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Effects of soil type and seed inoculants on germination, seedling vigor and yield of upland rice

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Abstract

A study was conducted to determine the effects of soil type and seed inoculants and the interaction of these soil type and inoculants on germination, seedling vigor and yield of upland rice. It was conducted from November 23, 2016 to March 3, 2017 at Cagayan State University, Lal-lo, Cagayan. There were two factors used in the study. Factor A (Soil Type) T_1- Clay, T_2- Silty Clay and T_3- Silty clay loam, and Factor B (Seed Inoculants) S_1- Rhizobia, S_2- Mycovam and S_3- *Azospirillum* (Bio-N). The Completely Randomized Design in 3x3 factorial was used in the experiment. Based from the result of the study, it was concluded that the soil type affects the seed germination at 14 days after sowing but not at 7 and 21 days after sowing, the soil type 3 (silty clay loam) obtained the longest root length at 7 DAS, the Rhizobia and Mycovam influenced the number of productive tiller, number of filled spikelets, length of panicles and weight of 1000 seeds. Therefore, Rhizobia (S1) and Mycovam (S2) are recommended because it influenced the seedling vigor and seed germination, root length, increased the number of productive tillers, number of filled spikelets, length of panicles and weight of 1000 grains.

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Introduction

Rice (*Oryza sativa* L.) is the staple diet of over 40% of the world's population, making it the most important food crop (Hossain and Fischer, 1995). It is difficult to increase the production area as the cultivable lands in many countries are decreasing due to rapid urbanization. Therefore, it is necessary to increase the production capacity per unit area which currently requires high input. The seed is one of the most important inputs for higher grain production and the necessity of quality seed is not to be eluded. Quality seed is required for rapid and synchronous seedling emergence, a pre-requisite for successful stand, establishment and uniform plant growth and development. Vigorous seedling growth is important for the successful establishment of rice and other crops. Plant growth promoting rhizobacteria, microbial inoculants have been used for plant growth and development in different leguminous and non-leguminous crops for several decades (Bashan, 1998). Investigations in several countries have shown that growth of rice seedling was enhanced by inoculation with plant growth promoting microorganisms which led to increased grain and straw yield and increased the efficiency of fertilizer-N. The capacity of microorganisms to stimulate germination and improve development of plants has been adapted for *in vitro* and *in vivo* conditions of some agricultural plants (Ayyadurai *et al.*, 2006; Biswas *et al.*, 2000; Noel *et al.*, 1996; Wilkison *et al.*, 1994; Tsavkelova *et al.*, 2007). Plant growth stimulators are applied to improve seed germination, seedling vigor and plant development. The inoculation of seeds or seedlings with microorganisms has been adopted as a method of modifying microbial populations around crop plants to promote both development and yield. The stimulation of seedling development by bacteria has been attributed to the production of biologically active compounds. The major limitation to a more widespread use of seed germination has generally been the variability in effects in both field and laboratory studies.

On the other hand, some reports have demonstrated the role of rhizobia in promoting growth of non-legumes following inoculation but little is known about the mechanism(s) involved. Probable mechanisms increase root growth that favor higher nutrient uptake. Enhanced seed emergence and consequently vigor seedlings are also influenced by Plant Growth Promoting Rhizobacteria (PGPR) inoculation. Inoculated PGPR produced Indole Acetic Acid (IAA) in the presence of seed exudates that might have triggered faster germination. Significant increases in crop yields following application of PGPR have been documented under diverse field conditions (Bashan, 1998; Mia *et al.*, 2005). Recent advances in symbiotic *Rhizobium*-legume interactions at the molecular level and the ability to introduce new genes into rice through genetic transformations have created an excellent opportunity to investigate the possibilities for growth promoting activities in rice. Thus, this study was conducted to determine the effects of soil type and seed inoculants on upland rice. Specifically, it was conducted to determined the effects of soil type and seed inoculants and its interaction on seed germination, seedling vigour and yield of upland rice.

