into the soil before growing). Seeds of two upland rice varieties were sown per hole with spacing of 30 cm within rows and 30 cm between rows. The plants were thinned to three plants per hole after 14 days of seedling emergence. The total area of each plot was 10 $m^2$. Weeds were eliminated by using hoes twice at the age of 20 and 40 days after the seeds germinated. Harvesting was done when all the seeds reached maturity. After threshing, the seeds were sun-dried, sieved and weighed after the measurement of the moisture content. The good seeds were tested for their quality; seed size, 1,000 seed weight, standard germination, soil emergence, speed of germination index, seedling dry weight, root length and shoot length, conductivity and age acceleration (AOSA, 2002). Data of daily rainfall and daily minimum and maximum temperatures from July to November, 2012 were gathered from the Tha Ta Pao Agrometeorological Station, Muang Chumphon, Chumphon, Thailand. All data were analyzed using the analysis of variance and means separated by Duncan's Multiple Range Test (DMRT) at the 5% level of significance.

## RESULTS AND DISCUSSION

**Environmental data:** Effects of number of rainy days, rainfall, maximum and minimum temperatures on organic seed production of upland rice (Dokkam and Nangchuan varieties) grown during the rainy season. The results showed that the rainfall during the moths July to November, 2012 resulted in the rice plants in their vegetative, reproductive and grain formation

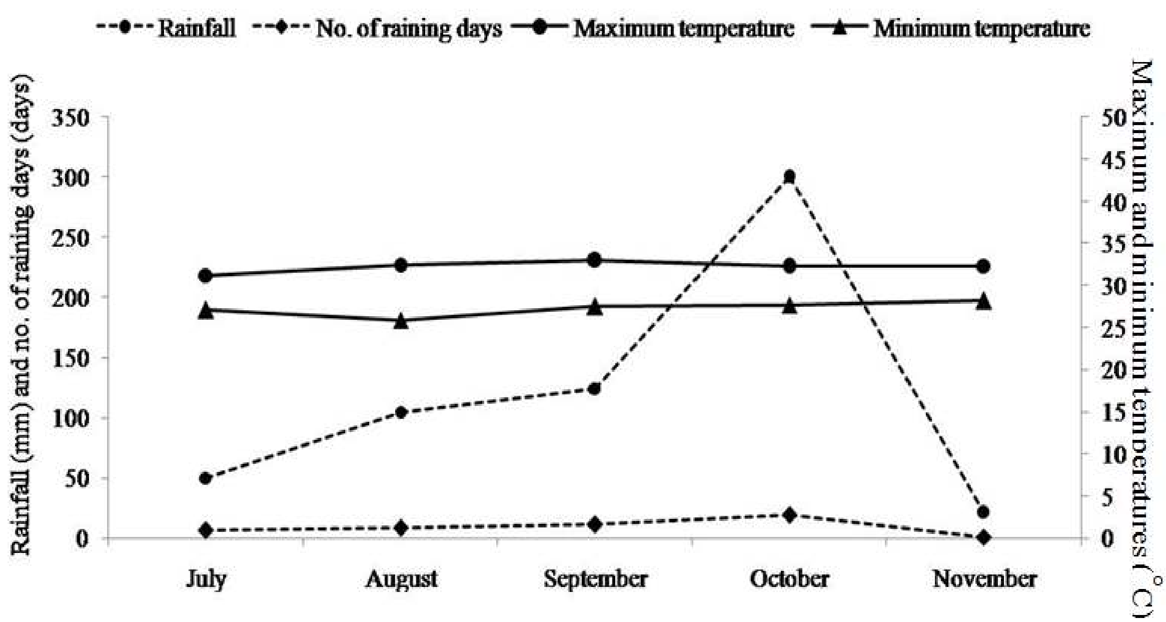


Fig. 1: Data of amount of monthly rainfall and number of rainy days, maximum and minimum temperatures in the experiment location, King Mongkut's Institute of Technology Ladkrabang, Chumphon Campus, Thailand during July to November, 2012

stages receiving an average monthly rainfall ranging from 50.00 to 300.00 mm. The two tested varieties got 50.00-104.60 mm of rainfall during their vegetative stage, over 14 raining days, 124.00 mm in their reproductive stage, over 11 raining days, 300.00 mm in their grain formation stage, over 19 raining days and after harvest the two tested varieties got 21.00 mm of rainfall, over 1 raining day (Fig. 1). The upland rice needs rainfall during the growing season of about 92 mm of rainfall/month (Pande *et al*., 1994). The average monthly temperatures ranged from 31.20 to 32.93°C. It is a temperature suitable for growing upland rice in the south of Thailand.

