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Nutrient Management in Different Millet Crops Under Pongamia based Agri Silvi System in Semi-arid Region of Telangana State, India

M. A. Aariff Khan*, P.Rajesh, A. Pratap Kumar Reddy** & A.Krishna***

ABSTRACT: *AAgroforestry is one of the appropriate and efficient land use systems for dry lands, site improvement and also for optimization of productivity of agricultural crops as well as forest crops. The field experiments were conducted in sweet sorghum during* rabi, *2008-09, pearl millet* kharif, *2010 and* rabi, *2010-11 in young plantation of* Pongamia pinnata *at Agroforestry research block, Professor Jayashankar Telangana State Agricultural University, Hyderabad, T.S. All field experiments were laid out in randomized block design, replicated thrice with nine treatment combinations in sweet sorghum and pearl millet. The experimental soil was red sandy loam in texture, neutral, non saline and medium in organic carbon, low to medium in available NPK.*

*Integrated use of 75% RD N + 25% N through poultry manure significantly influenced the grain (2850 kg ha^{-1}) and stover (8465 kg ha^{-1}) yield, the NPK content in grain (1.41,0.319, 0.46%) and stover (1.36, 0.282, 2.68%) of sweet sorghum (*Rabi, *2009-2010) in pongamia based agri silvi system. The same treatment also influenced significantly the organic carbon content (0.63%) and available nutrients NPK (242.7, 23.96, 233.4 kg ha^{-1}) over control. In case of pearl millet* kharif, *2010, the results showed that, integrated use of 80 kg N ha^{-1} along with 10 t ha^{-1} pongamia green leaf manure (PGLM) was significantly influenced the grain (2345 kg ha^{-1}) and stover yield (3600 kg ha^{-1}) in Pongamia based agri silvi system. The combined application of 80 kg N ha^{-1} + PGLM 10 t ha^{-1} significantly the NPK content in both grain (1.54, 0.51, 0.53%) and stover (0.40, 0.22, 2.7%). Pertaining to soil parameters significant and higher available N (171 kg ha^{-1}) and P (27.86 kg ha^{-1}) was found with 80 kg N + PGLM 10 t ha^{-1}, where as higher available K (292.0 kg ha^{-1}) was found with by fertilizer alone i.e. 80 N kg ha^{-1}. In* rabi *pearl millet 2010-2011, the grain (2167 kg ha^{-1}) and stover yield was significantly affected by the conjunctive use of 75% RD N + 25% N through Poultry manure. Regarding soil parameters the highest content of OC (0.73%) and available N and P (219.8 and 24.53 kg ha^{-1}) was found with same type of nutrient management method.*

Key words: Nutrient management, agroforestry system, agri silvi culture, millets, organic manures

INTRODUCTION

Agroforestry is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and livestock. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land use systems (Dagar and Singh, 2001). Low and erratic rainfall with recurrent droughts has been the deciding factor for the various cropping pattern. Nutrient management, fertilizer efficiency, soil quality improvement and land productivity as a holistic approach is good efficient indication will be achieved through cropping system studies rather than single season crop. There is a great risk of growing food grains in degraded and cultivable wastelands. The ever growing demands of the increasing population for food, fodder, fuelwood, fruit, fibers, timber, pulpwood, etc. requires emphasis on checking land degradation for which agroforestry practices are considered a most vital technology, and a potential farming system for minimizing the land degradation (Sharma, 2014; Dutta and Thakur, 2004).

* AICRP on Agroforestry, Professor Jayashankar Telangana Sate Agricultural University Rajendranagar, Hyderabad -500030, T.S. *E-mail:abdulaariffkhan61@gmail.com*
** Department of Agronomy, College of Agriculture, PJTSAU, Hyderabad-500030, T.S *E-mail: shishupal_bhu@yahoo.co.in*

In view of diversity of the problems in rainfed areas, an integrated approach of land management to utilize the natural resources more efficiently in dry land agriculture is essential to meet the requirements of farming community and their deteriorating live stock, enhances land productivity and also to generate continuous and stable income. In order to achieve an intensive production of grain with good quality of sweet sorghum in low fertile red sandy loam soils, it is necessary to follow simultaneously all management practices through integrated nutrient management to sustain the productivity and to improve the soil fertility. Keeping in view of above facts an attempts were made through field experiments to find out the effect of organic manures, biofertilizers along with chemical fertilizer on yield, quality, nutrient content and uptake of sweet sorghum in agri silvi culture system.