Materials and method

a) Procurement of Seeds

The seeds of upland rice was procured at PhilRice San Mateo Station, San Mateo, Isabela.

b) Experimental Site

The experiment was conducted at the agricultural nursery of Cagayan State University, Lal-lo, Cagayan.

c) Soil Media Preparation Experimental Layout and Design

Two hundred seventy polyethylene bags with a capacity of five kilograms soil were used in the study. Ten polyethylene bags were filled-up with one type of soil which were replicated three times. There were two factors to be used in the study. Factor A (Soil Type) T_1 – Soil Type 1,T_2 – Soil Type 2,T_3 – Soil Type 3 and Factor B (Seed Inoculant) S_1 – Rhizobia, S_2 – Mycovam, S_3 – *Azospirillum* (Bio-N). The different treatments were laid out following the Completely Randomized Design (CRD).

d) Application of Inoculants

Two hundred grams of inoculant were mixed with 10 kilograms seeds. The different inoculants using the imposed treatments were applied in slurry method. The seed was coated before planting.

f) Seeding and water management

Tens seeds were planted in their assigned pots at a one centimeters depth. The seeds were covered with thin soil. Watering the plants was done as the need arises.

g) Data Gathered:

Rate of Germination Index (RGI)

Germination was recorded at 7, 14 and 21 days after sowing. Normal seedlings, abnormal seedling and dead seeds were counted separately and expressed in percentage. Rate of germination index (RGI) will be calculated by the following formula (Haque *et al*., 2007):

$$RGI = \frac{\text{Number of seedlings at 14 days}}{\text{Number of seedlings at 21 days}} \times 100$$

Shoot Length

The shoot length was measured at 7, 14, and 21 days after sowing.

Root Length

The root length was measured at 7, 14, and 21 days after sowing.

Vigor Index

The seedling vigor was determined following the formula of Baki and Andersen (1972) as cited by Haque *et al*. (2007) as shown below: Vigor index = (Mean of root length + Mean of Shoot length) ×% Seed germination.

h) Statistical Analysis

The data gathered was collated, tabulated analyzed using the Analysis of Variance for the Completely Randomized Design in Factorial. The Least Significant Differences was used for the comparison of means for each single factor and the Duncan's Multiple Range Test was used to compare means of the different treatment combinations if the result is significant.

Observation

Percent Germination. Germination percentage is considered high among all the plants with different soil types (clay, silty, and silty clay loam) and different seed inoculants (Rhizobia, Mycovam, *Azospirillum*) except at 7 days after sowing.

Stand and vigor of the Seedlings. Generally, all the seedlings were vigorous and were all healthy except some seedlings that used with *Azospirillum* (S_3) where it exhibited a shorter length of seedlings and the color of the leaves is more or less chlorotic and pale while the seedlings used with Mycovam (S_2) and RHizobia (S_1) were have a good stand, healthy and vigorous. Occurence of Insect Pest and Diseases. It was observed that few mole cricket (Scapteriscus spp.) during thirty days to fifty days of the plants. The insect pests cut the stem and attack during night time as revealed in the next morning where it damage or cut their shoot.

Result and discussion

Seed Germination at 7, 14, and 21 Days after Sowing

The soil type did not affect the germination at 7 and 21 days after sowing but it influenced on the 14 DAS. The Rhizobia and Mycovam is highly significant on the germination of seed at 14 and 21 days after sowing. The interaction of soil type and seed inoculants had comparable effects on germination at 7, 14 and 21 days after sowing.

Rate of Germination Index (RGI) and Shoot length at 7, 14 and 21 days

Both factors (soil type and inoculants) showed no significant effect on the rate of germination index (RGI) of upland rice. The result of the study implies that the germination index showed that no phytotoxicity in the soil. The data revealed that no significant effect of soil type on shoot growth of the germinated seedlings 7, 14 and 21 days after sowing. This indicates that soil type had the same effect on shoot growth of the seedlings.

Table 1. Seed germination of Upland Rice as Affected by Soil Type and Seed Inoculants (Percent).

