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## Comparison of different planting methods and physiological studies for yield enhancement in rice

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**Abstract**

A field experiment was conducted at Annamalai University Experimental Farm, Annamalai Nagar, during *Samba* season 2017 (August-November) to evaluate different methods of rice cultivation along with certain levels of nutrients and sources, on its growth and yield parameter. The experiment was laid out in Split Plot Design. The planting methods was assigned to main plots while, different levels and sources of nutrients to the sub plots. Two planting methods *viz.*, (M<sub>1</sub>) wet seeded method and (M<sub>2</sub>) transplanting method were tried. The sub treatments were, Control (No manure) (S<sub>1</sub>), Recommended dose of fertilizer (120:38:38 N, P and K kg ha<sup>-1</sup>) (S<sub>2</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + Pressmud (5 tons ha<sup>-1</sup>) + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>3</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>4</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tons ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>). The results of the study revealed that, among the main plot treatments, *i.e.*, various levels of crop establishment, transplanting method recorded significantly higher growth rate than compare to direct seeded method of planting. Among different sources and levels, *i.e.*, five sub plot treatments, large variation were noticed RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tons ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>) recorded higher growth and yield attributing characters compared to the rest of the treatments, yet, it was found on par with (S<sub>3</sub>).

**Keywords:** planting methods, soil health, crop management, environment, recycling, micronutrients

**Introduction**

Rice (*Oryza sativa*) is the most vital food crop and a major food grain for more than one third of the world's population (Zhao *et al.*, 2011) [15]. Global demand for food is rising because of population growth, increasing affluence and changing dietary habits. The UN/FAO forecasts that global food production will need to increase by over 40 per cent by 2030 and 70 per cent by 2050 (FAO, 2009) [5].

Direct seeding of rice is the process of establishing the crop from seeds sown in the field rather than by transplanting seeding from the nursery. Direct seeding avoids three basic operations namely puddling (process of soil is compacted to reduce water seepage), transplanting and maintain standing water (Farooq *et al.*, 2011) [6]. It requires less labour and direct seeded plants mature 7 to 10 days earlier than transplanted rice. The other way of establishment is not by sowing seeds but by transplanting seedlings that are grown in nursery first. Transplanting requires less seeds but much more labour, and the crop takes longer to mature because of transplant shock. Manual transplanting of seedlings is very labour intensive. Planting in straight rows will make it easier to weed or apply fertilizers, herbicides, or insecticides.

The concept of integrated nutrient management through the judicious mixing of organic as well as inorganic sources of nutrients is an appropriate, which will not only economize the use of chemical fertilizers but also improve the physio-chemical status of the soil (Goud and Konde, 2009) [7].

Under these circumstances, more emphasis is now being given on integration of inorganic and organics including crop residues, agro-based industrial wastes and by-products to improve the soil productivity. Besides improving nutrient status of soil, it also helps in improving physical, chemical and biological properties of soil towards betterment of soil quality, and permeability which increases fertilizer use efficiency due to higher addition of humus (Mankotia *et al.*, 2008) [13]. Zinc deficiency is the wide spread micronutrient disorder in lowland rice and application of zinc along with nitrogenous fertilizers increased the grain yield dramatically in most cases (Chaudhary *et al.*, 2007) [2].

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Zinc deficiency in rice appears right from seedling stage in nursery and three weeks after transplanting in main field. Zinc deficiency is considered the most widespread disorder in lowland rice (Fageria *et al.*, 2002)<sup>[4]</sup>.

## Materials and Methods

A Field experiment was conducted in the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar to study the response of rice variety CO 47 to varied levels of RDF (Recommended dose of fertilizer) with organic sources (Pressmud and *Azospirillum brasilense*) and inorganic sources (Recommended dose of fertilizers and Zinc sulphate) *viz.*, wet seeded rice and transplanted rice. The study was conducted during 2017 (August – November). The experiment was laid out in Split Plot Design.