Pongamia pinnata a nitrogen fixing tree besides multipurpose is very much suitable for semi-arid region of Telangana state. Off late the plantations were raised in variety of soils for biodiesel purpose. Millet crops sorghum and pearl millet were very important, suitable and economical rainfed crops in semi-arid areas of Telangana state.

MATERIALS AND METHODS

The field experiments on nutrient management was conducted in sweet sorghum during *rabi,* 2009-2010, pearl millet *kharif,* 2010 and *rabi* 2010-2011 in young plantation of Pongamia at Agroforestry research block, Prof. Jayashankar Telangana State Agricultural University, Rajendranagar campus, Hyderabad, T.S. All three experiments were laid out in randomized block design, replicated thrice with nine treatment combinations in sweet sorghum and pearl millet. The sources of organic manures were FYM, vermicompost, poultry manure, neemcake, biofertilizers as Azospirillum, Azotobactor, VAM, green leaf manure and inorganics fertilizers as urea, single super phosphate, muriate of potash. The varieties of crops selected as SSV-84 (Sweet sorghum) and PHB-3 (Pearl millet). The experimental soil was red sandy loam in texture, neutral, non saline and medium in organic carbon, low to medium in available NPK. The soil parameters and plant nutrient contents were analysed by adopting standard procedures (AOAC, 1980).

RESULTS AND DISCUSSION

Sweet sorghum (Rabi, 2009-2010)

The results on grain and stover yield of sweet sorghum was significantly affected by different treatments over control (Table 1). Maximum grain and stover yield (3078 and 9225 kg ha^{-1}) was recorded by the 100% RDF (80-60-40 NPK kg ha^{-1}) followed by integrated use of 75% RD N + 25 % N through poultry manure (2850 and 8465 kg ha^{-1}) and lowest being control (1838 and 4888 kg ha^{-1}). The 100% recommended dose of fertilizer (80-60-40 NPK kg ha^{-1}) favoured an additional grain and stover yield over its lesser level i.e. 75% RD N. This could be ascribed to over all improvement in plant growth and contribution of yield attributes, which in turn resulted higher production and translocation of photosynthates and nutrients ultimately reflected into higher grain and stover yield (Sumant Kundu *et al.* 2010). The results further revealed that combined application of organic manures and biofertilizers along with 75% RD N produced more yields than sole application of FYM 10 t ha^{-1}. The enhanced yields might be due to increased growth parameters of tops and roots, caused due to enhanced nutrient availability and improvement in soil physical and microbial properties as well as increased use of efficiency of chemical fertilizer in the presence of organics (Rajamani, 2009; Aariff Khan, *et al*. 2012).

Table 1
Yield and quality of sweet sorghum as influenced by nutrient management in Pongamia based agri silvi system (*Rabi*, 2009-10) Age of the trees 3 years

Treatment	*Yield (kg ha^{-1})*		*Brix (%)*	*Sucrose(%)*
	Grain	*Stover*		
T1 Control (No manure and fertilizer)	1838	4888	9.07	7.24
T2 FYM 10 t ha^{-1}	2117	5270	9.73	7.68
T3 100% RDF (80-60-40 NPK kg ha^{-1})	3078	9250	11.80	8.85
T4 75% RD N + 25% N through Vermicompost	2706	7075	11.60	9.29
T5 75% RD N + 25% N through FYM	2741	6465	11.45	9.07
T6 75% RD N + 25% N through Poultry manure	2850	8465	12.40	9.86
T7 75% RD N + through Azospirillum @ 5 kg ha^{-1}	2233	5475	10.17	8.09
T8 75% RD N + through VAM @ 5 kg ha^{-1})	2835	5800	10.03	7.93
T9 75% RD N + through Azospirillum + VAM @ 5 each kg ha^{-1}	2678	6525	10.73	8.36
CD (P=0.05)	3.19	12.49	1.37	0.31

