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Effect of Legume - Grass Mixture on Forage Yield and Quality in the Pothwar Plateau of Pakistan

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Abstract: Appropriate ratio of rice bean and blue panic were studied to maximize forage yield and to assess crude protein content. There were five planting ratios consisted of sole rice bean legume, 75 % rice bean and 25% blue panic, 50% rice bean and 50% blue panic, 25 % rice bean and 75% blue panic and 100% blue panic grass. The experiment was conducted without fertilizer or irrigation. The mixtures were in general high yielding than any of the sole crops while, 75 % rice bean and 25% blue panic produced the highest dry matter yield of 7 t ha^{-1}. Crude protein content in the legume component was relatively higher and decreased with the increase of grass ratio.

Key words: Legume-grass mixture, forage yield, crude protein, Pothwar plateau

Introduction

Pakistan is facing huge pressure in agricultural land due to increasing human and livestock population pressure (Economic Survey of Pakistan, 1996). Due to economic pressure and reduction in productive agricultural land, intensive farming is required for better crop yields. Therefore farmers grow more and more cereals and omit the traditional fallow system. However, this practice is non-sustainable as soils are continuously being depleted of nutrients and addition of chemical fertilizers is not economically feasible due to their relatively high cost and lack of credit facilities.

The total productivity of agricultural systems in the developing countries depends not only on food crops but also on livestock production. In Asia, for example, more than 60% of food is produced by small-scale farmers who keep livestock in mixed crop-livestock farming systems (Qamar *et al.*, 1999). Moreover, biological fixation by legumes is an alternate to the inorganic nitrogenous fertilizers. Legumes can be grown successfully in soils that are depleted of nitrogen if conditions permit adequate rate of biological nitrogen fixation. Additionally when grown in rotation with cereals, legumes are known to have benefits other than those derived from an additional supply of N that are reduced build up of diseases and weeds (Welty *et al.*, 1988).

When livestock have fed with diets largely consisting of grasses, protein contents may often be below critical threshold. Therefore, increasing contents in animal diet will not only improve protein content but may also increase voluntary intake of entire diet (Osman and Osman, 1982). Intercropping forage legumes with grasses also increase forage yield and forage quality in terms of crude protein content, voluntary intake and digestibility (Tukel and Yilmaz, 1987). Grown in mixtures, erect grass plants provide support to twining legume stems potentially facilitating the mechanical harvest of the whole crop (Osman and Osman, 1982). Moreover, when grown in cereals may meet some of their nitrogen requirement from that provided by companion legumes and may also take advantage of the bulk of available soil nitrogen (Craig *et al.*, 1981). Thus grass productivity may also benefit somewhat from the presence of legumes in the mixture.

The soils of the Pothwar plateau are, in general, low in fertility and in particular, deficient in organic matter. Maize, sorghum and millet in summer and wheat in winter are cultivated and this continuous crop sequence has depleted the soil from nitrogen, as inorganic nitrogenous fertilizers are very restricted. Almost no fertilizer, either organic or inorganic is used for forage crops. Therefore introduction, and management of foragelegumes in the present farming system is crucial for sustainable crop-livestock production in the area. In this experiment, rice bean legume was intercropped with the bluepanic grass. The specific objectives are to determine the appropriate ratio for grass legume mixture of rice bean and blue panic to maximize forage yield, and to assess the variability in crude protein content available to livestock as a result of rice bean and blue panic mixture.

Materials and Methods

The experiment was conducted at the National Agricultural Research Centre, Islamabad, situated in the sub-tropical and sub-humid Pothwar plateau. Average annual rainfall recorded in the last 80 years is 944 mm mostly received in the monsoon season (Jilani *et al.*, 2001). Summers are very hot and the temperature may rise above 40°C in June and winters are cold with occasional frost events in January. The soil of the experimental site was loam deep and slightly alkaline. No fertilizer was applied at the time of sowing/tuft planting. Tufts of blue panic grass were planted with 50 cm plant-to-plant distance and the seeds of rice beans were sown with a hand pulled drill with a seed rate of 100 kg ha^{-1}. Row to row distance was 50 cm. No further irrigation or fertilization was applied throughout the study period.

Five planting ratios were imposed as sole rice bean legume, 75 % rice bean and 25% blue panic, 50% rice bean and 50% blue panic, 25 % rice bean and 75% blue panic and sole blue panic grass. The experiment was laid out in a randomized complete block design. The plots were harvested at the panicle stage of blue panic grass on 3rd October, 1998. Five plants were selected at random for recording data on plant height and number of branches per tillers. Fresh yield was recorded from 1m row selected at random avoiding the edge effect. The samples were placed in an oven at 72°C for 48 h and dry weights were recorded. The dried plant material was ground for crude protein content using the micro Kjeldahl methods (AOAC, 1975). Data were analyzed by ANOVA and the means were separated using Least Significant Difference (LSD) range test (Steel and Torrie, 1997).

Results and Discussion

Plants of blue panic were significantly taller than those of rice beans (Table 1). Maximum height of rice bean plants was observed in case of 25% rice beans and 75% blue panic (152

Table 1. Forage yield and quality of different mixtures of rice bean legume and blue panic grass in the Pothwar plateau of Pakistan.

