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Effect of Phosphate Fertilization on Biological Compatibility of *Chlorisgayana* and *Centrosemapubescens* Mixture

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Abstract: ***Intercropping between grass andlegume in recent years has received great attentions because of potential advantage it offers to improved utilization of growth resources. In this respect, an experiment on biological compatibility of Rhodes grass (Chlorisgayana) planted with Centro (Centosemapubescens) andapplied with phosphate fertilizer had been conducted.The experimental design used was randomized block design arranged in factorial combinations of five Rhodes grass – Centro mixture with the ratios of 4 : 0, 3 : 1, 2 : 2, 1 : 3 and 0 : 4, and two levels of phosphate application. The biological compatibility indices used were relative yield total, relative crowding coefficientand aggressivity index. Competition indices revealed that all mixtures showed Relative Year Total (RYT) values of greater than one, with 2 : 2 ratio in unfertilized and 1 : 3 ratio in fertilized mixtures resulted in the highest RYT value. Relative crowding coefficient of Rhodes in mixtures were higher than that of Centro except for1 : 3 Rhodes – Centro mixture. Aggressivity index revealed that Rhodes was the most aggressive at 3 : 1 in unfertilized mixture and Centro was the most aggressive at 1 : 3 in phosphate fertilized mixture. Rhodes – Centro in the ratio of 2 : 2 and fertilized with phosphate was the most compatible combination.***

Keywords: *Centrosemapubescens*, *Chlorisgayana*, phosphate fertilization, plant composition, biological compatibility

1. Introduction

Rhodes grass (*Chlorisgayana*Kunth) is a perennial or annual tropical grass originated from Eastern and Southern Africa and now has been cultivated throughout the tropical and subtropical countries including Indonesia. It is primarily used as forage of moderate to high quality.Rhodes grass is valued for its ability to seedset, relative ease to establish and ability to cover ground, tolerance for drought, frost, soil salinity and suitability to be grown in association with many tropical legumes (Ketfasa, 1990). This grass is growing well under many soil conditions, from poor sandy soils to heavy clay alkaline and saline soils. It is full sunlight species which doesnot grow well under shade (Cook *et al*., 2005).

The nutritive value of Rhodes grass is found to be similar to the other tropical grasses like *Cenchrusciliaris*, and *Panicumcoloratum* (Mero and Uden, 1997). However, its nutritional quality steeply declines with maturity, the crude protein declines to 9 – 10% after 10 weeks of regrowth, and can be lower than 8% after 15 weeks of regrowth (Milford and Minson, 1968).

One way to increase the nutritive value of Rhodes grass and delaying the decrease of its nutritional quality is through cultivation with forage legumes. Grass-legume mixtures are usually superior to either pure stands of grass or legume, both in herbage yield and quality and ease of utilization. Besides, grass-legume mixture has extra advantages of extending the period of pasture growth and quality (Foster *et al*., 2014).

The performance of grass – legume mixturesdepend on their compatibility. Rhodes grass has been reported can be grown with a number of legumes such as alfalfa (*Medicago sativa*), stylo (*Stylosanthesguianensis*), centro (*Centrosemapubescens*), etc. (Cook *et al*., 2005). In Indonesia, the forage legume that most successful to persist in pasture area is *Centrosemapubescens*.Although it has been extensively used as forage, biological compatibility of association of Rhodes grass with legume is rarely published. Thisstudy was conducted with the objective of determiningthe effectphosphate fertilization on biological compatibility of the mixtures of Rhodes grass and Centro.

2. Materials and Method

The study was arranged in randomized block design in factorial combinations of five Rhodes grass – Centro initial plant proportions and two levels of phosphate applications with three replications. The proportion of Rhodes grass – Centro in mixtures were 4 : 0, 3 : 1, 2 : 2, 1 : 3 and 0 : 4, and levels of phosphate applications were nil (control) and 0.8 g/pot (200 kg P_2O_5/ha).The plants were planted in pots with population of four plants/pot.

The pots (15 cm height, bottom diameter of 15 cm and top diameter of 13 cm) filled with sandy loam textured soil that has been passed through a 5 mm sieve. Soil pH was 7.67, N total was 0.40%, $P_2O_5$was 15.5 mg/100 g, and K_2O was 10.47 mg/100 g. Rhodes grass was planted using tiller splitting and Centro using seeds. Sowing of Centro and phosphate fertilization were conducted 30 days beforeplanting of Rhodes grass.

During the study, the pots were watered to field capacity. All pots were cleaned from the weeds by hand weeding. Seventy days after Rhodes grass planting, all plants were cut 5 cm above soil surface. Rhodes grass and Centro from each pot were separated and oven dried at 100^o C for 24 hours to determine dry matter yield. Dry matter yield, relative crowding coefficient and aggressivityindex were used to measure the biological compatibility of the Rhodes grass and Centro mixtures.

