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PERFORMANCE OF DIRECT SEEDED RICE (*Oryza sativa* L.) UNDER DIFFERENT SEED RATES

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ABSTRACT

An experiment was conducted at the Rice Research Station, at Sammanthurai in Ampara, Sri Lanka to assess the performance of direct seeded rice (*Oryza sativa* L.) under different seed rates. This experiment was laid in a Randomized Complete Block Design (RCBD) with three replicates. Five seed rates viz., 3, 5 (recommended), 7, 9 and 10 bu/ha were included in the study, which is equivalent to 61.5, 102.5, 143.5, 184.5 and 205 kg/ha, respectively. The area of each plot was 4 x 3 m^2. The seeds were broadcasted and the seedlings were maintained as per the recommendation by the Department of Agriculture.

The results revealed that the seed rate (143.5 kg/ha) significantly increased the number of tillers/ha, straw, roots, total dry matter and economic yield/ha. The lowest economic yield/ha was obtained at the seed rate of 61.5 kg/ha and highest economic yield/ha was obtained at the seed rate of 143.5 kg/ha (7 bu/ha) whereas the lowest grain yield/plant was recorded at the highest seed rate of 205 kg/ha and highest economic yield/plant was recorded at the lowest seed rate (widest density) of 61.5 kg/ha. Therefore, the seed rate of 143.5 kg/ha (7 bu/ha) produced maximum economic yield than the recommended seed rate of 102.5 kg/ha (5 bu/ha). So the performance of direct seeded rice (BG 94-1) @143.5 kg/ha (7 bu/ha) is the best choice for obtaining maximum yield in the Ampara District.

Key words: Seed rate, dry matter,

INTRODUCTION

Rice (*Oryza sativa* L.) is the leading and a main source of food for more than half of the world's population (Boers *et al*., 2015). It is a staple food of 20.4 million people in Sri Lanka and supply 45% of daily calories intake (Thirumarpan, 2014).

In Sri Lanka, rice is sown in an extent of 1,223,000 ha during Maha and Yala seasons 2012/2013 and 2013 with the production of 6,237,300 Mt (Ministry of Agriculture Production Plan 2012-2015).

Ampara District is recognized as the ''rice bowl'' of Sri Lanka. In 2011 Yala season, rice was sown in an area of 58,000 ha and with the production of 285,000 Mt. The average yield per ha was 4.3 Mt (Ampara District development plan - 2013). It was reported that broadcasting is the popular method of stand establishment adopted by more than 70% of the farmers (Jeyasekara, 1966). The broadcast crop could yield better than transplanted crop if properly managed (Jeyasekara, 1966). Seeding rate is one of the important factors that affect the yield and economic returns of rice production (Li, 2004). Incorrect spacing reduced yield up to 20-30% (IRRI, 1997).

The effect of seed rate has not been systematically studied in this district for the broadcast rice. Even though the Department of Agriculture in Sri Lanka recommends the seed rate of 5 bu/ac (102.5 kg/ha) for broadcast sowing, farmers in the Ampara district hardly adhere this recommendation and resort to a seed rate of as high as 6-8 bu/ac with the belief that high seed rate would increase yield. The increase in seed rate may increase the yield up to a point and remain static thereafter it declines. Any rates above the optimum would result in wastage of seeds and money. This study was, therefore, undertaken with the object of studying the performance of direct seeded rice (*oryza sativa* l.) (cv. BG 94-1) under different seed rates in the Ampara District.

MATERIALS AND METHODS

A field experiment was carried out at the Rice Research Station at Sammanthurai in Ampara, Sri Lanka during the period November 2013 to March 2014. It belongs to the DL_2 agro-ecological region of the low country dry zone in Sri Lanka. The experiment was laid out in a randomized complete block design (RCBD) with three replicates (3). Five seed rates viz., 3, 5 (recommended), 7, 9 and 10 bu/ha were included in the study, which is equivalent to 61.5, 102.5, 143.5, 184.5 and 205 kg/ha respectively. The area of each plot was 4 x $3m^2$. The seeds were broadcasted and the seedlings were maintained as per the recommendation by the Department of Agriculture. Ten plants were randomly selected for sampling at each occasion. The dry weight of straw, roots and grains were determined by drying the samples in a forced draught oven at 80^0C for a period of 48 hours. At harvest, plants were uprooted from an area of $1m^2$. Data were statistically analyzed using SAS 9.1 and mean comparison was performed within treatments using Least Significant Difference at 5% significant level.

