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Research Article

Effects of Zeolite Application on Seed Yield and Yield Component of Organic Upland Rice

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Abstract: Effects of zeolite application on seed yield and yield component of organic upland rice was studied in a field experiment conducted at the King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus from July to November, 2012. Our objective was to determine the effects of zeolite on seed yield and yield component of organic upland rice varieties: Dokkam and Nangchuan. The experimental design was Randomized Complete Block (RCB) with four replications and four treatments as follows: 1) chemical methods 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) and 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 zeolite was applied at the rate of 16 and 32 kg/ha (T3 and T4), respectively, (mixing into the soil before growing). The results showed that the applying T4 had number of seeds per panicle of Dokkam variety of 286 seeds which was not statistically different from the seed production using T1 and T2 of 272 and 263 seeds, respectively, but were statistically different from T3 which had number of seeds per panicle of 239 seeds. The Nangchuan variety had number of seeds per panicle ranged from of 280 to 294 seeds which was not statistically different among the treatments. Both varieties from the seed production among the treatments had perfect seeds per panicle ranged from of 216 to 264 seeds, imperfect seeds per panicle ranged from of 7 to 18 seeds, empty seeds per panicle ranged from of 8.50 to 36.75% which were not statistically different among them. The Dokkam variety from the production using T4 had seed yield of 222.35 kg/ha which was not statistically different from the production using T2 of 216.81 kg/ha, but was statistically different from T1 and T3 of 188.66 and 196.60 kg/ha, respectively. The Nangchuan variety from the seed production in all four treatments had seed yields ranged from of 149 to 176.19 kg/ha which was not different from those among the treatments. These results confirm that zeolite could replace the application of chemical fertilizers. That can be used to produce upland rice under organic farming system. Besides, it minimizes pollution of environment and economic costs.

Keywords: Organic farming, organic upland rice, seed yield, yield component, zeolite

INTRODUCTION

Upland rice is also known as aerobic rice grown in rain-fed, naturally well-drained soils, without surface water accumulation. Upland rice is mainly grown in Asia, Africa and Latin America. It's growing area of about 17 million ha worldwide, including, 10.5 million ha in Asia, 3.7 million ha in Latin America and 2.8 million ha in Africa (Fageria, 2001). In Thailand, most upland rice is grown in the north and south. About 40% of upland rice is devoted to rice production in the southern part of Thailand due to it has the lowland and less area than other sectors and cannot produce enough rice for domestic consumption. Upland rice is planted as alternative crops of farmers for household consumption or for sale in local markets (Nokkoul and Wichitparp, 2013a). Three years ago, organic upland rice played an important role in terms of production for consumption income in the southern part of Thailand due to the overuse of chemicals for upland rice production and its negative impacts for human health and environment.

Alternative management organic upland rice farming system is the reduction of production cost, improving soil quality and the minimization of the pollution risk for the environment. 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, 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 prompted slow release of fertilizers and other materials (Artiola, 1991). The

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chemical composition of the natural zeolites is silicon 55.80%, sodium 3.90%, potassium 2.35%, calcium ions 5.75% and manganese 0.70% (Curkovic *et al*., 1997). Especially, silicon is a beneficial element for plant growth. It helps plants to overcome multiple stresses, alleviates metal toxicity, improves nutrient imbalance, increases number of spikelet fertility and decreases blank spikelet. Malidareh (2011), increases cellular wall thickness, provides mechanical resistance to the penetration of fungi, improves the opening angle of leaves and makes them more erect, decreases self-shading and increases resistance to lodging (Jafari *et al*., 2013). Zeolite is organic matter and an alternative for organic upland rice production. Our objective was to determine the effects of zeolite application on seed yield and yield component of organic upland rice varieties: Dokkam and Nangchuan.