3. Biological compatibility of the mixture

Relative yield total

The relative yield of Rhodes grass and Centro was calculated according to de Wit (1960) as follows:

$$RY_R = DMY_{RC} / DMY_{RR}$$
$$RY_C = DM_{CR} / DMY_{CC}$$

Where: RY_R is relative yield of Rhodes grass, RY_C is relative yield of Centro, DMY_{RC} is dry matter yield of Rhodes grass grown in mixture with Centro, DMY_{RR} is dry matter yield Rhodes grass as sole crop, DMY_{CR} is dry matter yield of Centro grown in mixture with Rhodes grass, and DMYCC is dry matter yield of Centro as sole crop. Relative yield total or land equivalent ratio (LER) was calculated according the formula de Wit (1960):

$$RYT\ (LER) = RY_G + RY_C$$

Relative Crowding Coefficient (RCC)

This parameter was calculated to determine competitive ability of grass – legume mixture to measure the component that has produced more or less DMY than expected in grass – legume mixture (de Wit and Van Den Bergh, 1960):

For 50 : 50 initial plant proportion:

$RCC_{RC} = DMY_{RC} / (DMY_{RR} - DMY_{RC})$,

$RCC_{CR} = DMY_{CR} / (DMY_{CC} - DMY_{CR})$

For mixtures different from 50 :50 :

$RCC_{RC} = DMY_{RC} \times Z_{CR} / (DMY_{RR} - DMY_{RC}) \times Z_{RC}$

$RCC_{CR} = DMY_{CR} \times Z_{RC} / (DMY_{CC} - DMY_{CR}) \times Z_{CR}$

Where :Z_{RC} - The initial plant proportion of Rhodes grass in combination with Centro

Z_{CR} - The initial plant proportion of Centro in combination with Rhodes grass

RCC_{RC} – Relative crowding coefficient of Rhodes grass – Centro mixture

RCC_{CR} – Relative crowding coefficient of Centro – Rhodes grass mixture

Aggressivity index

Aggressive / dominance ability of components of mixture, calculated as follows (Trenbath, 1986):

For 50: 50 initial plant proportion:

$AI_{RC} = (DMY_{RC}/ DMY_{RR}) - (DMY_{CR} / DMY_{CC})$

$AI_{CR} = (DMY_{CR} / DMY_{CC}) - (DMY_{RC}/DMY_{RR})$

For mixtures different from 50 : 50:

$AI_{RC} = DMY_{RC}\ (DMY_{RR} - DMY_{RC}) - DMY_{CR} / (DMY_{CC} \times DMY_{CR})$

$AI_{CR} = DMY_{CR}\ (DMY_{CC} - DMY_{CR}) - DMY_{RC} / (DMY_{RR} \times DMY_{RC})$

4. Results and Discussion

Relative Yield Total

Dry matter yield and biological compatibility of Rhodes grass – Centro mixtures are shown in Table 1.

The RYT value represents the biological efficiency achieved by growing two crops together in association as compared to sole cropping. In the present study, all Rhodes grass – Centro mixtures resulted in RYT value > 1 and harvesting the unfertilized Rhodes – Centro (RC 1 : 1) mixture resulted in the highest RYT value of 1.27, andit increased to 1.39in RC(3 : 1)with phosphate fertilization (Table 1). Thus, there are 27% and 39% more yield advantages in unfertilized RC (1 : 1) and phosphate fertilizedRC (1 : 3) mixtures over sole cropping, respectively

Table 1: Dry matter yield, relative yield and relative yield total of Rhodes grass and Centro mixtures

Plant composition/ Phosphate Fertilization	Rhodes grass (g/pot)	Centro (g/pot)	Total (g/pot)	Relative yield		Relative Yield Total
				Rhodes grass	Centro	
Control						
Rhodes – Centro 4 : 0	3.77	0	3.77	1	0	1
Rhodes – Centro 3 : 1	3.43	1.08	3.51	0.9	0.27	1.17
Rhodes – Centro 2 : 2	2.65	2.21	4.86	0.7	0.57	1.27
Rhodes – Centro 1 : 3	1.37	3.09	4.46	0.36	0.79	1.09
Rhodes – Centro 0 : 4	0	3.87	3.87	0	1	1
Phosphate fertilized						
Rhodes – Centro 4 : 0	5.1	0	5.1	1	0	1
Rhodes – Centro 3 : 1	4.72	1.99	6.81	0.92	0.4	1.32
Rhodes – Centro 2 : 2	3.64	3.09	6.73	0.71	0.62	1.33
Rhodes – Centro 1 : 3	2.44	4.56	7	0.47	0.92	1.39
Rhodes – Centro 0 : 4	0	4.94	4.94	0	1	1