Regarding quality parameters of sweet sorghum such as brix and sucrose content in green stalks influenced significantly among various nutrient sources in comparison to control (Table 1). Among different combination treatments the highest brix content was recorded in conjoint use of 75% RD N + 25 % N Poultry manure (12.40%) on par with 100% RDF (11.8%). In case of sucrose content the trend was in the following order 75% RD N + 25% N poultry manure (9.86%) > 75% RD N + 25% N vermicompost (9.29%) > 75% N FYM (9.07%) > 100% RDF (8.85%). The higher content of brix and sucrose content is due to more availability of nutrients from soil by the influence of poultry manure and consequent improvement in metabolic activity during physiological maturity stage which might have triggered the processes related to quality parameters (Kange *et al*. 2008). Integration of Azospirillum + VAM each @ 5 kg ha^{-1} along with 75% RD N relatively better than no inoculation and sole application of FYM 10 t ha^{-1} in terms of brix (10.73 and 9.73%) and sucrose content (8.36 and 7.68%) in grain and stalk respectively. This clearly indicated the role of biofertilizers in increasing the quality parameters in several crops (Prabhakar Reddy, 2007).

Perusal data on macronutrient content in grain and stover was significantly effected by the judicious use of inorganic fertilizer with organic manures i.e. poultry manure, vermicompost, FYM and biofertilizers i.e. Azospirillum, VAM (Table 2). Among different treatments, integration of 75% RD N + 25% N Poultry manure was found to be the best nutrient management practice which resulted significantly higher N, P, K content in grain and stover (1.41, 0.319, 0.46 and 1.36, 0.282, 2.68%) respectively in comparison with 100% RDF. The higher content by sweet sorghum in both grain and stover by 75% RD N + 25% N through poultry manure than alone 100% RDF may be attributed to better crop growth and higher removal nutrients may be due to positive effect and impact of poultry manure (Guled *et al.* 2003). Among three manurial combinations the superiority of poultry manure over vermicompost and FYM is well established in increasing the nutrient concentration may be due to its higher nutrient content and easily mineralization with low C:N ratio. With regard to biofertilizer combinations tested inoculation of mixed biofertilizer i.e. Azospirillum + VAM each @ 5 kg ha^{-1} along with 75% RD N significantly better than non inoculation and individual application of FYM 10 t ha^{-1} and control both in nutrient content and uptake. This significant improvement in content and removal of nutrients as a consequence of 25% reduction of inorganic fertilizer with biofertilizers was important in increasing the nutrient availability pattern of soil which might have reflected on biological yield and resulted ultimately in nutrient content and uptake. Similar findings were reported by Naphade *et al.* (1995). The soil organic carbon was significantly influenced by the type of manure and biofertilizer applied in combination 75% RD N + 25% N poultry manure (0.63%) was superior to other two combinations and biofertilizer treatments (Table 3). The increase in OC content may be attributed to addition of organic materials and biofertilizers might have enhanced the OC content in soil. Similar results were reported by Vasanthi and Kumar swamy (1999).

Available nutrients

Available N was influenced significantly by different manurial and biofertilizer combination with the conjoint use of 75% RD N followed the order as 25% N through poultry manure > 25% N through vermicompost > 25% N through FYM (Table 3). These treatments were relatively better compared to alone

Table 2
Nutrient content of sweet sorghum as influenced by nutrient management in Pongamia based agri silvi system

Treatment	*Grain (%)*			*Stover (%)*		
	N	*P*	*K*	*N*	*P*	*K*
T1 Control (No manure and fertilizer)	0.81	0.120	0.28	0.73	0.040	2.01
T2 FYM 10 t ha^{-1}	1.08	0.180	0.30	0.80	0.050	2.16
T3 100% RDF (80-60-40 NPK kg ha^{-1})	1.15	0.253	0.40	1.14	0.150	0.38
T4 75% RD N + 25% N through Vermicompost	1.37	0.299	0.44	1.25	0.246	2.57
T5 75% RD N + 25% N through FYM	1.23	0.280	0.41	1.21	0.210	2.47
T6 75% RD N + 25% N through Poultry manure	1.41	0.319	0.46	1.36	0.282	2.68
T7 75% RD N + through Azospirillum @ 5 kg ha^{-1}	1.11	0.208	0.35	0.92	0.080	2.23
T8 75% RD N + through VAM @ 5 kg ha^{-1})	1.10	0.213	0.32	0.85	0.090	2.21
T9 75% RD N + through Azospirillum + VAM @ 5 each kg ha^{-1}	1.12	0.224	0.37	1.08	0.100	2.24
CD (P=0.05)	0.28	0.027	0.01	0.15	0.03	0.07