MATERIALS AND METHODS

Two varieties of 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 part of Thailand, situated at Latitude 10°00' 30.05" N, Longitude 99° 25' 45" E, Altitude 17.84 m above the sea level. The study was conducted in randomized complete block design with four treatments:

- Chemicals method by using fertilizer (15N-15P-15K) rated 4.80 kg/ha for control (T1)
- 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 zeolite was applied at the rate of 16 and 32 kg/ha (T3 and T4), respectively, (mixing into the soil before growing). Seeds of two organic 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 emergency. 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 were germinated. Harvesting was done when all the seeds were mature. The data collected were plant height, flowering age at 50%, harvesting age of the seeds, number of plants per tiller, number of panicles per tiller, panicle length, number of seeds per panicle, perfect seeds per panicle, imperfect seeds per panicle, empty seeds per panicle and seed yield. After threshing, the seeds were sun-day, sieved and weighted after the measurement of the moisture content. The seed yields were determined for corresponding weight of standard moisture of 10%. Data of daily rainfall and daily maximum and minimum 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

Growth characters: The results in Fig. 1 showed that the plant height, flowering age at 50%, harvesting age and number of plants per tiller of Dokkam and Nangchuan varieties of seed production using chemical methods by using fertilizer (15N-15P-15K) rated 4.80 kg/ha for control (T1), cattle manure rated 160 kg/ha (T2), zeolite rated 16 kg/ha (T3) and zeolite rated 32 kg/ha (T4) were not significantly different among the treatment. The Dokkam variety had plant height of 103.16 to 108.81 cm (Fig. 1A), flowering age at 50% of 101 to 102 Days After Germination (DAG) and harvesting age of 129 to 130 DAG (Fig. 1B), number of plants per tiller of 7 plants among the treatment (Fig. 2A). The Nangchuan variety had plant height of 102.98 to 106.25 cm (Fig. 1A), flowering age at 50% of

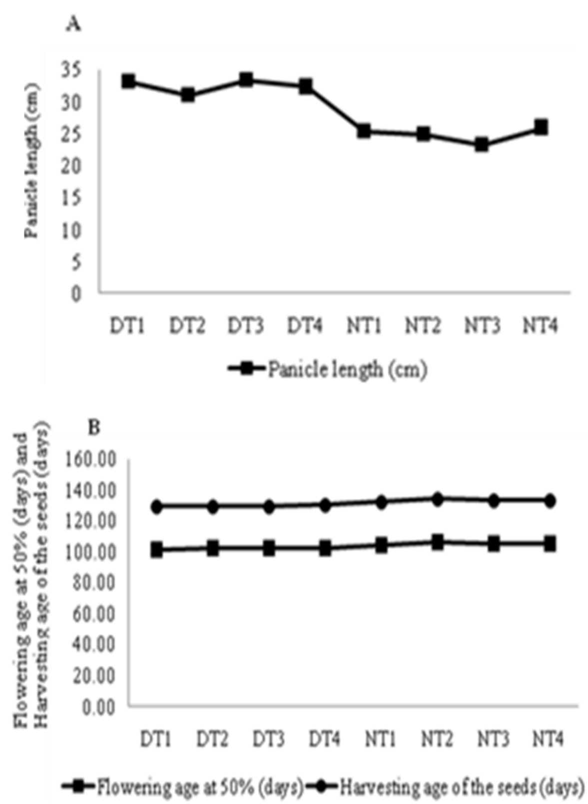

Fig. 1: Plant high, flowering age at 50%; (A): Harvesting age of the seeds; (B): Of organic upland rice seed produced using chemical method, cattle manure, zeolite rated 16 and 32 kg/ha