The intercropping system resulted in higher cumulative total dry matter yield than either of the pure stand crop. The reason for increased dry matter yield in mixtures over sole cropping may be attributed to nitrogen fixing ability of Centro and extensive root system of Rhodes grass. The nitrogen fixed by Centro may be available for Centro and Rhodes to boost their growth. It is also suggested that differences in morphology and physiological traits between grass and legume increased the efficiency ofuse of growth resources. It means that when Rhodes grass and Centro grown in mixture, they are able to complement each other and make better use of overall resources than when they were grown separately. The results are in agreement with Yilmaz*et al.* (2008) who reported that in maize – common bean and maize – cowpea mixtures, RYT of intercrops were greater than one. This also is in agree with Yisehak*et al.* (2010) who reported that mixture of Rhodes grass and *Melilotus alba* in the proportion of 3 : 1 produced the highest yield, and crude protein, IVDMD and ME concentration were higher in mixture than in pure grass.

Phosphate fertilization increased RYT values (Table 1). This indicates that to increase efficiency of utilization of land planted with Rhodes – Centro mixtures, phosphate fertilization is needed. This may be attributed to the higher nitrogen fixing capacity of Centro applied with phosphate. Thisis in line with Ermanet *al.* (2008) who reported the increased plant height, number of branches, shoot dry weight, number of pod, seed and biomass yield of inoculated *Pisumsativum* with phosphorus application.

Relative Crowding Coefficient

Relative crowding coefficient plays an important role in determining the competition effects and advantages of intercropping. In the present study, RCC values for Rhodes in unfertilized and fertilized intercrops were higher in RC (3 ; 1) and RC (2 : 2) than that of RC (1 : 3), however RCC value of Rhodes reduced in phosphate fertilizedRC (1 : 3) (Table 2). This indicates that in general, Rhodes grass was more competitive than Centro, but phosphate fertilization decreased competitive ability of Rhodes and increased the competitive ability of Centro.

The higher competitive ability of Rhodes grass over Centro under unfertilizedconditions may be attributed to the highergrowth rate of tropical grasses(C_4) over legumes (C_3) and the ability of tropical grasses to grow rapidly when resources are plentiful and to tolerate multiple limitations when resources are scarce (Nippertet *al*., 2008).

Table 2: Effect of phosphate fertilization on relative crowding coefficient and aggressivitas index of Rhodes grass – Centro mixtures

Plant mixture	Relative Crowding Coefficient		K = R x C	Agressivity index	
	Rhodes (R)	Centro (C)		Rhodes	Centro
Control					
Rhodes - Centro 3 : 1	7.13	1.21	8.63	0.63	-0.63
Rhodes – Centro 2 : 2	2.35	1.33	3.36	0.13	-0.13
Rhodes – Cento 1 : 3	1.71	1.95	3.33	-0.13	0.13
Phosphate fertilized					
Rhodes – Centro 3 : 1	6.22	1.21	8.4	0.52	-0.52
Rhodes – Centro 2 : 2	2.49	1.67	4.16	-0.09	0.09
Rhodes – Centro 1 : 3	1.82	6.01	10.9	-0.45	0.45

Aggressivity index

Aggressivity index is important competition function to determine the competitive ability of a crop when grown in association with another crop. Rhodes grass and Centro in the present study were not equally competitive, because no aggressivity index values was zero.Aggressivity index of intercrops revealed that, under conditions ofunfertilized RC (3 : 1 and 2 : 2), Rhodes grass was more aggressive than Centro, as indicated by their positive sign (+), however,under conditions of phosphate fertilized RC (2 : 2 and 1 : 3), Centro was more aggressive than Rhodes grass, as indicated by their positive sign (Table 2). This indicates that to gain aggressivity index of Centro planted with Rhodes grass, phosphatefertilization is needed. Results of this study indicates that phosphate fertilized RC (2 : 2) produced the lowest aggressivity index value, low K value (Table2) and high value of RYT (Table 1). Thus, it can be inferred that the most compatible of plant mixture is in the present study was phosphate fertilized RC (2 : 2).

5. Conclusion

The results of this study confirm many earlier reports concerning the positive advantages of intercropping over pure stand and enhancing biological compatibility of grasses - legumes by phosphate fertilization. Phosphate fertilization of Rhodes grass – Centro mixture with the proportion2 : 2 is recommended to be practiced to obtain the high dry matter yield and good biological compatibility.

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