

Comparison of Growth of Azuki, Cowpea and Mungbean with Aeration and Non-aeration under Hydroponic Technique

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Abstract

The comparison of growth of azuki, cowpea and mungbean on different conditions in the hydroponic technique was investigated. *Vigna angularis* (Azuki), *V. unguiculata* (Cowpea) and *V. radiata* (Mungbean) were cultivated using Kimura A solution at pH 6.5 with aeration and non-aeration. Measurement was determined at 30 days after transplanting. Aeration condition had effect to *Vigna* species with non-aeration had significantly greater height and leaf area than with aeration while the reverse results were got for the root length and leaf number. However, SPAD of azuki and cowpea in non-aeration were significantly higher than in aeration while mungbean in non-aeration were significantly lower than in aeration. Dry weight of stem, root and whole plant of cowpea and mungbean in non-aeration were significantly higher than with aeration. From these results, azuki, cowpea and mungbean should be cultivated in the non-aeration condition. They would give more growth and yield.

Keywords: aeration, non-aeration and growth

1. Introduction

The genus *Vigna* is a large pan-tropical genus with 82 describes species distributed among 7 subgenera (Marechal *et al.*, 1978). Among the subgenera in the genus *Vigna* only subgenus *Ceratotropis* has its center of species diversity in Asia. The Asian *Vigna* consists of

21 species, eight of these are used for human or animal food (Tomooka *et al.*, 2002). The subgenus *Ceratotropis* of the genus *Vigna* is an economically important taxonomic group because it includes seven cultivated species, mungbean [*Vigna radiata* (L.) Wilczek], black gram [*V.mungo* (L.) Hepper], moth bean [*V. aconitifolia* (Jacquin) Maréchal], azuki bean [*V.*

angularis (Willdenow) Ohwi & Ohashi], rice bean [*V. umbellata* (Thunb.) Ohwi & Ohashi], jungle bean [*V. trilobata* (L.) Vercourt] and *V. reflex-pilosa* Hayata subsp. *glabra* (Roxburgh) Tateishi (Tateishi, 1985; Lawn, 1995). The natural distribution of *Ceratotropis* is mainly in Asia (Tomooka *et al.*, 2000). Among these species, several members have been cultivated for human food, erosion control, green manure, pasture and forage (Jain and Mehra, 1980; Duke, 1981). The genus *Vigna* is very important protein resource in both tropical and sub-tropical areas, especially in arid or semi-arid land (Madoka *et al.*, 2010). The Asian *Vigna* may have greater potential for a major advance in crop improvement than other major crop groups that have already experienced major production advances (Tomooka *et al.*, 2002). Furthermore, *Vigna* plants are generally considered to be tough against dry conditions and have a high ability of nitrogen fixation. Even so, there is more need to breed new cultivars that have high resistance against saline stress (Madoka *et al.*, 2010).

In rice, there are no data available for rice grown in deoxygenated solutions. In recent study, radial oxygen loss from roots of plants grown in different conditions (aerated and stagnant) was related to the pattern and composition in the outer part of rice roots. However, in plants grown in deoxygenated solutions, the absolute amounts of these substances in root peripheral layers were significantly greater, developing a strong

barrier to radial oxygen loss (Kotula *et al.*, 2009). Moreover, lettuce (*Lactuca sativa* L.) and cucumber (*Cucumis sativus* L.) have been successfully grown by large tank non-aerated, non-circulating hydroponic methods where no additional nutrient solution was added to the tank as plants developed (Kratky, 1993; Kratky *et al.*, 2000). Recently, there was some information that *Vigna* could be grown in non-aeration under the hydroponic technique. So, it is interesting to study in this case.

2. Materials and methods

2.1 Plant materials

Three species of *Vigna* were used in this experiment; *V. angularis* (Azuki), *V. unguiculata* (Cowpea) and *V. radiata* (Mungbean). They were transplanted to hydroponic culture with and without aeration conditions with 4 replications, using Factorials in Completely Randomized Design. Each replication consisted of 2 plants.

2.2 Germination and transplanting method

All seeds were soaked in 70 % alcohol solution for 1 minute, rinsed with distilled water for 3 times, soaked in 1 % sodium perchlorate (NaClO_4) solution for 15 minutes, and then rinsed in distilled water for 4 times for sterilization. The cleaned seeds were scarified for stimulating the germination by drilling a small hole on the seed coat for water absorption, and soaked on the net floating on the tap water for germination under the

incubator at 25°C for 9 days. Seedlings of each species were transplanted into 8-hole styrofoam plates on hydroponic pools.