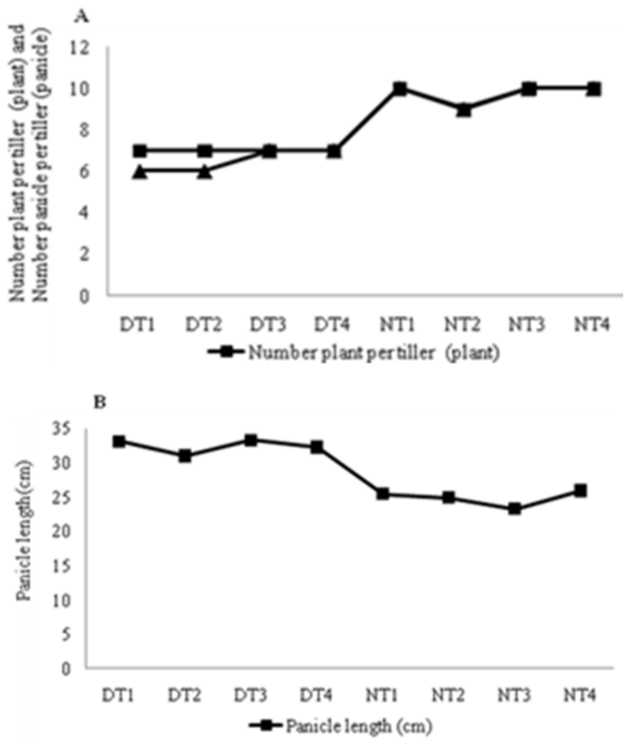

Fig. 2: Number of plants per tiller and number of panicles per tiller; (A): Panicle length; (B): Of organic upland rice seeds produced using chemical method, cattle manure and zeolite rated 16 and 32 kg/ha

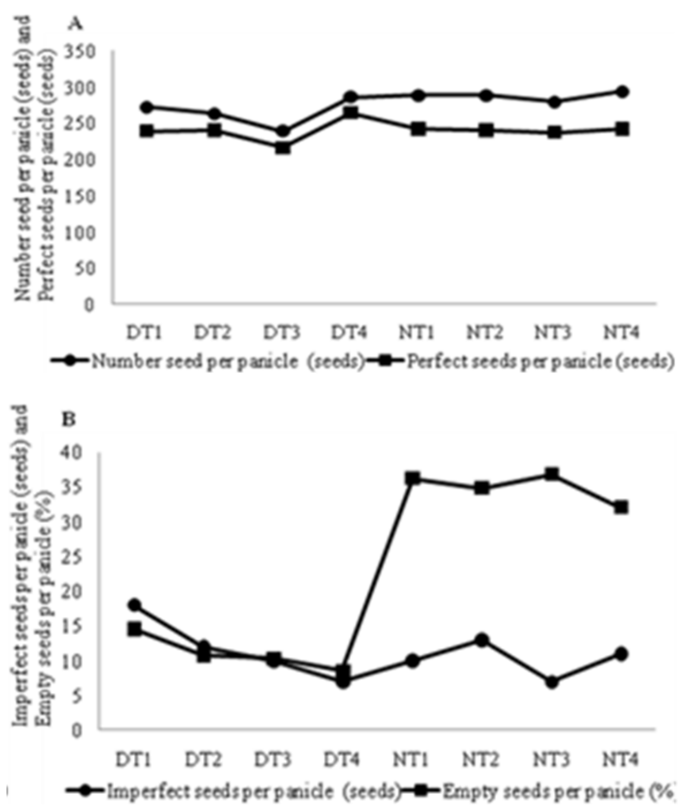

Fig. 3: Number of seeds per panicle, perfect seeds per panicle; (A): Imperfect seeds per panicle and percentage of empty seeds per panicle; (B): Of organic upland rice seeds produced using chemical methods, cattle manure and zeolite rated 16 and 32 kg/ha

104 to 106 DAG and harvesting age of 132-133 DAG (Fig. 1B). The number of panicles per tiller of the Dokkam variety from the seed production using T3 and T4 had the same number of per tiller of 7 panicles, which were not statistically different from the seed production using T1 and T2 of 6 panicles, the Nangchuan variety from the production using T1, T3 and T4 had the same number of panicles per tiller of 10 panicles, which were not statistically different from the seed production using T2 of 9 panicles (Fig. 2A).