**Seed quality responses:** Both varieties of organic upland rice seed quality, all four treatments had high quality, which were not significantly different ($p\leq0.05$) among the treatments. The Dokkam and Nangchuan varieties having seed moisture content of 9.91 to 10.64 and 11.56 to 14.58%, respectively. 1,000-seed weight of 23.22 to 24.91 mg and 22.30 to 25.24 mg, respectively, (Fig. 2A). The seed production of Dokkam and Nangchuan varieties by the application of zeolite rated 16 kg/ha (T3) and (T4) zeolite rated 32 kg/ha (T4) were similar 1,000-seed weight as compared with chemical application (control) because in zeolite structures had silicon contents. Thus, the increase in seed weight would be the deposition of silicon element on the paleae and lemmas (Balastra *et al*., 1989). According to Mauad *et al*. (1996) silicon increased weight of rice seed.

Seed size (width, length and thickness) of the Dokkam variety from the production using T1, T2, T3 and T4 were not significantly different ($p\leq0.05$) among the methods, with the Dokkam seed having a width, length and thickness of 0.22 to 0.23, 0.98 to 1.01 and 0.18 to 0.19 cm, respectively. Seed size of the Nangchuan variety from the production using T1, T2 and T4 were not significantly different ($p\leq0.05$) among the treatments with the seed having a width of 0.29, 0.28 and 0.28 cm, respectively, but these were statistically different ($p\leq0.05$) from T3 which had a seed width of 0.26 cm. The length and thickness of seed of the Nangchuan variety from the production using T1, T2, T3 and T4 were not significantly different ($p\leq0.05$) among the treatments with the seed having a length and thickness of 0.90 to 0.92 and 0.19 to 0.20 cm, respectively (Fig. 2B). The two upland rice varieties from seed production using a zeolte (T4) gave maximum seed having a width as compared by any of the treatments. Similar were reported by Ahmad *et al*. (2013) silicon (0.50% silicon solution) produced maximum grain diameter of rice.

Both varieties of organic upland rice from the production all four treatments had seed germination and vigor which were not significantly different ($p\leq0.05$) among the treatments. The Dokkam variety from the production using T4 had high standard germination of 92.50% with the seed production using T1, T2, T3 had standard germination of 91.50, 92.00 and 91.50%, respectively, standard germination of Nangchuan variety from the production using T1 had high standard germination of 95.50% with the seed production using T2, T3 and T4 had standard germination of 94.50, 92.00 and 95.00%, respectively. The soil emergence of Dokkam and Nangchuan varieties from the production using T4 had high soil emergence of 92.50 and 94.00%, respectively, with the seeds production using T1, T2 and T3 of Dokkam variety had soil emergence of 90.00, 91.50 and 90.50%, respectively, the Nangchuan variety from the production using T1, T2 and T3 had soil emergence of 90.50, 91.50 and 91.00%, respectively. The Dokkam variety from the production using T2 had high speed of germination index and seedling dry weight of 6.79 and 4.84 mg/seeding, respectively, with the seed production using T1, T3 and T4 had speed of germination index and seedling dry weight of 8.31, 7.55, 8.42 and 4.45, 4.57 and 4.38 mg/seeding, respectively, the Nangchuan variety from the production using T4 had high speed of germination index of 8.80 with the seeds production using T1, T2

