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Growth, yield and forage quality influence of intercropping and fertilization schemes on adlay (*Coix lacryma-jobi* L.) ratoon

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Abstract

Adlay has the potential in improving livestock production in the Philippines as it can be utilized both as grain and forage crop. The study was conducted to evaluate the growth, yield and forage quality of adlay ratoon at various intercropping and fertilization schemes. It was laid out in split-plot arranged in Randomized Complete Block Design (RCBD) with three mainplots and five subplots replicated four times. The intercropping scheme did not significantly influence the parameters gathered. However, fertilization scheme significantly influenced the height, number of tillers hill^{-1}, fresh herbage yield and dry matter yield of adlay ratoon. Application of 120 kg N ha^{-1} resulted in significantly better effect on the aforementioned parameters compared to without fertilization and application of 2 t ha^{-1} chicken dung but at par with the rest of the fertilized treatments. As to forage quality, adlay ratoons with napier at 1:1 ratio had the least percentage of crude protein (CP), acid detergent fiber (ADF) and acid insoluble ash (AIA) but with highest dry matter (DM). Ratoons applied with 120 kg N ha^{-1} had the highest and lowest percentage of CP and DM, respectively, among fertilization schemes while the unfertilized ones had the least percentage of ADF and AIA.

Key words: forage, ratoon, herbage, dry matter, crude protein, acid detergent fiber, ash

Introduction

Forage crop production is one of the essential components in the production of livestock in the Philippines. It is important then to look for a crop that has the potential to meet such need. Adlay or Job's tears (*Coix lacryma-jobi* L.) is one of those crops that may possibly augment the forage requirements of livestock as aside from being a nutritious grain crop, it can be ratooned several times and the herbage are excellent fodder (Jansen, 2006). It yielded 13.9 t ha^{-1} green material in India containing 29.9% DM, 8.5% CP and 8.96% ash (Skerman and Riveros, 1990). In Mali, it provided 45-53 t ha^{-1} fresh fodder (Kumar et al., 2014). Furthermore, it can withstand heavy rains and long dry spell (Loeffler, 2012).

It is essential to supply the nutrient needs of forage crops to be grown for better growth and development. However, to have sustained production, the kind of fertilizer and its rate, method and timing of application have to be considered first. The use of organic fertilizer is a better choice over the inorganic ones as it will not degrade the soil quality with continuous use. It also mitigates climate change as the practice prevents CO_2 emission by substituting the use of inorganic fertilizers and from injection of carbon into the soil that enhances its sequestration (Lemus and Lal, 2007).

Chicken dung is one of the organic fertilizers which has the potential in sustaining the growth and development of crops. In fact, it is the best organic fertilizer for the production of napier-bajra hybrid grass which resulted in higher fresh and dry matter yields (Bandeswaran et al., 2013). Moreover, the yield and yield components of hybrid rice were all highest in plots under poultry manure as compared with cattle and sheep manures (Amanullah et al., 2016).

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Materials and Methods

After the harvest of the adlay seed crop, hand weeding was done in the experimental area to study the growth, yield and forage quality of the ratoons. The area was laid out in split-plot arranged in RCBD with intercropping and fertilization schemes as mainplot and subplot, respectively replicated four times. The intercropping schemes were as follows: C_1 = Ratooned monocrop adlay, C_2 = Ratooned adlay and napier at 1:1 row ratio and C_3 = Ratooned adlay and napier at 2:1 row ratio. The fertilization schemes were: F_0 = Unfertilized, F_1 = 120 kg N ha^{-1} of inorganic fertilizer, F_2 = 60 kg N ha^{-1} inorganic fertilizer + 1 t ha^{-1} chicken dung, F_3 = 30 kg N ha^{-1} inorganic fertilizer + 1.5 t ha^{-1} chicken dung and F_4 = 2 t ha^{-1} chicken dung. The full amount of the aforementioned chicken dung and inorganic fertilizer treatments were applied right after the harvest of the seed crop. Appropriate cultural management practices were undertaken until the completion of the study.

The data gathered were days to shoot emergence, percent dead ratooned tillers, plant height, number of tillers per hill, fresh herbage yield and dry matter yield of the adlay ratoons. Likewise, forage samples were taken from each treatment plot and composited per treatment for the analysis of their percent crude protein (CP), dry matter (DM), acid detergent fiber (ADF) and acid insoluble ash (AIA) contents. The ratoons were harvested 60 days after the cutting of the stalks of the seed crop.

