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IMPACT OF INTERCROPPING AND FERTILIZER APPLICATION ON BIOMASS PRODUCTION OF FODDERS

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To evaluate the effect of intercropping *Panicum maximum* (Blue Panic) grass and legumes (*Vicia sativa* and cowpeas) alone or coupled with fertilizer application, a study was conducted under rain-fed conditions for two consecutive years (2005 to 2007) at National Agriculture Research Center Islamabad, Pakistan. In this experiment, intercropping (33, 50 and 67%) of grass and legumes alone as well as coupled with fertilizer application at the rates of 25, 75 and 50 kg ha^{-1} (N, P_2O_5 and K_2O) was evaluated. Intercropping and fertilizer application studied substantially increased fodder biomass production along with enhancement of soil N and organic matter during both years. The grass and legumes biomasses under control treatment were recorded as 7.09 and 8.17 t ha^{-1} during first and second year of study, respectively. Mixed fodder production increased to 11.62, 13.6 and 14.13 t ha^{-1} with 33, 50 and 67% intercropping, respectively. Respective values of biomass were 12.71, 14.79 and 17.72 t ha^{-1} due to fertilizer supplementation. Thus, combination of 67% intercropping and fertilizer proved to be the best treatment in both years.

Keywords: *Panicum maximum*, *Vicia sativa*, cowpeas, tillering, intercropping, dry biomass

INTRODUCTION

Livestock accounts for 52.2 percent of agricultural value added products in Pakistan, contributes 11 percent to GDP and supports the lives of 30-35 million people in rural areas of the country. Livestock rearing is a highly labour-intensive activity and if proper attention is given to this sector, it will not only absorb more rural workforce but also help to alleviate rural poverty in the country. In order to achieve higher sustained growth in agriculture, it is absolutely necessary for the government to pay more attention to livestock and dairy sector. Presently, there are 176.4 million livestock heads in Pakistan which contributes around 11.9 percent towards GDP (Anonymous, 2014) that was 169.5 million heads during 2012-13 which was accounting for11.8 percent to GDP (Anonymous, 2013). Thus, there has been an increase of only 0.1 percent share in GDP in last year that indicates very poor performance of this important sector and also that the vast resource of the country is not being managed on scientific basis. Thus, only 10-50% of their actual potential is being realized (Ali *et al.,* 2001).

One of the major problems hindering expansion of ruminant production in the country is the un-availability of good quality fodder in sufficient quantity. Livestock has been receiving 51, 38, 3, 6 and 2 % of nutrients from green fodder, crop residues, grazing (bare lands and post harvest), cereal by-products and oil cakes meals, respectively (Sarwar *et al.,* 2002).Production of good quality fodder is of great importance for economical animal production. Both quality and quantity of fodders are influenced due to plant species (Kaiser and Piltz, 2002), stage of growth (Kim *et al.,* 2001) and agronomic practices (Rehman and Khan, 2003). Leguminous plants supply the major portion of protein consumed by man either directly or indirectly through animals (Bose and Balakarishnon, 2001).

The grass species *Panicum maximum* var. Tanzani is a tall growing (2-3m), vigorous, coarse, tufted perennial and shows considerable variation in growth habit. Vetches (*Vicia* spp.) are legumes which are well adapted to winter growth in Mediterranean environments throughout the world on a variety of soil types and are used in West Asia and Australia for various purposes as green forage, hay, seed crop or green manure. Cowpeas (the legume species *Vigna unguiculata*) native to South and Southern Asia are known for their diverse distribution and range of adoption from the humid sub-tropical to warmed cool temperate climate. It is highly palatable, nutritious and rich in protein, calcium and phosphorus than many other summer legumes. Legume forages are rich in proteins, minerals and vitamins. Forage legumes increase soil fertility and also control soil erosion. These are also used with diets that are largely consisting of grasses and whose protein content often falls below minimum critical level. Therefore, increasing leguminous share in animal diet not only increases protein content but also enhances voluntary intake and digestibility of entire diet (Parveen *et al.,* 2001). Keeping in view the limitations and constraints regarding fodder faced by the farmers engaged in livestock production, the present study was conducted to evaluate the yield performance of grass-legume mixtures under different growing seasons and to assess the impact of fertilizer for better fodder production.

MATERIALS AND METHODS

The study was conducted at National Agricultural Research Center, Islamabad where an appropriate site was selected, leveled and soil samples were obtained from 0-15 cm soil depth. The samples were prepared and analyzed having soil pH 8.4, ECe 0.53 dS m^{-1}, total N 0.037%, available P 4.7 mg kg^{-1}, extractable K 79.6 mg kg^{-1}, O.M 0.53% and textural class was sandy clay loam. *Panicum maximum* grass was planted in 2005 as perennial fodder. After its establishment, winter legume (*Vicia sativa,* commonly known as vetch) and summer legume (*Vigna unguiculata,* commonly known as cowpeas) were sown as intercrop in the established grass after its harvesting. Summer legume was followed winter legume in the next year. The experiment was laid out in randomized complete block design (RCBD) with 4 replications, under rain fed conditions and no irrigation was applied. The treatments were as T_1 = Grass (*Panicum maximum)* 100%, T_2 = Seasonal legume (*Vicia sativa)* and (*Vigna unguiculata)* T_3 = 67%, Grass + 33% legumes, T_4 = 50% Grass + 50% legumes, T_5 =33% Grass + 67% legumes, T_6 = T_1 + NPK fertilizer, T_7 =T_2 + NPK fertilizer, T_8 = T_3 + NPK fertilizer and T_9 = T_4 + NPK fertilizer and T_{10} = T_5 + NPK fertilizer. Two lines of legumes with four lines of grass were grown to establish T_3 (33% legumes) while there were three lines of each in case of T_4 (50% legumes). In case of T_5, four lines of legumes were grown with two lines of grass to obtain the share of 67% of the former. A basal dose of fertilizer was applied to the treatments T_6 to T_{10} at the rates of 25, 75 and 50 Kg NPK ha^{-1} in the form of urea, single super phosphate and sulphate of potash, respectively. Grass was harvested at panicle stage whereas legumes were harvested at 100% flowering.