Germination Index			
Treatment	7 DAS	14 DAS	21 DAS
Factor A (Soil Type)			
T_1- Clay	50.66	98.22b	96.53
T_2-Silty Clay	59.92	99.25a	97.17
T_3- Silty Clay Loam	57.55	95.42b	97.11
ANOVA	ns	*	ns
LSD		4.81	
Factor B (Inoculants)			
S_1 - Rhizobia	66.00	98.66a	99.17a
S_2 - Mycovam	46.59	99.66a	98.22a
S_3- *Azospirillum*	55.55	95.12b	93.42b
ANOVA	ns	**	**
LSD		4.81	6.44
T_1xS_1	71.56	99.56	99.78
T_1xS_2	35.33	99.11	99.11
T_1xS_3	45.11	96.00	90.71
T_2xS_1	62.89	99.11	99.31
T_2xS_2	55.78	99.78	97.11
T_2xS_3	61.11	98.89	95.11
T_3xS_1	63.56	97.33	98.45
T_3xS_2	48.67	98.44	98.45
T_3xS_3	60.44	90.49	94.44
ANOVA	ns	ns	ns

Notes: Mean with common letters are not significantly different with each other using LSD

Table 2. Shoot Length of Upland Rice as Affected by Soil Type and Seed Inoculant (centimetres).

Treatment	Shoot Length (cm)		
	7 DAS	14 DAS	21 DAS
Factor A (Soil Type)			
T_1 - Clay	9.69	32.47	57.03
T_2 - Silty clay	9.57	33.40	55.15
T_3 - Silty clay loam	9.65	32.16	54.56
ANOVA	ns	ns	ns
Factor B (Inoculants)			
S_1 - Rhizobia	9.50	33.91	55.01
S_2 - Mycovam	10.13	33.49	53.49
S_3 - *Azospirillum*	9.29	32.16	52.16
ANOVA	ns	ns	ns
T_1xS_1	9.35	36.05	56.79
T_1xS_2	10.31	29.77	53.70
$T_1x S_3$	9.42	31.60	60.61
T_2xS_1	9.37	31.67	55.25
T_2xS_2	10.04	34.76	54.45
T_2xS_3	9.31	33.77	55.76
T_3xS_1	9.78	34.01	53.00
T_3xS_2	10.04	35.96	57.70
T_3xS_3	9.15	31.12	52.99
ANOVA	ns	ns	ns

Root length at 7, 14, and 21 days after sowing

The soil types significantly influenced the growth of roots among the seedlings 7 days after sowing. The seeds sown in silty clay loam (T3) had the longer roots with mean of 14.65 and 14.99 centimeters, respectively. However, at 14 and 21 days, root lengths of the seedlings were comparable. The effect of inoculation was observed at the later stage of the seedlings. Significant variation in the root length was obtained at 14 and 21 DAS. Longer roots were acquired from Mycovam treated plants, two weeks after sowing with mean root length of 22.98 cm; while 17.96 and 17.98 cm for Mycovam and *Azospirillum*-inoculated plants.

Table 3. Root Length of Upland Rice as Affected by Soil Type and Seed Inoculant (centimetres).

Treatment	Root Length (centimetre)		
	7 DAS	14 DAS	21 DAS
Factor A (Soil Type)			
T_1 - Clay	14.65b	19.83	22.97
T_2 - Silty clay	14.99b	20.48	22.42
T_3 - Silty clay loam	16.67a	18.61	20.52
ANOVA	*	ns	ns
LSD	2.99		
Factor B (Inoculants)			
S_1 - Rhizobia	15.46	17.96b	24.28a
S_2 - Mycovam	15.33	22.98a	21.16b
S_3 - *Azospirillum*	15.52	17.98b	20.48b
ANOVA	ns	*	*
LSD		4.08	4.68
T_1xS_1	15.17	21.16	25.62
T_1xS_2	14.10	21.38	23.04
$T_1x S_3$	14.68	16.97	20.28
T_2xS_1	14.39	17.22	23.24
T_2xS_2	15.71	26.01	21.29
T_2xS_3	14.90	18.24	22.73
T_3xS_1	16.82	15.52	23.98
T_3xS_2	16.21	21.57	19.17
T_3xS_3	16.99	18.74	18.43
ANOVA	ns	ns	ns

Note: Means with common letters are not significantly different with each other using LSD.

Vigor Index

The interaction of soil type and inoculants did not show any significant effect on the growth of upland rice. The vigor index of seedlings grown from the different soil types revealed insignificant result from 14 and 21 days after sowing. With mean vigor index ranged from 12.46 to 68.33 percent. Likewise, inoculants did not affect the vigor index of upland rice as shown from the mean of 11.90 to 16.65 percent.

Plant Height

The effect of soil types was significant on the plant height of plants at 25 and 55 days after sowing. The plants sown in soil type 1 (T1) had the highest height with 83.22 centimetres.