Results and Discussion

Days to shoot emergence

The number of days to shoot emergence of adlay ratoons as influenced by intercropping and fertilization schemes and their interaction is shown in Table 1. No significant variation was observed among intercropping scheme on ratoon shoot emergence although a slightly earlier emergence of shoots was observed on ratoons with napier at 1:1 row ratio as compared to the monocrop ratoons which emerged a day later. These findings suggest that the ratooning ability of adlay was not affected by the presence of the napier intercrop.

Likewise, the fertilization scheme did not significantly influence the emergence of the ratoon shoots although those applied with 120 kg ha^{-1} had shoots emerging slightly later than the other fertilization treatments. The results seem to indicate that increasing nitrogen levels may delay the emergence of ratoon shoots but such effect may be offset by combining with chicken dung. According to Exley & Snaydon (2008), N fertilizer partially alleviated the effects of root competition but did not affect shoot competition.

No interaction effect was noted between intercropping and fertilization schemes on shoot emergence implying their independent effect on the measured parameter.

Table 1. Number of days to shoot emergence, percent (%) dead ratooned tillers and plant height (cm) at harvest of adlay ratoons as affected by fertilization scheme

Treatments	Days to Shoot Emergence	Dead Ratooned Tillers (%)	Plant Height at Harvest (cm)
Intercropping Scheme			
C_1 = Ratooned adlay monocrop	7.0	17.42	93.11
C_2 = Ratooned adlay and napier at 1:1 row ratio	6.2	14.05	92.92
C_3 = Ratooned adlay and napier at 2:1 row ratio	6.5	15.39	90.46
F-test	ns	ns	ns
CV_a (%)	11.60	18.08	11.51
Fertilization Scheme			
F_0 = Unfertilized	6.7	7.77^{c}	76.83^{c}
F_1 = 120 kg N ha^{-1}	7.8	31.78^{a}	100.49^{a}
F_2 = 60 kg N ha^{-1} + 1 t ha^{-1} chicken dung	6.7	19.07^{ab}	99.33^{ab}
F_3 = 30 kg N ha^{-1} + 1.5 t ha^{-1} chicken dung	5.8	11.61^{bc}	97.32^{ab}
F_4 = 2 t ha^{-1} chicken dung	5.9	7.88^{c}	86.84^{bc}
F-test	ns	**	**
Intercropping x Fertilization Schemes			
F-test	ns	ns	ns
CV (%)	14.33	26.51	12.46

Means within a column with the same letter and those without letters are not significantly different at 5% level of significance based on Tukey's HSD test.

ns = not significant ** = highly significant

Dead ratooned tillers (%)

Table 1 shows the influence of intercropping and fertilization schemes and their interaction on the percentage of dead ratooned tillers (Figure 1). The percentage of dead tillers ranged from 14 - 17% and were not significantly influenced by the intercropping scheme. Monocrop adlay ratoons had

slightly higher percentage of dead tillers while those with napier at 1:1 row ratio had the least dead tillers. These show that the napier intercrop did not influence the death of the cut tillers.

Among fertilization scheme, the percentage of dead tillers vary significantly. Higher percentage of dead tillers were observed in ratoons applied with full or half of the recommended amounts of inorganic nitrogen source and half the recommended rate of chicken dung. Ratoons applied with 2 t ha^{-1} chicken dung and those that were unfertilized had the least percent dead tillers. These show that as the number of tillers increase as a consequence of N application, the percentage of dead tillers will likewise increase. Vasantha (2014) reported high tiller mortality in narrow spacing due to heavy competition for nutrients among the tillers.

Absence of interaction between intercropping and fertilization schemes was noted revealing their independent influence on the percentage of dead tillers of ratooned adlay.

Figure 1. Dead ratoon tillers

Plant height (cm)

The height of adlay ratoons as influenced by intercropping and fertilization schemes and their interaction is presented in Table 1. Although not significantly different, monocrop ratoons were slightly taller than the other treatments. This implies that the napier intercrop had no adverse effect on the height of the ratoons.