RESULTS AND DISCUSSION

Number of tillers

The number of tillers was significantly affected by seeding rate (plant density) (Table 1). At 30 DAS, highest number of tillers/ha was recorded ($P<0.001$) at the highest seed rates (205 and 184.5 kg/ha) and followed by 102.5, 143.5 kg/ha and lowest number of tillers/ha was observed at the seed rates of 61.5 kg/ha (Table1). At 60 DAS, the highest number of tillers per ha was observed ($P<0.05$) at the seed rate of 143.5 kg/ha and the lowest number of tillers was seen at the seed rate of 61.5 kg/ha (Table 1). The highest number of tillers/plant was obtained from lowest seed rate (data not given) whereas the highest number of tillers/ha was at higher seed rate. As the spacing between the plants becomes closer, the plants tend to produce the lower number of tillers. There was a positive and significant correlation between the economic yield and number of tillers (R^2=0.67*).

Number of tillers/plant is the prime factor that improves the yield of rice. In a rice population, number of tillers per unit area is essentially a function of plant density (seed rate) (Datta, 1981).
Depending on the variety and environment, the tiller number is positively or negatively correlated with crop environment (Kawano and Tanaka, 1968). The reason for the higher number

of tillers at the seed rate of 143.5 kg/ha might be due to the optimum plant population than that of other seed rates tested. This is consistent with the studies reported by Sher *et al.* (2015), Akbar and Ehsanullah (2004) and Shukla (1974) who reported that the plant density above optimum level decreased the number of effective tillers per unit area. As the seeding rate increases, the interplant competition for growth resources (both aerial and below- ground) also increases (Miah *et al*., 1990 and Bhowmik *et al*., 2012). This results in the reduction in productive tillers due to mutual shading and lodging. Shahram Lack *et al*. (2011) Shrirame *et al*. (2000) also reported that the total number of tillers/ plant was higher at the wider spacing (lower seed rate). This is in agreement with this finding.

At high seed rate (high plant density) growth is limited due to limited sunlight, space and nutrients, i.e. greater inter plant competition. Thus, results in reduction and death of fertile tillers (Shahram Lack *et al*., 2011) while the lowest seed rate (low density) increases the number of tillers/plant due reduction in interplant competition.

It is clear that restricted vegetative growth at high density. Therefore, most of the photosynthates will be utilized for maintenance of the plants and resulted in less mobilization of photosynthates towards grains.

Table 1: Effect of different seed rate on number of tillers per ha

Seed rate	Days After Planting	
(kg/ha)	30	60
61.5	8987652^{c}	14123454^{c}
102.5	13740739^{b}	19629627^{ab}
143.5	13407406^{b}	22345677^{a}
184.5	17407406^{a}	17407406^{bc}
205	19333332^{a}	19333332^{ab}
F Test	*	*

*****P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Dry weight of straw

The dry weight of straw was significantly influenced by different seed rates (Table 2 and 3). The dry weight of straw/ha at 30, 60 and 90 DAS, increased with increasing plant density and time (Table 3). At 30 DAS, dry weight of straw/ha did not have a significant effect on seed rate (Table 2).

At 60 DAS, the highest dry weight of straw/ha was recorded (P<0.003) at the highest seed rate of 205 kg/ha, followed by 143.5 kg/ha. Lowest dry weight of straw/ha (2273.2 kg/ha) was obtained at the lowest seed rate (61.5 kg/ha). At 90 DAS, the highest dry weight of straw/ha was

perceived (P<0.024) at the seed rate of 143.5 and 184.5 kg/ha. The lowest straw yield (4338 kg/ha) was obtained from 61.5 kg/ha.
The increase in dry weight of straw per unit area (ha) with increasing plant density may be mainly due to additive straw weight and /or tillers of a larger number of plants per unit area whereas the lowest straw yield (4338 kg/ha) from 61.5kg/ha also due to the lowest number of tillers per unit area. This trend of result is also in agreement with those of Shahram lack *et al*. (2011) who reported that the highest density accounted for the largest dry matter remobilization from leaves.