The plants sown in soil type 2 (T2) and soil type 3 (T3) had comparable plant height with means of 72.90 and 69.86 centimetres. The seed inoculants did not affect the height of upland rice at 25 and 55 days after sowing. It means that height of upland rice obtained comparable soil type with means ranging from 73.99 to 77.20 centimetres.

No significant interaction was observed on the height of plants at 55 DAS among the different treatment combinations.

Table 4. Plant Height of Upland Rice as Affected by Soil Type and Seed Inoculant (centimeters).

Treatment	Plant Height (cm)	
	25 DAS	55 DAS
Factor A (Soil Type)		
T_1 - Clay	83.22a	174.06a
T_2 - Silty clay	72.90b	166.11b
T_3 - Silty clay loam	69.86b	164.39b
ANOVA	*	**
LSD	10.07	16.87
Factor B (Inoculants)		
S_1 - Rhizobia	77.20	67.79
S_2 - Mycovam	73.99	169.43
S_3 - *Azospirillum*	74.80	167.34
ANOVA	ns	ns
T_1xS_1	83.98	169.23
T_1xS_2	82.09	176.16
$T_1x S_3$	83.61	176.81
T_2xS_1	76.80	166.78
T_2xS_2	70.59	168.42
T_2xS_3	71.34	163.13
T_3xS_1	70.84	167.38
T_3xS_2	69.29	163.73
T_3xS_3	69.45	162.08
ANOVA	ns	ns

Notes: Means with common letters are not significantly different with each other using LSD.

Number of Productive and Unproductive Tillers

Tiller counts among plants grown in the three soil types were the same as shown by the comparable counts either productive or unproductive. Production of tiller did not affected by soil type. Inoculation showed significant effect on tiller count. Plants inoculated with Rhizobia, obtained more productive tiller and lesser unproductive tiller than the plants inoculated with Mycovam and Azospirillum.

Number of Filled and Unfilled Spikelets per Panicle

There was no significant effect of soil type and the interaction among the treatment combination on the number of filled spikelets per panicle of the plant. It means that they had comparable effects on the different treatments. The seed inoculants were significantly effect on the number of filled spikelets per panicle of the plants. The seeds inoculated with Rhizobia (S_1) and Mycovam (S_2) had comparable number of filled spikelets per panicle with means of 158.55 and 143.13. The seeds inoculated with *Azospirillum* (S_3) had the lowest number of filled spikelets per panicle with 3.75.

Table 5. Number of Productive and Unproductive Tillers of Upland Rice as Affected by Soil Type and Seed Inoculant.

Treatment	Number of Tillers	
	Productive	Unproductive
Factor A (Soil Type)		
T_1 - Clay	6.00	3.53
T_2 - Silty clay	6.13	3.38
T_3 - Silty clay loam	5.93	3.70
ANOVA	ns	ns
Factor B (Inoculants)		
S_1 - Rhizobia	7.03a	3.32b
S_2 - Mycovam	5.85b	3.53b
S_3 - *Azospirillum*	5.18b	3.75a
ANOVA	*	*
LSD	2.30	0.55
T_1xS_1	5.72	3.13
T_1xS_2	5.10	3.70
$T_1x S_3$	8.01	2.76
T_2xS_1	7.23	3.20
T_2xS_2	6.02	3.30
T_2xS_3	5.15	3.65
T_3xS_1	6.67	3.64
T_3xS_2	5.83	3.61
T_3xS_3	5.30	3.87
ANOVA	ns	ns

Notes: Means with common letters are not significantly different with each other using LSD.

Length of Panicles

There was no significant effect of soil type and the interaction among the treatment combination on the length of panicle of the plant. The Rhizobia (S_1), Mycovam (S_2) and *Azospirillum* (S_3) seed inoculants were significantly effect on the length of panicle of the plants. The Rhizobia (S_1) and Mycovam (S_2) seed inoculants had comparable effect on the length of panicle with means of 21.95 and 21.51 centimeters. The seed inoculants with *Azospirillum* (S_3) had the shortest length of panicle with means of 18.87 centimetres.

Table 6. Number of Filled and Unfilled Spikelets per Panicle of Upland Rice as Affected by Soil Type and Seed Inoculant.