On the other hand, the height of ratoons significantly vary among fertilizer treatments. All nitrogen fertilizer-treated plants were taller than the unfertilized ones. This can be attributed to the role of nitrogen as a major component of chlorophyll and amino acids essential for plant growth and development. Said findings contradicted the insignificant difference in height of fertilized and unfertilized adlay plants reported by Torred (2017) but in conformity with the findings of Amin (2011) on fodder maize and Tiwana et al. (2020) on napier bajra hybrid that nitrogen application resulted in increased plant height.

There was no significant interaction between intercropping and fertilization schemes. This means the variables had independent effects on the height of adlay ratoons.

Number of tillers hill^{-1}

The number of tillers per hill of adlay ratoons as influenced by intercropping and fertilization schemes and their interaction is indicated in Table 2. Although not significantly different, slightly more tillers per hill were developed from adlay ratoons with napier at 1:1 row ratio. This shows that the napier intercrop had no adverse effect on the tillering of the ratoons.

Significant variation was observed in the tillering of adlay ratoons as affected by fertilizer scheme. Ratoons applied with 30 kg N ha^{-1} + 1.5 t ha^{-1} chicken dung had the most number of tillers per hill (14 tillers) but comparable to those applied with 60 and 120 kg N ha^{-1} fertilizers. The least number of tillers were the unfertilized ratoons although comparable with those applied with 2 t ha^{-1} of chicken dung. The findings corroborated the significant effect of fertilization on the production of vegetative tillers of adlay reported by Torred (2017). Similarly, Farid et al. (2000) observed significant increase on the number of shoots per stump of sugarcane with increasing rate of nitrogen.

There was no significant interaction between variables on the number of tillers per hill of ratoons implying their independent effects on the parameter being measured.

Fresh herbage yield (t ha^{-1})

As shown in table 2, there was no significant variation on the fresh herbage yield of adlay ratoons (Figure 2) as influenced by intercropping scheme.

Figure 2. Harvestable adlay ratoons

The monocrop ratoons had slightly higher yield of 7.8 t ha^{-1} than those with napier intercrop which seems to indicate a slight adverse effect of the latter.

The fertilization scheme significantly affected the fresh herbage yield of the ratoons. Higher herbage yields were observed on F_1 to F_3 treatments (9 - 11 t ha^{-1}). This indicates that the higher the nitrogen rates applied, the higher the herbage yield. Those plants applied with 2 t ha^{-1} of chicken dung had a comparable lower herbage yield with the unfertilized ones. This means that adlay ratoons are

responsive to nitrogen fertilization which is in conformity with the findings of Amin (2011) that different sources of nitrogen significantly affected the fresh forage yield of fodder maize. However, Salvador Sr. (2016) found no significant effect of nitrogen fertilization on adlay growth and yield parameters.

No significant interaction was observed between independent variables implying their independent effect on the herbage yield of adlay ratoons.

Table 2. Number of tillers per hill, herbage yield (t ha^{-1}) and dry matter yield (t ha^{-1}) of adlay ratoons as affected by fertilization scheme

Treatments	No. of Tillers $Hill^{-1}$	Yield (t ha^{-1})	
		Herbage	Dry Matter
Intercropping Scheme			
C_1 = Ratooned adlay monocrop	11.4	7.800	0.618
C_2 = Ratooned adlay and napier at 1:1 row ratio	12.4	7.562	0.627
C_3 = Ratooned adlay and napier at 2:1 row ratio	11.5	6.465	0.506
F-test	ns	ns	ns
CV_a (%)	27.01	21.47	13.11
Fertilization Scheme			
F_0 = Unfertilized	9.3^{c}	3.123^{b}	0.243^{b}
F_1 = 120 kg N ha^{-1}	12.6^{abc}	11.007^{a}	0.841^{a}
F_2 = 60 kg N ha^{-1} + 1 t ha^{-1} chicken dung	12.7^{ab}	9.315^{a}	0.782^{a}
F_3 = 30 kg N ha^{-1} + 1.5 t ha^{-1} chicken dung	14.3^{a}	8.610^{a}	0.703^{a}
F_4 = 2 t ha^{-1} chicken dung	9.9^{bc}	4.322^{b}	0.349^{b}
F-test	**	**	**
Intercropping x Fertilization Schemes			
F-test	ns	ns	ns
CV (%)	24.18	22.14	13.50

Means within a column with the same letter and those without letters are not significantly different at 1% level of significance based on Tukey's HSD test.