The planting methods was assigned to main plots while, different levels and sources of nutrients to the sub plots. Two planting methods *viz.*, (M<sub>1</sub>) wet seeded method and (M<sub>2</sub>) transplanting method were tried. The sub treatments were, Control (No manure) (S<sub>1</sub>), Recommended dose of fertilizer (120:38:38 N, P and K kg ha<sup>-1</sup>) (S<sub>2</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + Pressmud (5 tonnes ha<sup>-1</sup>) + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>3</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>4</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonnes ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>).

Pressmud with N - 0.12 %, P<sub>2</sub>O<sub>5</sub> - 2.41 %, K<sub>2</sub>O - 0.64 % @ 5 tonnes ha<sup>-1</sup> was applied in last puddling at basal as per the treatment schedule or two days before sowing or transplanting based on the treatments. *Azospirillum brasilense* @ 2 kg/ha as a soil application was applied at basal as per the treatment schedule two days last puddling before sowing or transplanting based on the treatments. The fertilizers were applied to the experimental field as per the recommended manurial schedule of 120:38:38 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>. Urea (46 % N), Single super phosphate (16 % P<sub>2</sub>O<sub>5</sub>) and Muriate of potash (60 % K<sub>2</sub>O) fertilizers were used to supply N, P and K nutrients, respectively.

Zinc sulphate @ 25 kg ha<sup>-1</sup> was applied in last puddling at basal as per the treatment schedule or two days before sowing or transplanting based on the treatments. Biometric observations on plant height, number of tillers m<sup>-2</sup>, leaf area index (LAI), dry matter production (DMP), yield parameters were recorded at harvest. The data was subjected to statistical scrutiny to arrive at meaningful for the effect of treatments on rice crop.

## Result and Discussion

The present investigation showed significant difference in main as well as sub treatments. All the growth components *viz.*, plant height, number of tillers m<sup>-2</sup>, LAI, DMP and yield and yield attributes showed superior performance with transplanting method, compared to wet seeded method of rice cultivation.

### Growth Components

#### Plant height

The data on plant height showed significant difference among main as well as sub treatments at all the stages of observation *viz.*, flowering and harvesting stages are presented in Table 1. Among the main treatments, wet seeded method gave the highest mean plant height of 77.4 cm followed by transplanting method with a plant height of 73.6 cm at

flowering stages and transplanting method gave the highest mean plant height of 85.3 cm followed by wet seeded method with a plant height of 81.6 cm at harvesting stage respectively. The least plant height was recorded in flowering stage by transplanting method and harvesting stage by wet seeded method.

Regarding sub treatments, *i.e.*, certain levels and sources of nutrients, RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) recorded the highest plants height of 84.9 and 92.8 cm which was on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>) at flowering and harvesting stages respectively. The least plant height was obtained with no fertilizer plot (S<sub>1</sub>), the plant height being 63.0 cm and 71.2 cm at flowering stage and harvesting stages respectively.

There was significant interaction between the planting methods and application of different nutrients on rice for plant height. The treatment combination of wet seeded method + RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>1</sub>S<sub>5</sub>) recorded the highest plant height of 87.6 cm at flowering stage of crop. The least plant height was recorded by the treatment transplant method + control (No manure) (M<sub>2</sub>S<sub>1</sub>).

The treatment combination of transplanting method + RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest plant height of 95.5 cm at harvesting stage of crop. The least plant height of 71.2 cm was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

This might be due to the fact that, younger seedlings in transplanting method had higher vigour, more root growth and transplantation shock occur during the initial growth stages after which stimulated plant height. Transplanting plants had more open architecture, with tillers spread wide more widely covering more ground area and more erect leaves that avoid mutual shading of leaves, resulted in optimum LAI due to significant increase in leaf size. The above results are in accordance with earlier findings of Ehsanullah *et al.* (2000)<sup>[3]</sup>.

#### Number of tillers m<sup>-2</sup>

The data on number of tillers m<sup>-2</sup> are presented in Table 2. The main and sub treatments significantly influenced the tiller number transplanting method (M<sub>2</sub>) produced the largest number of tillers with 443.2 m<sup>-2</sup>, followed by wet seeded method (M<sub>1</sub>) with 408 tillers m<sup>-2</sup>.