Yield components: A yield component for the two organic upland rice varieties is given in Fig. 2 and 3.

The Dokkam variety from the seed production using T3 had high panicle length of 33.25 cm which was not significantly different from the seed production using T1, T2 and T4 which had the panicle length of 33.02, 30.99 and 32.26 cm, respectively. The Nangchuan variety from seed production using T4 had the highest panicle length of 25.88 cm which was not significantly different from T1 of 25.35 cm, but was significantly different from T2 and T3 of 24.88 and 23.25 cm, respectively (Fig. 2B).

The Dokkam variety from the production using T4 had high number of seeds per panicle of 286 seeds which was not statistically different from the seed production using T1 and T2 of 272 and 263 seeds, respectively, but were statistically different from T3 which had number of seeds per panicle of 239 seeds. The Nangchuan variety from the production using T4 had high number of seeds per panicle of 294 seeds which was not statistically different from the seed production using T1, T2 and T3 of 289, 288 and 280 seeds, respectively. The seed production using T4 of Dokkam variety had high perfect seeds per panicle of 264 seeds which was not different from the seed produced using T1, T2 and T3 of 239, 240 and 216 seeds, respectively, the perfect seeds per panicle of Nangchuan variety from the seed production using T1 and T4 had the same perfect seeds per panicle of 242 seeds which were not statistically different from the seed production using T2 and T3 of 243 and 234 seeds, respectively (Fig. 3A).

The imperfect seeds per panicle of Dokkam variety from the seed production using T4 had lower imperfect seeds per panicle of 7 seeds which was not statistically different from the seed production using T1, T2 and T4 of 18, 12 and 10 seeds, respectively. The Nangchuan variety from the seed production using T3 had lower imperfect seeds per panicle of 7 seeds which was not statistically different from the seed production using T1, T2 and T4 of 10, 13 and 11 seeds, respectively. The empty seeds per panicle of the Dokkam variety from the seed production using T4 had lower empty seeds per panicle of 8.50% which was not different from the seed production using T1, T2 and T3 of 14.50, 10.75 and 10.25%, respectively. The Nangchuan variety from the seed production using T4 had lower empty seeds per panicle of 32.00% which was not different from the seed production using T1, T2 and T3 of 36.25, 34.75 and 36.75%, respectively (Fig. 3B).

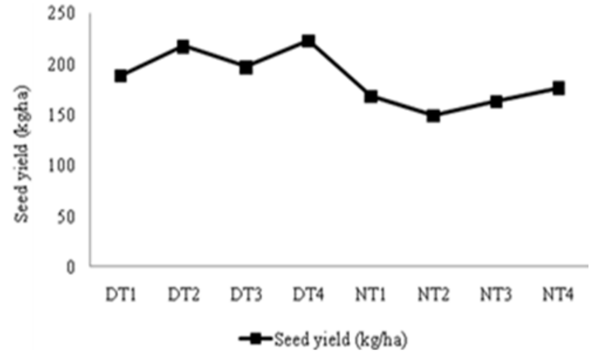

Fig. 4: Seed yield of organic upland rice seeds produced using chemical method, cattle manure and zeolite rated 16 and 32 kg/ha

Seed yield: The Dokkam variety had high seed yield of 222.35 kg/ha which was not statistically different from the seed production using T2 of 216.81 kg/ha, but which was statistically different from T1 and T3 which had seed yield of 188.66 and 196.60 kg/ha, respectively. The Nangchuan variety from the production using T4 had high seed yields of 176.19 kg/ha which was not different from those of the seeds produced by using T1, T2 and T3 which had seed yield of 168.26, 149.25 and 162.98 kg/ha, respectively, (Fig. 4). An increase in the seed yield at the treatments mentioned above might be because of the increase of number of panicles per tiller, number of fertile tillers, panicle length, number of seeds per panicle, perfect seeds per panicle and the decrease of imperfect seeds per panicle and empty seeds per panicle.