At 30 DAS, the highest dry weight of straw/plant was noted (P<0.0001) at the seed rate of 61.5 kg/ha, followed by 143.5 kg/ha and lowest dry weight of straw/plant were obtained at the seed rate of 205 kg/ha (Table 3). At 60 DAS, the highest dry weight of straw/plant was obtained (P< 0.05) at the seed rate of 61.5 kg/ha and followed by 143.5, 184.5 and 205 kg/ha. At 90 DAS, the highest dry weight of straw/plant was recorded (P<0.001) at the seed rate of 61.5 kg/ha and followed by 102.5 kg/ha and then by 184.5 kg/ha. At 30, 60 and 90 DAS, the highest dry weight of straw/plant was observed at the seed rate of 61.5 kg/ha and the lowest at the seed rate of 205 kg/ha. However, dry weight of straw/plant at the seed rate 61.5 kg/ha was 2.67 times greater than that of seed rate 205 kg/ha.

Stem plays a substantial role in the remobilization of dry matter to the grains than other organs in the plants (Ghosh and Singh, 1998 and Shahram Lack *et al*., 2011). Under normal conditions, 18% of the final grain yield in rice is supplied by carbohydrate reserves in the stem (Venkateswarlu, 1976). Chaturvedi and Ram (1996) found that rice stored a high amount of carbohydrates in the stem. Remobilization of dry matter had a significant influence on rice grain filling. This effect is more pronounced in tall cultivars (Souza *et al*., 1998) and greater contribution of remobilization of dry matter is made through stems and leaves. In this study, taller plants within the cultivar produced higher dry matter of stem.

Table 2: Effect of different seed rates on dry weight of straw per ha

Seed rate (kg/ha)	**Days After Planting (kg/ha)**		
	30	60	90
61.5	2508.3	2273.2^{d}	4338.0^{bc}
102.5	2019.8	2680.7^{cd}	5317.6^{ab}
143.5	2737.3	3521.5^{bc}	5534.9^{a}
184.5	2834.1	4093.9^{ab}	5552.8^{a}
205	2870.2	5216.9^{a}	4098.6^{c}
F Test	ns	*	*

*****P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Table 3: Effect of different seed rates on dry weight of Straw/plant (g)

Seed rate (kg/ha)	Days After Planting		
	30	60	90
61.5	0.66[a]	0.83[a]	1.15[a]
102.5	0.34[bc]	0.55[ab]	0.90[b]
143.5	0.40[b]	0.51[b]	0.83[bc]
184.5	0.32[bc]	0.41[b]	0.64[c]
205	0.29[c]	0.37[b]	0.43[d]
F Test	*	*	*

*****P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Dry weight of roots

At 30 DAS, dry weight of roots/ha was highest (P<0.01) at the seed rate of 102.5 kg/ha, followed by 61.5 and the by 143.5 and 205 kg/ha. At 60 (P<0.05) and 90 (P<0.01) DAS, the highest dry weight of roots was registered at the seed rate of 61.5 and 102.5 kg/ha and the lowest was recorded at the seed rate of 184,5 kg/ha. At early stages, root weight increased with increasing plant density (Table 4). At harvest, an increase in seed rate from 61.5 to 102.5 kg/ha increased the root dry weight by 3.6%. A further increase from 102.5 to 143.5 kg/ha dry weight of roots decreased by 32%. An increase from 143.5 to 184.5 kg/ha, decreased the root dry weight by 3.8%. A further increase from 184.5 to 205 kg/ha, reduced by 22.3%. The effect of an increase in plant density (seed rate) on root weight could be due to increasing in plant number and the wider distribution of roots.