Table 3
Organic carbon and available nutrients of sweet sorghum as influenced by nutrient management in pongamia based agri silvi system

Treatment	*OC (%)*	*Available nutrients (kg ha^{-1})*		
		N	*P*	*K*
T1 Control (No manure and fertilizer)	0.46	173.0	12.83	174.2
T2 FYM 10 t ha^{-1}	0.50	181.8	13.13	177.7
T3 100% RDF (80-60-40 NPK kg ha^{-1})	0.54	226.7	17.81	211.6
T4 75% RD N + 25% N through Vermicompost	0.60	237.8	21.25	225.0
T5 75% RD N + 25% N through FYM	0.59	232.6	19.76	219.0
T6 75% RD N + 25% N through Poultry manure	0.63	242.7	23.96	233.4
T7 75% RD N + through Azospirillum @ 5 kg ha^{-1}	0.49	215.3	14.02	203.1
T8 75% RD N + through VAM @ 5 kg ha^{-1})	0.49	214.0	14.99	202.2
T9 75% RD N + through Azospirillum + VAM @ 5 each kg ha^{-1}	0.52	216.8	15.68	204.4
CD (P=0.05)	0.06	4.6	2.46	6.6

application of 100% RDF (226.7 kg ha^{-1}) and FYM 10 t ha^{-1} (181.8 kg ha^{-1}). Highest build up of available N found in poultry manure (242.7 kg ha^{-1}) followed by vermicompost (237.8 kg ha^{-1}), which might be due to higher amount of N content present in poultry manure and vermicompost, might have hastened the process of mineralization during crop growth period. Another reason for higher availability of N may be attributed due to the addition of mineral fertilizer N along with organic sources, reduced the C:N ratio and thus increased the rate of decomposition resulting in faster availability of nutrients from manures. Gopal Reddy and Suryanarayan Reddy (1998) reported similar results in case of maize-soyabean cropping system. Combined application of biofertilizers either Azospirillum or VAM or both increased the availability of N, might be due to enhanced microbial activity and consequent increase in mineral N levels. Inoculation of Azospirillum increased the microbial activity in the rhizosphere, while other microbes like fungi and actinomycetes were also may have stimulated by inoculation resulting in more amount of N fixation from atmosphere (Prabhu *et al*. 2002).

Available phosphorous was significantly affected by different treatments over control (Table 3). Among them 75% RD N + 25% N through poultry manure was the best treatment (23.96 kg ha^{-1}) followed by 75% RD N + 25% N through vermicompost (21.25 kg ha^{-1}) and 75% RD N + 25% N through FYM (19.7 kg ha^{-1}). The higher available P might be due to the release of organic acids during microbial decomposition of organic matter which helped the solubility of native phosphates, thus increasing available phosphorous. Among biofertilizer treatments the results further revealed that inoculation of VAM and Azospirillum along with 75% RD N significantly increased the available P (15.68 kg ha^{-1}) over control (12.83 kg ha) and it was relatively better than individual FYM 10 t ha (13.13 kg ha^{-1}). inoculation of VAM and Azospirillum with inorganic fertilizer showed better synergistic effect by resulting root exudates and organic acids to solubilise the native insoluble Ca Phosphate, thus made available to plants. It is well known fact that cereal crops in general sorghum and maize in particular had great affinity with VAM as these crops have good fibrous root system and it responds better when soil has low initial available P status. In addition, application of VAM also may have favoured the microbial activity of bacteria and actinomycetes which in turn acted as phosphate solubilizers (Ramana Reddy, 2000).

Available potassium differed significantly by different treatment combinations over control (Table 3). Out of which 75% RD N + 25% N poultry manure was significantly superior (233.4 kg ha^{-1}). Compared to other manorial combinations i.e. 75% RD N + 25% N vermicompost (225.0 kg ha^{-1}) and 75% RD N + 25% N FYM and also better than lone application of 100% RDF (211.6 kg ha^{-1}). the beneficial effect of organic (poultry manure, vermicompost, FYM) on available K_2O may be ascribed to be the reduction of K fixation and release of potassium due to the interaction of organic matter with clay minerals besides the direct potassium addition to the potassium pool of the soil (Tolanur and Bedanur, 2003).