DISCUSSION

The seed production of Dokkam and Nangchuan varieties by the application of cattle manure rated 160 kg/ha (T2), zeolite rated 16 kg/ha (T3) and zeolite rated 32 kg/ha (T4) were compared with chemical methods. Both varieties of seed production using T4 had the highest seed yield and yield component compared with chemical methods (T1). Similar results were found by Azarpour *et al*. (2011) that applying zeolite raised grain yield through increasing the straw and tiller number of rice, increased seed yield of cucumber (Nokkoul and Wichitparp, 2013b), soybean (Khan *et al*., 2009), cowpea (Azarpour *et al*., 2011) and sunflower (Gholamhoseini *et al*., 2013) due to the zeolite had positive effects on crop yields, because zeolite increases

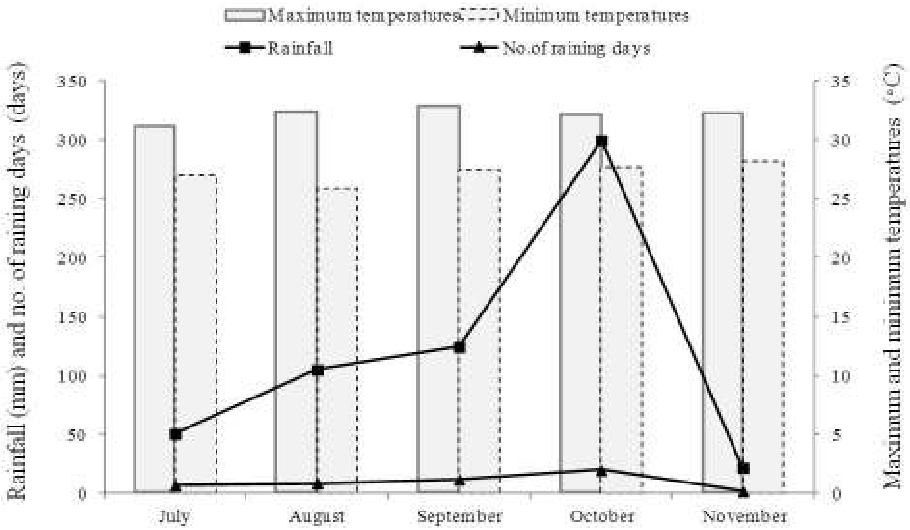

Fig. 5: Data of monthly rainfall amount and number of rainy days, maximum and minimum temperatures in the experiment location, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Thailand from July to November, 2012

the efficiency of water use, improves soil structure, holds nitrogen in the soil and moderates nitrification of ammonia, making it available to plants as needed (Silberbush *et al*., 1993). It's having prompted slow release of fertilizers and other materials (Artiola, 1991). Zeolite use nutrient efficiency by increasing the availability and uptake of macro-and micro-nutrient concentration in many crops (Kavoosi, 2007). In addition, the chemical composition of the zeolites is silicon 55.80%, sodium 3.90%, potassium 2.35%, calcium ions 5.75% and manganese 0.70% (Curkovic *et al*., 1997). Especially, silicon is a beneficial element for plant growth. It helps plants to overcome multiple stresses, alleviates metal toxicity, improves nutrient imbalance (Malidareh, 2011), decreases self-shading and increases resistance to lodging (Jafari *et al*., 2013), decreases in transpiration, increases photosynthesis (Yoshida *et al*., 1962), increases number of spikelet fertility and decreases blank spikelet per panicle (Malidareh, 2011). In addition, the environment during the production of the seeds (rainfall and temperature) was appropriate for upland rice seed production. It was found that the vegetative, reproductive and grain formation stages of rice plants received average monthly rainfall ranges from 50.00 to 300.00 mm (Fig. 1) The upland rice needs rainfall during the grown season about 92 mm of rain fall/month (Pande *et al*., 1994). The average monthly temperatures range from 31.20 to 32.93°C were suitable for growing upland rice in the southern part of Thailand (Fig. 5).