Mixture ratio	Plant height (cm)		No. of branches or tillers/plant		Forage yield (t ha^{-1})		Crude protein content (%)		Crude protein yield (kg ha^{-1})
	RB*	BP**	RB	BP	Fresh	Dry	RB	BP	
RB 100	109.2	----	8.2	----	22.3	4.85	20.1	----	980
RB75+BP25	108.7	182.6	10.1	8.7	20.1	5.1	18.8	4.9	732
RB50+BP50	127.0	170.3	10.2	6.7	14.7	3.9	17.9	4.4	470
RB25+BP75	152.1	177.5	11.9	6.0	11.6	3.3	17.2	4.1	266
BP 100	-----	151.1	----	6.6	9.5	2.8	----	3.8	100
LSD (0.05)	16.8	18.6	1.8	1.2	4.3	0.9	3.3	0.9	61.4

* Rice bean ** Blue panic

cm) while plants of blue panic growing in 25% rice bean mixture had a maximum height of 183 cm. The same trend was observed in case of number of branches or tillers per plant. Rice bean produced least number of branches (8.2 per plant) while growing as pure and increased in mixtures. In general, plants of rice bean produced significantly high number of branches (10-12 per plant) as the ratio of blue panic grass in mixtures increased from 25% to 75%. The same general trend was followed by the blue panic plants. However, the plant growing as a sole species had more number of tillers per plant (6.6 per plant) than growing in 25% rice bean mixture (6.0 per plant). Maximum tillering in blue panic (8.7 per plant) was observed in plants growing in 75% rice bean.

Highly significant differences in dry matter production of different mixture ratios of rice bean and blue panic were observed. Mixtures of the species were generally more productive than their cultivation as a pure. Dry matter yield in mixtures was significantly higher than any of the sole crops. Rice bean 75% + blue panic 25% was almost twice more productive than any of the sole species yielding highest dry matter of 5.1 t ha^{-1}.

Crude protein content was significantly higher (around 18%) in rice bean than in blue panic (around 4%). Crude protein content slightly decreased from 20.5 to 17.3% as the proportion of blue panic in mixtures increased from 25 to 75%. In case of blue panic grass, crude protein content was least in sole crop (3.69%) and increased gradually from 4.06 to 4.62% as the proportion of rice bean in the mixtures increased from 25 to 75% except for blue panic in 50:50 mixtures where crude protein content was almost similar to pure blue panic species (3.73%). There were highly significant differences for crude protein yield in various rice bean – blue panic mixtures. The highest amount of crude protein was found in pure rice bean (980 kg ha^{-1}) and least in blue panic species (100 kg ha^{-1}). In general, crude protein yield decreased as the ratio of blue panic in mixture increased.

It is quite clear from the results that the mixtures of rice bean and blue panic were much higher productive than either of the sole cultivation of these species. Increased productivity through mixtures has been reported by many researchers (Moreira, 1989 and Soya, 1994). This has been attributed to the availability of overall nitrogen nutrition, which is not only due to the additional yield of legume component but also from the productivity of individual plant of grass component through better nitrogen supply at the single plant level (Qamar *et al.*, 1999). This is also reflected in the data (Table 1) where crop height and tillering percentage were higher in plants grown in mixtures. This can be provided either through facilitative effect (Vallis *et al.*, 1967) arising from leakage of nitrogen from decaying leaf drops of growing rice bean in blue panic roots. Another reason may be the sparing effect, which results from decrease in interspecific competition for nutrient uptake especially nitrogen (Vallis *et al.*, 1967) because rice plant's nitrogen requirement is largely satisfied through symbiotic biological nitrogen fixation process which is clear from the nitrogen content and nitrogen yield.

Rice bean is a twining legume and commonly forms a dense mat of partially lodged material which might be a disadvantage compared to plants in mixtures that are supported by blue panic plants and have a greater ability to intercept and absorb solar radiation (Qamar *et al.*, 1999). Although the main reason of high yielding intercrops is the biological nitrogen fixation of the legume component, however, non-nitrogenous components may not be totally ignored (Peoples and Herridge, 1990). Use of legume - grass mixtures not only increases forage yield but also provides physical support to the twining legumes (Osman and Osman, 1982).

Among the different intercrop ratios, the mixture with the highest proportion of the legume component (75%) produced the highest dry matter yield. This is due to the fact that the proportion of grass (25%) growing in the legume (75%) produces much more forage than growing in the relatively lower proportions the legumes or growing as a sole species, thus maximizing the overall yield. The similar results have been reported by Munzur (1993), Soya (1994) and Qamar *et al.* (1999). Papastylianou (1990) has reported one example of the opposite effect but this was probably under the conditions where N supply was not limiting. If abundant supply of N is available in the soil which is available to the legume then the grasses or cereals are capable of producing much more yield than the legumes (Qamar, 1997). The improved performance of the intercrops was resulted not only from the overall productivity but also from the improvement in quality of the individual plant.

Dependency on chemical fertilizers is a major drawback in crop production in Pakistan especially in arid agriculture due to their relatively high cost and uncertain supply. There is an acute shortage of good quality forage (Nordblom, 1988). Therefore, it is suggested that grass/legume intercropping system may be introduced which will not only increase overall livestock production through enhanced availability of better quality but will have beneficial effects on the soil rehabilitation.

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