Among various sub treatments tried, RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) recorded the highest tillers with 509 m<sup>-2</sup> and 494 m<sup>-2</sup> which was on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>) respectively. Recommended dose of fertilizer (RDF) (S<sub>2</sub>) could produce 374.5 tillers m<sup>-2</sup> which was significantly lower to rest of the treatments except Control (S<sub>1</sub>). There was significant interaction between the planting methods and application of different nutrients on rice for number of tillers m<sup>-2</sup>. The treatment combination of transplant method + RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest tillers of 532 m<sup>-2</sup> and least tillers was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

Improvement in growth components as a result of application of organic fertilizers might be due to the enhanced metabolic activities which lead to increase in various plant metabolites responsible for cell division and cell elongation (Hatwar *et al.*, 2003)<sup>[8]</sup>. The increment in plant height may be brought

about by the presence of boron (B) which acts a constituents of cell walls and membranes (Krikby and Romheld, 2004)<sup>[11]</sup>.

#### Dry Matter Production (DMP) t ha<sup>-1</sup> at harvest

The significant difference among main as well as sub treatments was observed with dry matter production at harvesting stages are given in Table 2. Between the main treatments, the largest DMP of 11.6 t ha<sup>-1</sup> was obtained from transplanting method (M<sub>2</sub>) which was significantly higher than that of the rest of the treatments. Wet seeded method (M<sub>1</sub>) produced the least DMP of 10.4 t ha<sup>-1</sup>.

Among various sub treatments, RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) produced the largest DMP of 14.0 t ha<sup>-1</sup> and on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>). The least DMP (7.4 t ha<sup>-1</sup>) was with control (S<sub>1</sub>).

There was significant interaction between the planting methods and application of different nutrients on rice for dry matter production. The treatment combination of transplanting method + RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest DMP of 14.8 t ha<sup>-1</sup> and least DMP was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

#### Leaf area Index (LAI)

Noteworthy difference among main and sub treatments was observed on leaf area index at flowering stages are presented in Table 2. Between certain main treatments, the largest LAI of 6.0 was obtained with transplanting method (M<sub>2</sub>) which was significantly higher than that of the rest of the treatments. Wet seeded method (M<sub>1</sub>) produced the least LAI of 5.6.

Within sub plot treatments, RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) produced the largest LAI of 6.7 and was followed by on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>) with 6.6. The least LAI (4.6) was with control (S<sub>1</sub>).

There was significant interaction between the planting methods and application different nutrients on rice for leaf area index. The treatment combination of transplanting method + RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest LAI of 6.9 and least LAI was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

INM increased leaf area index, as proper decomposition of organic matter supply available plant nutrient directly to plants and created favourable soil environment, ultimately increased nutrient supplying capacity of soil for long time, which resulted in better growth of the crop. The present findings are in line with observation made by Kumar *et al.* (2010)<sup>[10, 12]</sup>.

#### Yield attributes

Among the main plot treatments, transplanting method (M<sub>2</sub>) showed a influence on yield attributing characters of rice such as on number of panicles m<sup>-2</sup>, number of filled grains panicle<sup>-1</sup> and thousand grain weight registered the highest values compared to wet seeded rice are presented in table 3.

With respect to subplot treatments, RDF + pressmud + *Azospirillum brasilense* @ 2 kg/ha as a soil application + zinc sulphate (S<sub>5</sub>) has significantly increased the number of

panicle<sup>-1</sup>, total number of grain panicle<sup>-1</sup>, number of filled grains panicle<sup>-1</sup> and test weight due to greater and balanced nutrient availability throughout the crop growth.

The increase in yield attributes of rice with use of integrated sources of plant nutrients might be due to availability of plant nutrient for longer period of crop growth. Similar results have also been reported by Aruna and Mohammed (2005)<sup>[11]</sup>.