** = highly significant

Dry matter yield (t ha^{-1})

Results showed that the dry matter yield of adlay ratoons did not vary significantly among intercropping scheme (Table 2). Slightly heavier dry matter was obtained from ratoons with napier at 1:1 row ratio as compared to the other treatments. This shows that the napier intercrop did not influence the dry matter production of the ratoons.

On the other hand, the fertilization scheme significantly influenced the dry matter yield of the ratoons as exhibited by the 0.841 t ha^{-1} dry matter of those applied with 120 kg N ha^{-1} although comparable with those ratoons applied with combinations of inorganic N source and chicken dung. The increase in dry matter yield of ratoons under nitrogen application can be attributed to the positive effect of nitrogen on all the growth parameters investigated in this study. This result points out that the growth of ratoons can be improved by application of nitrogen fertilizer (Oad et al., 2002; Pasaribul, 2018) as this is a component of chlorophyll that is essential in photosynthate assimilation (Mas, 2013).

No noticeable interaction between independent variables was observed implying their independent effect on the dry matter production of ratoons.

Correlation analysis

A number of parameters were correlated with the fresh herbage yield of adlay ratoons (Table 3). The number of adlay seed crop productive tillers was directly related to the herbage yield of the ratoons. This implies that herbage yield will increase if said adlay seed crop parameter will increase. Furthermore, ratoon plant height, number of tillers and dry matter yield were directly related to the herbage yield of ratoons. In other words, an increase in fresh herbage yield will be expected as the said factors will increase.

Table 3. Parameters correlated with the fresh herbage yield (t ha^{-1}) of adlay ratoons as influenced by intercropping and fertilization schemes

Parameters	Correlation coefficient, r	p-value	Linear relationship
No. of seed crop productive tillers	0.3752	0.0031	weak positive
Days to ratoon shoot emergence	-0.3457	0.0068	weak negative
Ratoon plant height	0.8210	0.0000	strong positive
Number of ratoon crop tillers	0.7682	0.0000	strong positive
Ratoon crop dry matter yield	0.9736	0.0000	strong positive

Arbitrary scale modified from Rumsey (2011) as cited by Torred (2017):

+/–1 = perfect positive/negative relationship

+/–0.70 – 0.99 = strong positive/negative relationship

+/–0.50 – 0.69 = moderate positive/negative relationship

+/–0.30 – 0.49 = weak positive/negative relationship

+/–0.10 – 0.29 = very weak positive/negative relationship

0 – 0.09 = No linear relationship

Forage quality

The percent crude protein (CP) of adlay ratoon forage as influenced by intercropping and fertilization schemes ranged from 7.35 - 7.76% and 5.79 - 9.05%, respectively (Table 4). Ratoons with napier at 1:1 ratio had the least %CP while those at 2:1 ratio had the highest %CP. On the other hand, application of 120 kg N ha^{-1} had the highest CP of 9.05% followed by plants applied with other inorganic fertilizers at lower rates and combined with chicken dung. The findings suggest that application of higher levels of nitrogen will increase the crude protein content of the forage, thus, conforming to reports that increasing nitrogen level increased the %CP of Marandu grass (Delevatti et al., 2019) and Mombasa grass (Escarela et al., 2017). Skerman and Riveros (1990) reported a CP of 8.5% on Job's tears green material in India.

As shown in Table 4, adlay ratoons with napier at 1:1 row ratio produced forage with slightly higher dry matter (DM) of 12.87% compared to adlay ratoons with napier at 2:1 row ratio (12.57%) and monoculture (11.88%). Kashat grass (*Coix lacryma-jobi*, L.) in India had DM content between 26.80 - 29.90% (Dnyandev, 2012; Skerman and Rivero, 1990). As to the influence of fertilizer scheme, the DM of adlay ratoon forage ranged from 11.56 - 13.57%. The forage of ratooned adlay applied with 2 t ha^{-1} chicken dung had the highest percentage of dry matter while those applied with 120 kg N ha^{-1} had the least. The findings suggest that application of higher levels of nitrogen will decrease the forage dry matter due to increase succulence. Rahman et al. (2016) stated that N fertilizer enhances the growth of shoot and makes the fodder juicy.