The dry weight of roots/plant at various seed rates is given in the (Table 5). At 30 and 90 DAS; dry weight of roots/plant was influenced by the seed rate (Table 5). At 30 DAS, as the seed rate increased, dry weight of roots per plant decreased. This effect was significantly different between 61.5 and 143.5 kg/ha seed rates tested. At later stages (90 DAS), root weight per plant decreased as the seed rate was increased from 61.5 to 143.5. An increase in seed rate (plant density) beyond 143.5 kg/ha, did not influence the root dry weight per plant. This may be attributed to the fact that when the plant density was increased, soil space becomes limiting which can restrict further root growth.

Table 4: Effect of different seed rates on dry weight of roots kg per ha

Seed rate (kg/ha)	Days After Planting		
	30	60	90
61.5	1503.2^{b}	2264.3^{ab}	4241.1^{ab}
102.5	2111.7^{a}	2600.3^{a}	4395.0^{a}
143.5	1056.9^{c}	2055.9^{abc}	3148.8^{bc}
184.5	1253.3^{bc}	1537.0^{c}	2135.6^{cd}
205	958.9^{c}	1907.0^{bc}	1925.4^{d}
F Test	**	*	**

*****P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Table 5: Effect of different seed rates on dry weight of roots per plant (g)

Seed rate (kg/ha)	Days After Planting		
	30	60	90
61.5	0.302^{a}	0.45	1.12^{a}
102.5	0.216^{b}	0.366	0.74^{b}
143.5	0.181^{cb}	0.263	0.42^{c}
184.5	0.147^{c}	0.18	0.37^{c}
205	0.143^{c}	0.193	0.23^{c}
F Test	***	ns	***

*****P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Total dry matter

Total dry matter/ha at different stages is given in Table 6. Total dry matter production was significantly influenced by different seeding rates. Total dry matter/ha increased gradually with time. At 30 and 60 DAS, seed rate did not influence total dry matter/ha. At 90 DAS, total dry matter/ha was significantly higher (P<0.05) at the seed rate of 143.5 kg/ha (15333.8 kg/ha), followed by184.5 kg/ha (13245.9 kg/ha) and lowest total dry matter was obtained at the seed rate of 205 kg/ha (11175.1 kg/ha).

Total dry matter/plant at different stages of growth is given in Table 7. Total dry matter/plant increased gradually with time. At 30 and 90 DAS, dry matter/plant decreased with increasing seed rate (Table 7). Total dry matter/plant was the highest at the lowest seed rate tested and lowest at the highest seed rate tested. At 30 DAS total dry matter/plant was highest (P<0.0005) at the seed rate of 61.5 kg/ha and followed by143.5 kg/ha (Table 7). Lowest dry matter/plant was obtained at the seed rate of 205 kg/ha. However, at 60 DAS, seed rate did not influence the dry matter/plant. At 90 DAS, dry matter/plant was decreased ($P<0.001$) with increasing seed rate in the order of 61.5, 184.5 and 205 kg/ha.

Planting density (seed rate) had a significant effect on total dry matter remobilization. Total dry matter/unit area increased with increasing seed rate but total dry matter/plant decreased with increasing seed rate. The decrease in per plant matter at the highest seed rates (density) was due to interplant competition for growth resources. The increase in the individual plant dry matter at the lowest seed rate as a result of adequate resources did not compensate for the increase in plant weight per unit area brought about by the larger number of smaller plants. The highest remobilization of total dry matter/plant (7.93 g/plant) was observed at the seed rate of 61.5 kg/ha (Table 7). This effect mainly due to the higher dry matter of straw and grain yield, and the number of tillers, however, it varies with cultivar as reported by Tahmasebi Sarvestani and Pirdashti (1998).

Table 6: Effect of different seed rates on total dry matter (kg per ha)

Seed rate (kg/ha)	**Days After Planting**		
	30	60	90
61.5	4011.5	4537.5	12810.8^{bc}
102.5	4131.5	5281	14628.2^{ab}
143.5	3794.2	5577.4	15333.8^{a}
184.5	4087.5	5630.9	$13245,9^{b}$
205	3829.1	7123.9	11175.1^{c}
F Test	ns	ns	**

*****P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Table 7: Effect of different seed rates on total dry matter per plant (g)

Seed rate (kg/ha)	**Days After Planting**		
	30	60	90
61.5	0.96^{a}	1.28	7.93^{a}
102.5	0.56^{cb}	0.92	6.98^{ab}
143.5	0.58^{b}	0.77	5.92^{bc}
184.5	0.47^{cb}	0.59	5.02^{c}
205	0.44^{c}	0.56	4.33^{c}
F Test	***	ns	*

*P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

Economic Yield

Economic yield per unit area increased up to a seed rate of 143.5 kg/ha and declined thereafter. However, grain yield/plant decreasing with increased seed rate.