2.3 Solution preparation

Kimura A solution consisting of 36.5 μM $(\text{NH}_4)_2\text{SO}_4$; 56.7 μM K_2SO_4 ; 72.8 μM MgSO_4 ; 109.6 μM KNO_3 ; 36.4 μM KH_2PO_4 ; 36.4 μM $\text{Ca}(\text{NO}_3)_2$; 2.9 μM Fe Citrate, was used and diluted in water at 1:500 in a 30-liter container with and without an air pump. The solution was changed every 2 days and its pH was adjusted to be 6.5 with 1 N H_2SO_4 and KOH.

2.4 Measurements were done as follows:

Thirty days after transplanting, plant height and expansible leaves were measured and counted, while SPAD value (chlorophyll content in plant leaf) were recorded using Minolta Co., Ltd., SPAD-502. Then root length was measured from the root starting point to the ending point of root. After that expansible leaves were cut in order to be scanned by a digital scanner and calculated by the ScnImage program. Finally, all samplings were separated into leaves, stems and roots and dried in an oven at 80°C for 72 hours.

3. Results and discussion

Azuki, cowpea and mungbean in aeration and non-aeration were harvested and measured. All species of *Vigna* in non-aeration had a significantly higher height and leaf area than those of aeration. However, in aeration,

there were higher root length and leaf number than those of non-aeration, but they were not significance (Table 1). According to, the presence of large interconnected intercellular gas-filled spaces that often extend from the shoots to near the root tip (aerenchyma) is feature shared by most (Justin and Armstrong, 1987). The spaces are created by cell separations resulting from differential rates of division or expansion by neighbouring cells or from the death of certain cells. The radially orientated spaces of the rice root is an example of aerenchyma formed by the death of particular cells that takes place mostly as a part of normal constitutive development. Mathematical modelling and direct experimentation have demonstrated that sufficient oxygen can diffuse through such tissue from the aerial shoot to satisfy the respiratory needs of root axes up to 30-cm-long at growing temperatures (Jackson and Armstrong, 1999). Islam *et al.* (1998) compared carrots grown in a soil ridge with aeration treatment with those grown in conventional ridge as a control under wet lowland field conditions. The maximum root length in the aeration treatment was 1.8 times greater than in the control. The Fresh and dry weights of the total phytomass per plant were approximately 1.6 times greater in the aeration treatment than in the control. Effects of flooding the root system have often been attributed to a deficiency of oxygen around the roots which influences their metabolism (Fulton and Erickson, 1964; Bolton and Erickson, 1970).

Mao *et al.* (2010) investigated on responses to non-aeration stress for one or three weeks, followed by a three-week aeration period in 2/5 Hoagland solution cultured with *Populus nigra* and *Populus alba* cuttings. Growth and biomass accumulation of *P. alba* showed a more rapid decrease in photosynthesis in response to the non-aeration stress. SPAD of azuki and cowpea in non-aeration were significantly higher than with aeration, but mungbean in non-aeration was significantly lower than with aeration (Table 1). Dry weights of leaves, stems, roots and whole plant of azuki with aeration were higher than those in non-aeration, but all dry weights of cowpea and mungbean in non-aeration were higher than in aeration as shown in Table 2. Those result showed cowpea and mungbean in non-aeration had growth both of upper and lower parts of

plant more than with aeration. This result was different from Kozlowski (1997) who explained that flooding during the growing season adversely affected all developmental stages of flood-intolerant plants. Flooding inhibited the seed germination, decreased the vegetative and reproductive growths, altered the plant anatomy, and might lead to early senescence and death. However, upper and lower growth of azuki in aeration was more than non-aeration: according to, Bhattarai *et al.* (2006) who investigated the effects of imposed aeration on yield and the physiological response of tomato. Subsurface irrigation with aerated water (12 % air in water) was found to stimulate the above-ground growth, and enhanced the reproductive performance through earliness for flowering and fruiting compared with the control.

Table 1 Plant growth of 3 *Vigna* species in aeration and non-aeration conditions at 30 days after transplanting.

<i>Vigna</i> sp. (S)	Plant growth (P)									
	Height (cm.)		Root length (cm.)		Leaf number		Leaf area (cm ²)		SPAD	
	A	NA	A	NA	A	NA	A	NA	A	NA
Azuki	45.60	45.70	28.56	26.50	6.63	6.38	206.41	295.24	19.49	21.93
Cowpea	73.21	92.99	28.40	23.93	8.63	8.25	142.86	285.53	25.30	25.48
Mungbean	26.14	32.81	18.90	17.51	4.60	4.25	56.00	123.59	23.85	21.84
S x P	*		ns		ns		*		*	
C.V. %	13.56		21.76		16.48		15.90		7.76	

A is aeration, NA is non-aeration, * is significant and ns is not significant by Duncan's multiple ranges test ($P \leq 0.05$).

Table 2 Dry weights of 3 *Vigna* species in aeration and non-aeration condition conditions at 30 days after transplanting.