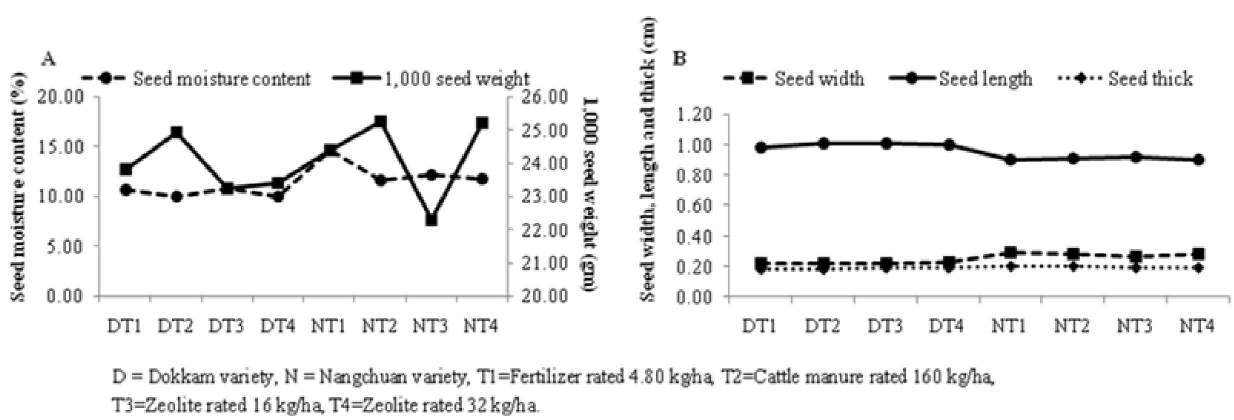


Fig. 2: Seed moisture content and 1,000 seed weight (A) and seed size (B) of Dokkam and Nangchuan upland rice varieties

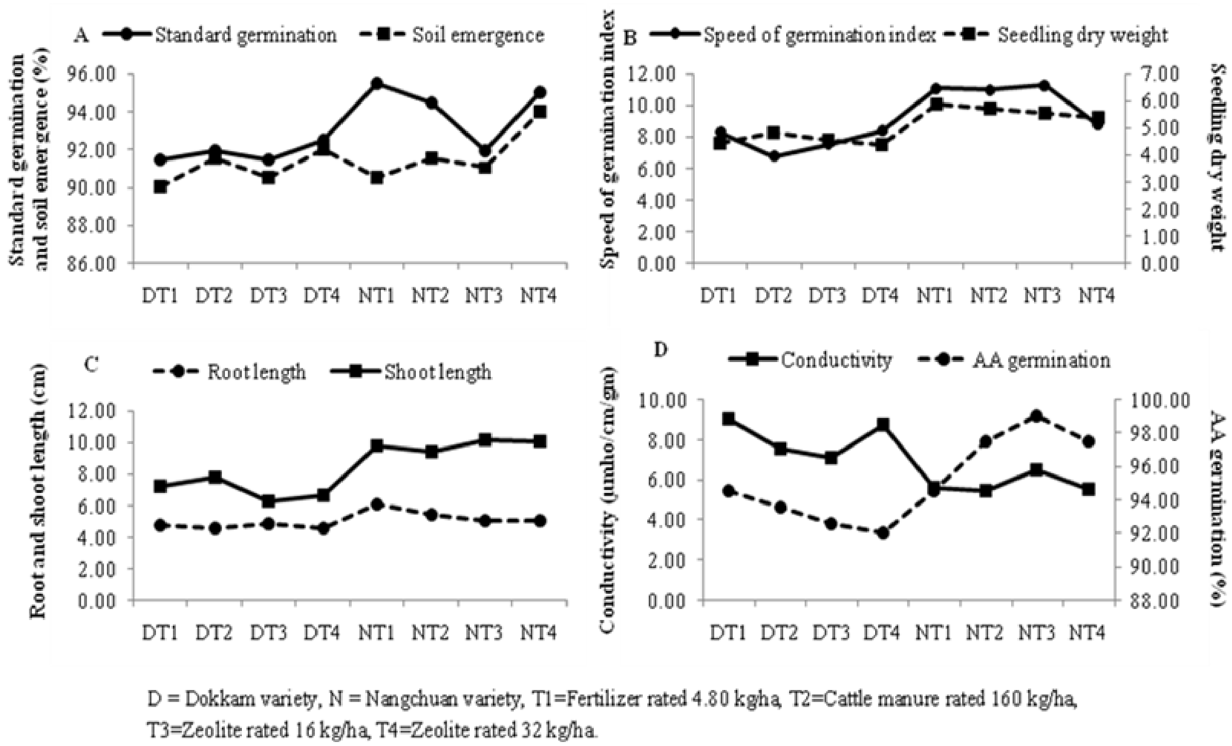


Fig. 3: Standard germination, soil emergence (A), speed germination, seedling dry weight (B), root and shoot length (C), conductivity and AA germination (D) of Dokkam and Nangchuan upland rice varieties