Seed rate had a significant effect ($P<0.05$) on economic yield (Table 8). The seed rates at 143.5 and 61.5 kg/ha had produced the highest and lowest economic yields/ha, respectively (Table 8). As the seed rate (density) increased, economic yield also increased up to a seed rate of 143.5 kg/ha and a further increase in seed rate decreased the yield (Table 8). Therefore, optimum seed rate under the conditions of this investigation is 143.5 kg/ha. Similar results showing that the economic yield of rice increased progressively with seed rate has been reported by Sher *et al.* (2015), Ameen *et al.* (2014), Islam *et al*.(2013), Shahram Lack *et al*. (2011), Akbar and Ehsanullah (2004) and Baloch *et al*. (2002).

In contrast, on per plant basis, the highest and the lowest economic yield/plant was recorded at the seed rate of 61.5 kg/ha and 205 kg/ha, respectively. In the lowest seed rate, the space between the plants is greater. So each plant has adequate space to capture sunlight and absorb nutrients, and results in improved photosynthesis than plants at highest densities (close spacing) (Roa *et al*., 1996). There was a positive and significant correlation between the economic yield and seed rates (R^2=0.76).

Table 8: Effect of different seed rates on economic yield

Seed rate	**At harvest Economic Yield**	
(kg/ha)	**Per plant(g)**	**Per ha (Mt)**
61.5	5.66^{a}	4.231^{c}
102.5	5.33^{ab}	4.915^{bc}
143.5	4.66^{bc}	6.650^{a}
184.5	4.00^{cd}	5.557^{ab}
205	3.66^{d}	5.15^{bc}
F Test	**	**

*P<0.05; * *Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

CONCLUSION

It is concluded that economic yield could be increased by 57% by increasing seed rate from 61.5 to 143.5 kg/ha. A further increase of seed rate from 143.5 kg/ha to 205 kg/ha reduced the yield by 35%. Therefore, the seed rate of 143.5 kg/ha (7 bu/ha) produced maximum economic yield than the recommended seed rate of 102.5 kg/ha (5 bu/ha). So the performance of direct seeded rice (BG 94-1) @143.5 kg/ha (7 bu/ha) is the best choice for obtaining maximum yield in the Ampara District.