<i>Vigna</i> sp. (S)	Dry weight (D)							
	Leaves (g.)		Stems (g.)		Roots (g.)		Whole plant (g.)	
	A	NA	A	NA	A	NA	A	NA
Azuki	0.55	0.50	0.39	0.33	0.13	0.10	1.07	0.93
Cowpea	0.29	0.39	0.23	0.33	0.07	0.09	0.59	0.82
Mungbean	0.12	0.18	0.08	0.21	0.03	0.04	0.23	0.43
S x D	ns		*		*		*	
C.V. %	27.76		38.45		26.30		26.50	

A is aeration, NA is non-aeration, * is significant and ns is not significant by Duncan's multiple ranges test ($P \leq 0.05$).

From the result of plant height, we could see plant elongation in non-aeration more than aeration condition because of the close functional interdependence between roots and shoots, stress on roots from soil waterlogging also threatens the shoot system. For the most part, the promotion of elongation by shoot or leaf are primary responses to ethylene entrapped in the growing tissue by the floodwater (Musgrave *et al.*, 1972). Other less well-researched possibilities for root to shoot signalling in waterlogged plants involve decreases in pH and in the delivery of cytokinin or gibberellin hormones. In addition to possibly contributing to closing the stomata these changes may also help explain other shoot responses to soil waterlogging such as depressed stem elongation rates and faster leaf senescence. In many species the shoot base become morphogenetically activated, studies in rice reveal a link with transverse veins and a

distinct interconnectedness between the cells that eventually die to create the aerenchyma (Jackson, 2012). Hypertrophic lenticels may also allow dissipation of metabolically generated volatiles such as ethanol, ethylene and acetaldehyde, although the physiological significance of this for plant performance and survival has not been examined. The leaf-base aerenchyma, and swelling of stem-base and lenticels are probably consequences of cell expansion promoted by endogenous ethylene trapped in the submersed tissue by the water covering (Kawase, 1974). Moreover, we observed root character in non-aeration condition; they had new small roots emerged on the stem higher than the beginning of root. Since, if those plants with deeper and thus more vulnerable roots are to revive, they must form replacement roots positioned near or at the better-aerated soil surface. There are three mechanisms for generating these replacement

root systems. One is a stimulation of the outgrowth of root primordia already present within the shoot base. A second is the induction of a new root system that involves initiation of root primordia and their subsequent outgrowth. Ethylene seems to be involved in both these processes (Jackson *et al.*, 1981). A third mechanism of placing roots at the soil surface involves a re-orientation of the root extension. Lateral roots of certain species grow upwards in waterlogged soils (Pereira and Kozlowski, 1977). When they reach the

surface, they offer a replacement pathway for aeration of other attached roots provided there is adequate internally interconnected aerenchyma (Jackson, 2012).

Finally, the result of this experiment was different rather than normally growth condition of *Vigna* and other plant. Maybe, we found the new condition for growth of *Vigna*. Therefore, we should study more in characters of physiology, chemistry and environment in non-aeration condition in the future experiment of *Vigna*.

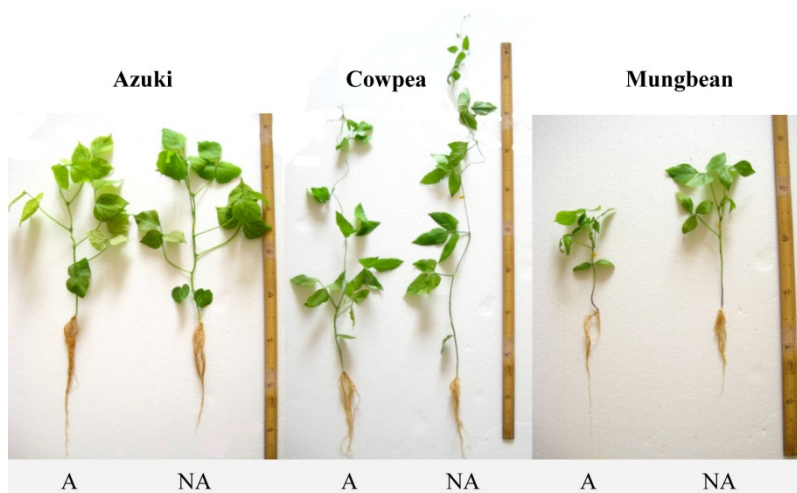


Figure 1 Comparison of plant growths at 30 days after transplanting between with aeration (A) and non-aeration (NA) of azuki, cowpea and mungbean.

4. Conclusion

All *Vigna* species were observed to be different in the aeration condition. *Vigna* species with non-aeration had significantly greater height and leaf area than with aeration while the reverse results were got for the root length and leaf number. However, SPAD of

azuki and cowpea in non-aeration were significantly higher than in aeration while mungbean in non-aeration were significantly lower than in aeration. Dry weight of stem, root and whole plant of cowpea and mungbean in non-aeration were significantly higher than with aeration. Therefore, azuki, cowpea and

mungbean should be cultivated in non-aeration condition.

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6. References

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