Pearlmillet (Kharif, 2010)

The perusal data in (Table 4) revealed that, the integrated use of 80 N kg ha-$^{-1}$ along with 10 t ha^{-1} of pongamia green manure leaf manure (PGLM) was significantly influenced the grain (2345 kg ha^{-1}) and stover yield (3600 kg ha^{-1}) of rainfed pearl millet in pongamia based agri silvi culture system followed by 80 N kg ha^{-1} (2267.8 and 3883.3 kg ha^{-1}). Combined

Table 4
Effect of pongamia green leaf manure and N levels on yield and nutrient content of rainfed pearl millet in Pongamia based agri silvi system (*Kharif*, 2010)
(Age of the trees 4 years)

Treatment	*Grain yield (kg ha^{-1})*	*Stover yield (kg ha^{-1})*	*Nutrient content (%)*					
			Grain			*Stover*		
			N	*P*	*K*	*N*	*P*	*K*
T1 Control (No fertilizer and manure)	891.7	1520.0	1.21	0.45	0.45	0.34	0.16	2.40
T2 Pongamia Green Leaf Manure (PGLM) 10t ha^{-1}	923.3	2200.0	1.25	0.47	0.46	0.36	0.17	2.47
T3 80 N kg ha^{-1}	2267.8	3883.3	1.54	0.51	0.52	0.41	0.21	2.69
T4 60 N kg ha^{-1}	1684.2	3066.7	1.53	0.51	0.53	0.39	0.20	2.68
T5 40 N kg ha^{-1}	1297.7	2859.3	1.51	0.49	0.51	0.38	0.19	2.68
T6 80 N kg ha^{-1} + PGLM 10 t ha^{-1}	2345.0	3916.7	1.54	0.51	0.53	0.40	0.22	2.70
T7 60 N kg ha^{-1} + PGLM 10 t ha^{-1}	2187.5	3600.0	1.54	0.51	0.52	0.39	0.20	2.68
T8 40 N kg ha^{-1} + PGLM 10 t ha^{-1}	1708.3	3350.0	1.53	0.50	0.51	0.37	0.19	2.67
T9 Sole crop Pearl millet with out trees	1953.3	3533.3	1.53	0.51	0.51	0.40	0.21	2.69
CD at 5%	145.7	335.9	0.02	0.010	0.016	0.02	0.015	0.04

application of 80 N kg ha^{-1} + PGLM 10 t ha^{-1} significantly influenced the NPK content over control in both grain (1.54, 0.51, 0.53% respectively) and stover (0.40, 0.22, 0.70% respectively) and was on par with 60 N kg ha^{-1} + PGLM 10 t ha^{-1} and 80 N kg ha^{-1} alone (Thakur *et al.* 2010).

Regarding soil data (Table 5), significantly higher available N (171.0 kg ha^{-1}) and P (27.86 kg ha^{-1}) was found with the application of conjoint use of 80 N kg ha^{-1} + 10 t ha^{-1} pongamia green leaf manure, where as higher available K (292.0 kg ha^{-1}) was found by alone 80 N kg ha^{-1} (Panwar *et al.* 1996).

Table 5
Effect of pongamia green leaf manure and levels on soil properties and available nutrients of rainfed pearl millet in Pongamia based agri silvi system (*Kharif*, 2010)

Treatment	*pH*	*EC (dSm^{-1})*	*OC(%)*	*Available Nutrient (kg ha^{-1})*		
				N	*P*	*K*
T1 Control	7.55	0.41	0.38	132.4	21.53	268.7
T2 Pongamia green leaf manure (PGLM) @ 10 t ha^{-1}	7.42	0.39	0.45	137.3	22.80	273.5
T3 80 N kg ha^{-1} with trees	7.49	0.39	0.43	162.6	26.73	292.0
T4 60 N kg ha^{-1} ˝	7.54	0.41	0.43	157.5	25.50	281.3
T5 40 N kg ha^{-1} "	7.51	0.45	0.40	153.7	23.80	272.7
T6 80 N kg ha^{-1} " + PGLM	7.31	0.44	0.52	171.0	27.80	281.7
T7 60 N kg ha^{-1} ˝ + PGLM	7.40	0.39	0.49	165.4	27.07	281.0
T8 40 N kg ha^{-1} "+ PGLM	7.34	0.40	0.45	154.4	26.77	275.0
Ts9 Pearl millet as sole crop	7.36	0.38	0.42	165.0	22.50	277.0
CD at 5%	NS	NS	0.08	15.1	3.73	9.45
Initial soil	7.46	0.47	0.39	138.7	23.67	270.0