The interaction effect of treatment, transplanting method and RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) has significantly increased the number of panicle<sup>-1</sup>, total number of grain panicle<sup>-1</sup>, number of filled grains panicle<sup>-1</sup> and test weight. This could be due to good crop stand by means of RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate which increased the synthesis of translocation from source of sink which in turn registered higher yield attributes. The above results are in accordance with earlier findings of Jagdish Kumar *et al.* (2010)<sup>[10, 12]</sup>.

#### Yield

Among the main plot treatments, transplant method (M<sub>2</sub>) showed a significant influence on grain and straw yield are given in table 4. This might due to transplant method of planting of crops better utilized space, light, nutrients and air. These reflects on higher grain and straw yield. Also the highest grain yield and straw yield was obtained by the effective utilization of resources which increased the performance of crop. This result is conformity with the reports of (Sarker *et al.* 2012)<sup>[14]</sup>.

With respect to subplot treatments, RDF + pressmud + *Azospirillum brasilense* @ 2 kg/ha as a soil application + zinc sulphate (S<sub>5</sub>) has significantly increased grain and straw yield. The application of organic sources and fertility levels significantly affected the grain and straw yield of rice due to their positive influence on growth and yield attributes especially number of panicle hill<sup>-1</sup>, total number of grains panicle<sup>-1</sup> and number of filled grains panicle<sup>-1</sup>.

The increased in grain and straw yield of rice with combined application of inorganic, organic and biofertilizers sources of plant nutrient was attributed to significant improvement in growth and yield characters. The efficient supply of nutrient delayed the senescence and increased the life cycle of the plant, which resulted in higher economic yield. Judicious use of organic and inorganic fertilizer enabled rice plant to assimilate sufficient photosynthates resulting in increased dry matter production and these together produced more productive tillers, panicle and number of filled grains leading to higher grain yield Hossaen *et al.* (2011)<sup>[9]</sup>.

Among the various treatment combinations, transplant method and RDF + pressmud + *Azospirillum brasilense* @ 2 kg/ha as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) exerted significant result on grain yield of crop, over other treatments combinations the better establishment of crops in transplant method resulted in favourable physical, chemical and biological condition of soil along with balanced application of nutrient by RDF + pressmud + *Azospirillum brasilense* @ 2 kg/ha as a soil application + zinc sulphate which efficiently increased the grain yield compared to other treatment combinations. The recorded higher straw yield due to higher LAI and dry matter production.

**Table 1:** Effect of planting methods and INM on Plant height of rice

Treatments	Flowering stage (cm)		Mean	Harvesting stage (cm)		Mean
	M <sub>1</sub>	M <sub>2</sub>		M <sub>1</sub>	M <sub>2</sub>	
S <sub>1</sub>	65.8	63.0	64.4	71.2	74.0	72.6
S <sub>2</sub>	71.5	68.7	70.1	76.7	79.4	78.0
S <sub>3</sub>	85.1	79.8	82.5	87.6	92.9	90.3
S <sub>4</sub>	77.0	74.3	75.7	82.1	84.9	83.5
S <sub>5</sub>	87.6	82.3	84.9	90.2	95.5	92.8
Mean	77.4	73.6		81.6	85.3	
	S.Ed	CD		S.Ed	CD	
Main	1.5	3.2		1.6	3.5	
Sub	2.1	4.5		2.0	4.3	
M at S	1.2	2.6		1.2	2.6	
S at M	1.1	2.4		1.0	2.3	

**Table 2:** Effect of planting methods and INM on tiller number m<sup>-2</sup> at tiller stage, DMP t ha<sup>-1</sup> at harvest stage and LAI at flowering stage of rice