REFERENCES

1. Akbar, N. and Ehsanullah, 2004. Agro-Qualitative response of direct seeded fine rice to different seeding densities. Pakistan Journal of Agricultural Science 41(1-2), 76-79.
2. Ameen, A., Aslam, Z., Uz Zaman, Q., Ehsanullah, Zamir, S. I., Khan, I., and Subhani, M.J., 2014. Performance of Different Cultivars in Direct Seeded Rice (*Oryza sativa* L.) with Various Seeding Densities. American Journal of Plant Sciences 5, 3119 - 3128.
3. Anonymous (2013). Ampara District development plan. http://dx.doi.org/10.4236/ajps.2014.521328.
4. Anonymous, (2012-2015). Ministry of Agriculture Production Plan.
5. Baloch, A. W., Soomro, A. M., Javed, M. A. and Ahmed, M., 2002. Optimum plant density for high yield in rice. Asian Journal of Plant Sciences 1, 25–27.
6. Bhowmik, D., Sampath-Kumar, K. P., Yadav, A., Srivastava, S., Paswan, S., Sankar-Dutta, A., 2012. Recent trends in Indian traditional herbs Syzygium aromaticum and its health benefits. Journal of Pharmacognosy and Phytochemistry 1(1), 6-17.
7. Boers, H. M., Seijen ten Hoorn, J. and Mela, D.J., 2015. A systematic review of the influence of rice characteristics and processing methods on postprandial glycaemic and insulinanemic responses. The British Journal of Nutrition 114(7), 1035–1045. doi:10.1017/S0007114515001841.
8. Chaturvedi, G.S., Ram, P.C., Singh, A.K., Ram, P., Ingram, K.T., Singh, B.B., Singh, R.K., Singh, V.P., 1996. Carbohydrate status of rainfed lowland rices in relation to submergence, drought and shade tolerance. In: Singh, V. P., Singh, R. K., Singh, B.B., Zeigler, R.S., eds. Physiology of stress tolerance in plants. Los Banos: International Rice Research Institute, 103–122.
9. Ghosh, D.C. and B.P. Singh, 1998. Crop growth modeling for wetland rice management. Environ and Ecology 16(2), 446-449.
10. IRRI, 1997. Screening rice for salinity tolerance. G.B. Gregorio, D. Senadhira & R.D. Mendoza. IRRI Discussion Paper Series No. 22.
11. Islam, M. S., Rashid, M. M., Mondal, M. K., Nath, S. C. and Karim, M. R., 2013. Effect of Planting Density on the Performance of Hybrid Rice (*Oryza sativa* L.) under Waterlogged Condition. The Agriculturists 11(2), 109-113.
12. Jayasekara, E.H.W., 1966. Varieties and cultural practices. Symposium on Research and Production of Rice in Ceylon (ed. D. V. W. Abeygunawardena, pp. 30-40. Department of Agriculture, Peradeniya.
13. Kawano, K. and Tanaka, A., 1968. Growth duration in relation to yield and nitrogen response in the rice plant. Japan Journal of Breeding 18, 46-52.
14. Li, Y., Bao, Y.M., Wei, C.H., Kang, Z.S., Zhong, Y.W., Mao, P., Wu, G., Chen, Z.L., Schiemann, J., Nelson, R.S., 2004. Rice dwarf phytoreovirus segment S6- encoded nonstructural protein has a cell-to-cell movement function. Journal of Virology 78, 5382–5389.
15. Miah, M.H.N., Karim, M.A., Rahman, M.S. and Islam, M.S., 1990. Performance of Nizersail mutants under different row spacing. Bangladesh Journal of Training and Development 3(2), 31-34.
16. Roa, K.S., Morthy, B.T.S., Dash, A.B. and Lodh, S.B., 1996. Effect of time of transplanting on grain yield and quality traits of Basmati - Type scented rice (*Oryza Sativa*) varieties in coastal. Indian Journal of Agriculture science 66(6), 333-337.
17. Shahram Lack, Mandana Baymani and Mehran Mombeni, 2011. The study of dry matter remobilization in rice cultivars due to planting density variations. Advances in Environmental Biology 5(10), 3338-3344.

18. Sher, F., Bashir, A., Tahir Latif, M. Hussain1, M., Iqbal, M.F., Waqar, M. and Anjum Ali, M., 2015. International Journal of Advanced Multidisciplinary Research 2(5), 33–36.
19. Shrirame, M.D., Rajgire, H.J. and Rajgire, A.H., 2000. Effect of spacing and seedling number per hill on growth attributes and yields of rice hybrid under lowland condition. Indian Journal of Agronomy 33 (3), 221-223.
20. Shukla, 1974. Effect of seed and nitrogen rates on the yield and plant ancillary characteristics of new high yielding variety of rice in Guyana. FAO, Bangkok (Thailand). Regional Office for Asia and the Far East. International Rice Commission Newsletter (FAO/IRC) 23(1) p. 29-40.
21. Souza, S.R., Stark, E.M.L.M. and Fernandes, M.S., 1998. Nitrogen remobilization during the reproductive period in two Brazilian rice varieties. Journal of Plant Nutrition 21, 2049–2063.
22. Tahmasebi Sarvestani and Pirdashti, 1998. Dry matter and nitrogen remobilization of rice genotypes under different transplanting dates. www. regional.org. (Accessed on February 2016).
23. Thirumarpan, K., 2014. Determinants of household food security of paddy farmers in Batticaloa District, Sri Lanka. Tropical Agricultural Research and Extension, 17(3 & 4), 135-142.
24. Venkateswarlu, B., 1976. Source – Sink interrelationship in low land rice. Plant and Soil 44, 575-586.