and T3 of Nangchuan variety had speed of germination index of 11.08, 11.01 and 11.30. The seedling dry weight of Nangchuan variety from the production using T1 had high seedling dry weight of 5.88 mg/seeding with the seeds production using T2, T3 and T4 had seedling dry weight of 5.71, 5.54 and 5.39 mg/seeding, respectively (Fig. 3A and B).

The Dokkam variety from the production using T3 had high a shoot length of 4.79 cm with the seeds production using T1, T2 and T4 had a shoot length of 4.61, 4.53 and 4.54 cm, respectively, the Nangchuan variety from the production using T1 had high a shoot length of 6.05 cm, which were not significantly different ($p \leq 0.05$) from the production using T2, T3 and T4 had a shoot length of 5.41, 5.05 and 4.99 cm, respectively. The Dokkam variety from the production using T2 had high a root length of 7.79 cm with the seeds production using T1, T3 and T4 had a shoot length of 7.19, 6.25 and 6.61 cm, respectively, the Nangchuan variety from the production using T3 had high a root length of 10.12 cm with the seeds production using T1, T2 and T4 had root length of 9.70, 9.36 and 10.00 cm, respectively (Fig. 3C).

The Dokkam variety of organic upland rice from the production using T3 had lower conductivity of 7.16 µmo/cm/gm with the seeds production using T1, T2 and T4 had conductivity of 9.07, 7.56 and 8.80 µmo/cm/gm, respectively with the conductivity of Nangchuan variety from the production using T2 had lower conductivity of 5.49 µmo/cm/gm with the seeds production using T1, T3 and T4 had conductivity of 5.63, 6.55 and 5.58 µmo/cm/gm, respectively (Fig. 3D). Seed age acceleration to find out their potential in storage time revealed that the seeds produced by T1 of Dokkam variety had high the germination rates after age acceleration of 94.50% with the seeds production using T2, T3 and T4 had the germination rates after age acceleration of 93.50, 92.50 and 92.00%, respectively, the Nangchuan variety from the production using T3 had high the germination rates after age acceleration of 99.00% with the seeds production using T1, T2 and T4 had the germination rates after age acceleration of 94.50, 97.50 and 97.50%, respectively, (Fig. 3D).

The organic upland rice seed production of Dokkam and Nangchuan varieties by the application of zeolite rated 16 kg/ha (T3) and (T4) zeolite rated 32 kg/ha (T4) were similar seed germination and vigor as compared with chemical application (control). All varieties had the highest seed quality which were not significantly different ($p \leq 0.05$) among the treatments. According to Khan *et al*. (2009) applying zeolite produced soybean seed which had high seed germination and vigor. Nutrient and plant nutrition play an important role in seed production and may affect the physiological quality. The chemical composition of the natural zeolites contained silicon 55.80%, sodium 3.90%, potassium 2.35%, calcium ions 5.75% and manganese 0.70% (Curkovic *et al*., 1997), silicon fertilization increased seed germination and reduced electrical conductivity of white oat seed (Toledo *et al*., 2011). In addition, silicon application improved seed coat development, indirectly increasing seed physiological quality of rice seed (Korndörfer *et al*., 2001). Silicon being a precursor for the synthesis of lignin, it may improve coat resistance, decreasing seed susceptibility to mechanical damage and metabolite leaching (Alvarez *et al*., 1997). In addition, the environment during the production of the seeds (rainfall and temperature) was appropriate for upland rice seed production (Fig. 1).

## CONCLUSION

This study investigated the effects of zeolite on organic seed quality of two varieties of upland rice; Dokkam and Nangchuan. The results showed that Dokkam and Nangchuan varieties from the production using zeolite rated 32 kg/ha could result in higher organic seed quality than those produced by other methods. These results confirm that a zeolite could replace the application of chemical fertilizers which could be used to produce agricultural products to satisfy the needs of the consumers who want to consume safe food, besides minimizing pollution of agricultural environment and economic costs.

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