CONCLUSION

This study investigated the effects of zeolite on seed yield and yield component of organic upland rice in two varieties: Dokkam and Nangchuan. The result showed that Dokkam and Nangchuan varieties from the production using zeolite rated 32 kg/ha could be higher than seed yield and yield component produced by other methods. These results confirm that zeolite could replace the application of chemical fertilizers. That can be used to produce upland rice under organic farming system. Besides, it minimizes pollution of environment and economic costs.

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REFERENCES

Artiola, J.F., 1991. Non uniform leaching of nitrate and solute in furrow irrigation sludge-amended field. Commun. Soil Sci. Plan., 22: 1013-1030.

Azarpour, E., M.K. Motamed, M. Moraditochaee and H.R. Bozorgi, 2011. Effects of zeolite application and nitrogen fertilization on yield components of cowpea (*Vigna unguiculata* L.). World Appl. Sci. J., 14(5): 687-692.

Burriesci, N., S, Valente, Z. Zipelli and J.C.J. Bart, 1984. Studies on zeolites in agriculture. Effect on crop growth of *Prunus persica* and *Vifis vinifera.* Zeolites, 4: 373-376.

Curkovic, L, S.C. Stefanovic and T. Filipan, 1997. Metal ion exchange by natural and modified zeolites. Water Res., 31: 1379-1382.

Fageria, N.K., 2001. Nutrient management for improving upland rice productivity and sustainability. Commun. Soil Sci. Plan., 32: 2603-2629.

Gholamhoseini, M., A. Ghalavand, A. Khodaei-Joghan, A. Dolatabadian, H. Zakikhani and E. Farmanbar, 2013. Zeolite-amended cattle manure effects on sunflower yield, seed quality, water use efficiency and nutrient leaching. Soil Till. Res., 126: 193-202.

Jafari, H., H. Madani, S. Dastan, A.G. Malidarreh and B. Mohammadi, 2013. Effect of nitrogen and silicon fertilizer on rice growth in two irrigation regimes. Int. J. Agron. Plant Prod., 4: 3756-3761.

Kavoosi, M., 2007. Effects of zeolite application on rice yield, nitrogen recovery and nitrogen use efficiency. Commun. Soil Sci. Plan., 38: 69-76.

Khan, H., A.Z., Khan, R., Khan, Matsue, N. and T. Henmi, 2009. Influence of zeolite application on germination and seed quality of soybean grown on allophonic soil. Res. J. Seed Sci., 2: 1-8.

Malidareh, A.G., 2011. Silicon application and nitrogen on yield and yield components in rice (*Oryza sativa* L.) in two irrigation systems. World Acad. Sci. Eng. Technol., 5: 88-95.

Nokkoul, R. and T. Wijitparp, 2013a. The effects of rainfall on yield and seed quality of three local upland rice varieties produced under organic farming system. Res. J. Environ. Earth Sci., 5: 462-465.

Nokkoul, R. and T. Wijitparp, 2013b. Quality of cucumber seed production under organic farming system. Proceeding of the 10th National Seeds Conference HANSA JB Hotel. Songkhla Province, Thailand, May 20-24, pp: 199-125.

Pande, H.K., D.V. Tran and T. Ton-that, 1994. Improved Upland Rice Farming Systems. Food and Agriculture Organization of the United Nations, Rome, pp: 117.

Silberbush, M., E. Adar and Y. De Malach, 1993. Use of an hydrophilic polymer to improve water storage and availability to crop grown in sand dunes I. Corn irrigates by trickling. Agr. Water Manage., 23: 303-313.

Yoshida, S., Y. Ohnishi and K. Kitagishi, 1962. Chemical forms, mobility and deposition of silicon in rice plant. Soil Sci. Plant Nutr., 8: 15-21.