Treatment	Number of Tillers	
	Productive	Unproductive
Factor A (Soil Type)		
T_1 - Clay	6.00	3.53
T_2 - Silty clay	6.13	3.38
T_3 - Silty clay loam	5.93	3.70
ANOVA	ns	ns
Factor B (Inoculants)		
S_1 - Rhizobia	7.03a	3.32b
S_2 - Mycovam	5.85b	3.53b
S_3 - *Azospirillum*	5.18b	3.75a
ANOVA	*	*
LSD	2.30	0.55
T_1xS_1	5.72	3.13
T_1xS_2	5.10	3.70
$T_1x S_3$	8.01	2.76
T_2xS_1	7.23	3.20
T_2xS_2	6.02	3.30
T_2xS_3	5.15	3.65
T_3xS_1	6.67	3.64
T_3xS_2	5.83	3.61
T_3xS_3	5.30	3.87
ANOVA	ns	Ns

Notes: Means with common letters are not significantly different with each other using LSD.

Table 7. Length of Panicle of Upland Rice as Affected by Soil Type and Seed Inoculants (centimetres).

Treatment	Length of Panicles (cm)
Factor A (Soil Type)	
T_1 - Clay	20.50
T_2 - Silty clay	20.38
T_3 - Silty clay loam	21.45
ANOVA	ns
Factor B (Inoculants)	
S_1 - Rhizobia	21.95a
S_2 - Mycovam	21.51a
S_3 - Azospirillum	18.87b
ANOVA	*
LSD	4.21
T_1xS_1	22.35
T_1xS_2	21.10
$T_1x S_3$	18.07
T_2xS_1	21.30
T_2xS_2	21.48
T_2xS_3	18.37
T_3xS_1	22.20
T_3xS_2	21.97
T_3xS_3	20.19
ANOVA	ns

Notes: Means with common letters are not significantly different with each other using LSD.

Weight of Grains per hill and Weight of 1000 Filled Grains

The soil type as single factor and the interaction among the treatment combination did not affect the weight of grains per hill but influenced by the different seed inoculants. The weight of grains per hill from soil type 1 (T_1), soil type 2 (T_2), and soil type 3 (T_3) ranged from 27.78 to 28.54 grams.

Table 8. Weight of Grains per Hill and Weight of 1000 Filled Grains of Upland Rice as Affected by Soil Type and Seed Inoculants (grams).

Treatment	Weight of Grains/Hill	Weight of 1000 Filled Grains
Factor A (Soil Type)		
T_1 - Clay	28.07	25.79
T_2 - Silty clay	28.54	26.55
T_3 - Silty clay loam	27.78	25.50
ANOVA	ns	ns
Factor B (Inoculants)		
S_1 - Rhizobia	30.43a	28.62a
S_2 - Mycovam	28.13a	25.99b
S_3 - *Azospirillum*	25.83b	23.23b
ANOVA	*	*
LSD	5.99	6.71
T_1xS_1	31.80	28.29
T_1xS_2	26.16	26.09
$T_1x S_3$	26.26	23.01
T_2xS_1	29.99	29.06
T_2xS_2	30.02	26.67
T_2xS_3	25.63	23.93
T_3xS_1	29.51	28.53
T_3xS_2	28.23	25.23
T_3xS_3	25.60	22.76
ANOVA	ns	ns

Notes: Means with common letters are not significantly different with each other using LSD.

Conclusion

Based from the result of the study, it was concluded that the soil type affects the seed germination at 14 days after sowing but not at 7 days and 21 days after sowing, the soil type 3 (silty clay loam) obtained the longest root length at 7 DAS, the Rhizobia and Mycovam influenced the number of productive tiller, number of filled spikelets, length of panicles and weight of 1000 seeds. The rate of germination index, vigor index, shoot lenght, plant height, tiller count, number of spikelets per panicle, length of panicle and 1000 filled grains were not affected by different soil type and seed inoculant. The treatment combination showed no significant effect in all parameters. The result implies that they have the same effect on the seed germinaiton, seedling vigor and yield of upland rice.

Recommendation

Based from the result of the study, all the soil types used in the study are recommended for upland rice production. The Rhizobia (S1) and the Mycovam (S2) are recommended because it influenced the seedling vigor and seed germination, root length, increased the number of productive tillers, number of filled spikelets, length of panicles and weight of 1000 grains.

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