Treatments	Tiller number m <sup>-2</sup> at tiller stage			DMP t ha <sup>-1</sup> of rice at harvest stage			LAI of rice at flowering stage		
	M <sub>1</sub>	M <sub>2</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	Mean
S <sub>1</sub>	304	332	318	7.0	7.9	7.4	4.5	4.8	4.6
S <sub>2</sub>	360	389	374.5	8.7	9.6	9.2	5.1	5.4	5.3
S <sub>3</sub>	472	516	494	12.4	14.1	13.2	6.4	6.8	6.6
S <sub>4</sub>	418	447	432.5	10.5	11.4	11.0	5.7	6.0	5.9
S <sub>5</sub>	486	532	509	13.2	14.8	14.0	6.5	6.9	6.7
Mean	408	443.2		10.4	11.6		5.6	6.0	
	S.Ed	CD		S.Ed	CD		S.Ed	CD	
Main	12.73	27		0.5	1.1		0.1	0.3	
Sub	16.50	35		0.6	1.3		0.2	0.5	
M at S	10.37	22		0.3	0.8		0.1	0.2	
S at M	8.49	18		0.3	0.6		0.08	0.1	

**Table 3:** Effect of planting methods and INM of rice at No. of panicles (m<sup>-2</sup>), No. of filled grains panicle<sup>-1</sup>, Thousand grain weight (g)

Treatments	No. of panicles (m <sup>-2</sup> )		Mean	No. of filled grains panicle <sup>-1</sup>		Mean	Thousand grain weight (g)		Mean
	M <sub>1</sub>	M <sub>2</sub>		157.5	M <sub>1</sub>		M <sub>2</sub>	88.8	
S <sub>1</sub>	152	163	248.5	86.6	91.0	97.7	14.9	15.0	15.2
S <sub>2</sub>	239	258	320.5	95.4	100.0	117.6	15.1	15.3	15.5
S <sub>3</sub>	310	331	283.5	113.3	121.9	106.7	15.4	15.6	15.3
S <sub>4</sub>	274	293	325.5	104.5	108.9	121.8	15.3	15.4	15.5
S <sub>5</sub>	315	336	157.5	117.5	126.1	88.8	15.4	15.6	14.9
Mean	258	276.2		103.5	109.6		15.2	15.4	
	S.Ed	CD		S.Ed	CD		S.Ed	CD	
Main	7.07	15		2.7	5.7		0.02	NS	
Sub	8.96	19		3.7	7.9		0.2	NS	
M at S	5.66	12		2.0	4.3		0.2	NS	
S at M	4.24	9		1.6	3.5		0.3	NS	

**Table 4:** Effect of planting methods and INM of rice at Grain yield and straw yield (Kg ha<sup>-1</sup>)

Treatments	Grain yield (Kg ha <sup>-1</sup> )		Mean	Straw yield (Kg ha <sup>-1</sup> )		Mean
	M <sub>1</sub>	M <sub>2</sub>		M <sub>1</sub>	M <sub>2</sub>	
S <sub>1</sub>	2235	2800	2517.5	3017	3394	3205.5
S <sub>2</sub>	3458	3881	3669.5	4311	4602	4456.5
S <sub>3</sub>	4796	5366	5081	5429	5947	5688
S <sub>4</sub>	4106	4572	4339	4873	5165	5019
S <sub>5</sub>	5002	5486	5244	5672	6182	5927
Mean	3919.4	4421		4660.4	5058	
	S.Ed	CD		S.Ed	CD	
Main	213.6	453		180.1	382	
Sub	249.5	529		225	477	
M at S	102.8	218		121.6	258	
S at M	90.5	192		100.4	213	

M<sub>1</sub> - wet seeded methodM<sub>2</sub> - Transplanting methodS<sub>1</sub> - Control (No manure)S<sub>2</sub> - Recommended dose of fertilizer (120:38:38 N, P and K kg ha<sup>-1</sup>)S<sub>3</sub> - RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + Pressmud (5 tonns ha<sup>-1</sup>) + zinc sulphate (25 kg ha<sup>-1</sup>)S<sub>4</sub> - RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>)S<sub>5</sub> - RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonns ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>)

## Conclusion

Transplanting method of rice cultivation showed the maximum performance when combined with RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate returned the maximum growth parameter its leads to increase the yield of the rice crop. Hence, the above treatment can be suggested to the rice farmers to augment the rice productivity with sizeable economic gains and without any significant loss on soil health.

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