Pearlmillet (Rabi, 2010-2011)

The grain and stover yield of pearl millet (Table 6) was significantly influenced by nutrient management practices over control. Among them, conjoint use of 75 % RD N + 25 % N poultry manure recorded highest grain (21.67 q ha^{-1}) and stover (3033 kg ha^{-1}) yield followed by 75 % RD N + 25 % N vermicompost (2013 and 2866 kg ha^{-1}). This might be due more availability of nutrients and better soil conditions by combined application of organics and inorganics (Arbad *et al.* 2008) Regarding soil parameters (Table 7) there was no significant effect by pH and EC by the treatments. However, OC content was significantly influenced by the integrated use of 75% RD N along with 25% N poultry manure with highest content (0.73%), closely followed by 75 % RD N + 25 % N vermicompost (0.70%). Same trend was found with available N (219.8 kg ha^{-1}) and P (22.95 kg ha^{-1}) (Jadho *et al*. 2002).

It is finally conclude that the agroforestry system such as agri silvi culture is also as good as sole agriculture and it is one of the best alternate land use system. Integrated use of 75% RD N + 25% N poultry manure is the best nutrient management practice for sustaining higher yields, organic carbon content and available nutrients in sweet sorghum and pearl millet. It is further revealed that other combined nutrient management practices i.e. inorganics with organic manures and biofertilizers are also comparatively better than absolute control or farmers practice.

Table 6
Effect of nutrient management on yield of pearl millet in Pongamia based agri silvi system (*Rabi*, 2010-2011) Age of the trees 5 years

Treatment	*Grain yield ($kg\ ha^{-1}$)*	*Stover yield ($kg\ ha^{-1}$)*
T1 Control (No manure and no Fertilizer)	1330	2400
T2 FYM 10 t ha^{-1}	1422	2683.
T3 100% RD Nitrogen (80 kg ha^{-1})	1729	2883
T4 75% RD of N + 25% N Vermi compost.	1840	2833
T5 75% RD of N + 25% N FYM	2013	2866
T6 75% RD of N + 25% N Poultry manure	2167	3033
T7 75% RD of N + Azospirillum @ 5 kg ha^{-1}	1400	2583
T8 75% RD of N + VAM @ 5 kg ha^{-1}	1498	2617
T9 75% RD of N + Azospirillum + VAM each @ 5 kg ha^{-1}	1505	2650
CD (P=0.05)	212	269

Table 7
Effect of nutrient management on soil physico-chemical properties of pearl millet in Pongamia based agri silvi system (*Rabi*, 2010-2011)

Treatment	pH	EC (dsm^{-1})	OC (%)	N ($kg\ ha^{-1}$)	P
T1 Control (No manure and no Fertilizer)	7.06	0.34	0.43	165.8	12.58
T2 FYM 10 t ha^{-1}	7.02	0.31	0.66	173.5	14.00
T3 100% RD Nitrogen (80 kg ha^{-1})	7.08	0.38	0.62	214.7	21.57
T4 75% RD of N + 25% N Vermicompost.	7.00	0.30	0.70	217.0	22.95
T5 75% RD of N + 25% N FYM	7.04	0.32	0.65	211.5	18.08
T6 75% RD of N + 25% N Poultry manure	6.98	0.33	0.73	219.8	24.53
T7 75% RD of N + Azospirillum @ 5 kg ha^{-1}	7.01	0.35	0.53	171.0	15.07
T8 75% RD of N + VAM @ 5 kg ha^{-1}	7.04	0.31	0.55	169.7	19.84
T9 75% RD of N + Azospirillum + VAM each @ 5 kg ha-$^{-1}$	7.05	0.33	0.57	179.5	18.70
CD (P=0..05)	NS	NS	0.08	6.9	2.75
Initial soil	7.05	0.32	0.40	163.0	11.77

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