The acid detergent fiber (ADF) content of the forage of adlay ratoons as influenced by intercropping schemes ranged from 34.30% to 46.44% (Table 4). Forage of monocrop adlay ratoons had the highest % ADF while those ratoons with napier at 1:1 row ratio had the least percentage. It seems to point out that an increase in napier grass intercrop density will result in less fibrous forage of adlay ratoons. Among fertilizer schemes, application of 30 kg N ha^{-1} + 1.5 t ha^{-1} chicken dung resulted in the highest ADF (53.81%) of adlay ratoon forage while the least fibrous were forage of unfertilized ratoons. The findings indicate that fertilizer application, either organic or inorganic, will result in increased fiber content of forages. In contrast, Delevatti et al. (2019) reported a decrease in ADF of Marandu grass with increasing nitrogen level and Amin (2011) recorded highest crude fiber content only under unfertilized maize fodder. In India, Dnyandev (2012) reported 37.70% ADF content of Kashat grass (*Coix lacryma-jobi*, L.). Saha et al. (2017) stated that forages with higher ADF are lower in digestible energy than forages with lower ADF, which means that as the ADF level increases, digestible energy levels decrease.

The percentage of acid insoluble ash (AIA) in the forage of adlay ratoons ranged from 7.11 - 7.56% as influenced by intercropping scheme (Table 4). Such little difference in ash content implies that it was not affected by the napier grass intercrop. On the other hand, the percentage of AIA of adlay ratoon forage ranged from 6.64 - 8.94% as influenced by fertilization scheme. The higher AIA of 8.94% was observed on ratoon forage applied with 2t ha^{-1} chicken dung while the unfertilized ones had the least (6.64%). Said values were higher than the 2.23% AIA content of Kashat grass (*Coix lacryma-jobi*, L.) reported by Dnyandev (2012). The findings imply that chicken dung application probably enhanced the uptake of silicon which vary greatly with plant species ranging from 0.1 to 10.0 Si% in d.wt. (Tamai and Ma, 2003).

Table 4. Percent (%) crude protein (CP), dry matter (DM), acid detergent fiber (ADF) and acid insoluble ash (AIA) of ratooned adlay forage as influenced by intercropping and fertilization schemes

Treatments	CP (%)	DM (%)	ADF (%)	AIA (%)
Intercropping Scheme				
C_1 = Ratooned adlay monocrop	7.64	11.88	46.44	7.56
C_2 = Ratooned adlay and napier at 1:1 row ratio	7.35	12.87	34.30	7.11
C_3 = Ratooned adlay and napier at 2:1 row ratio	7.76	12.57	36.10	7.30
Fertilization Scheme				
F_0 = Unfertilized	6.82	13.37	25.10	6.64
F_1 = 120 kg N ha^{-1}	9.05	11.56	40.01	6.65
F_2 = 60 kg N ha^{-1} + 1 t ha^{-1} chicken dung	8.44	11.68	36.90	7.29
F_3 = 30 kg N ha^{-1} + 1.5 t ha^{-1} chicken dung	7.80	12.03	53.81	7.08
F_4 = 2 t ha^{-1} chicken dung	5.79	13.57	38.91	8.94

Conclusion

Based on the results obtained, the following conclusions can be drawn:

1. The intercropping scheme did not significantly influence the growth and yield components of adlay ratoons.
2. The fertilization scheme significantly influenced the % dead tiller, height, number of tillers $hill^{-1}$, fresh herbage yield and dry matter yield of adlay ratoons.
3. Application of 120 kg N ha^{-1} resulted in significantly better effect on the aforementioned parameters compared to without fertilization and application of 2 t ha^{-1} chicken dung but at par with the rest of the fertilized treatments.
4. Adlay ratoons with napier at 1:1 ratio had the least percentage of crude protein (CP), acid detergent fiber (ADF) and acid insoluble ash (AIA) but with highest dry matter (DM).
5. Adlay ratoons applied with 120 kg N ha^{-1} had the highest and lowest percentage of CP and DM contents, respectively, while the unfertilized ones had the least percentage of ADF and AIA among treatments.

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