Fresh and dry matter yield were recorded from each treatment separately after harvesting of fodder crops. Data were collected for fresh biomass and dry matter yield. Fresh biomass (t ha^{-1}) was collected from each plot of grass and legumes. All the plants in one square meter were clipped close to ground level. Three quadrates were harvested randomly for fresh biomass. The data of fresh biomass and dry matter yield were calculated on t.ha^{-1} basis. The fresh samples were oven-dried to a constant temperature at 70°C for 72 hours. The samples were weighed and dry matter yield (t ha^{-1}) was recorded. Meteorological data during the crop growth were recorded pertaining to rainfall, humidity, pan evaporation, wind speed, sunshine hours and temperatures were obtained to elaborate and understand the experimental results under the light of climatic changes. The meteorological data of three years i.e. 2005, 2006 and 2007 were collected and divided by 36 months. This data is overall average of months during three years of study. Monthly average rainfall was 86 mm, 104 mm and 118 mm, wind speed 60 km day^{-1}, 51 km day^{-1}, and 46 km day^{-1}, pan evaporation 4 mm day^{-1}, 4 mm day^{-1} and 4 mm day^{-1}, sunshine 8 hours day^{-1}, 8 hours day^{-1} and 8 hours day^{-1}, monthly maximum and minimum average temperature 28°C & 13°C, 28°C & 14°C and 28°C & 13°C, and average maximum and minimum relative humidity were 83% & 49%, 81% & 51% and 83% & 50% during the study period i.e., 2005, 2006 and 2007, respectively (WRRI, 2007). Data were analyzed using one-way analysis of variance with the help of computer program of MSTAT-C least significant difference (LSD) and treatment means were compared by employing at 5% probability level was applied for multiple comparisons (Bicker, 1991).

RESULTS AND DISCUSSION

A significant increase in forage production of grass as well as legumes was recorded when these were fertilized with NPK as starter dose (Tables 1 & 2). Such effect was observed not only in case of grass and legumes alone but also in all the intercropping combinations. Nhamo *et al.* (2003) concluded the potential of cowpea to improve soil fertility, household food security and income was high. Most farmers intercropped cowpea with maize Positive effect of fertilizer was persistent in all the four crops during two years of study. However, increase in biomass production was more in the later three crops (Two seasonal legumes and second established grass) as compared to the first crop (Grass) that might be due to more production of legumes. These results are similar to those of Canan and Orak (2007) who recorded lower biomass yield in oats and vetch mixture stands in first year as compared to the next year. The effect of intercropping of legumes (winter and summer) to extent of 67% was not found detrimental on total biomass yield. A significant increase was observed over grass alone when legumes were intercropped by 33, 50 and 67%. Intercropping was significant in all the crops. Dantata (2014) concluded that intercropping with legumes is a desirable agronomic practice towards boosting crop production. Webster and Wezi (2003) concluded that intercropping of maize and pigeon pea has proved to be the most successful. However, fertilization and intercropping combinations

Table1. Effect of fertilizer on fresh weight (t ha^{-1}) in grass-legumes intercropping.

Treatments	1st Crop	2nd Crop	3rd Crop	4th Crop
T1 Grass alone	5.13 i	4.40 g	5.36f	7.67g
T2 Legume alone	5.62 h	4.75 fg	4.28g	7.53h
T3 Intercropping 33%	5.93 g	5.42 e	6.34e	8.25f
T4 Intercropping 50%	7.00 f	8.58 d	7.22d	9.34d
T5 Intercropping 67%	7.37 e	10.03 b	8.58c	10.08c
T6 Grass + Fertilizer	7.77 d	5.93 e	6.37e	9.20d
T7 Legume + Fertilizer	7.84 cd	8.82 cd	5.25f	8.79e
T8 Intercropping 33%+ Fertilizer	7.98 c	8.97 bcd	8.24c	10.42c
T9 Intercropping 50% + Fertilizer	9.47 b	9.63 bc	10.94b	11.61b
T10 Intercropping 67% + Fertilizer	9.70 a	12.38 a	12.30a	12.57a
LSD	0.1394	0.7980	0.5895	0.3970

Fresh weight included grass and respective legume together

Table 2. Effect of fertilizer on dry weight (t ha^{-1}) in grass-legumes intercropping.

Treatments	1st Crop	2nd Crop	3rd Crop	4th Crop
T1 Grass alone	1.56 e	1.90 g	1.87g	2.57f
T2 Legume alone	1.91 d	1.83 g	1.51g	2.71f
T3 Intercropping 33%	1.95 d	2.38 i	2.19f	2.95ef
T4 Intercropping 50%	2.16 d	3.65 d	2.50b	3.22d
T5 Intercropping 67%	2.29 d	4.53 d	2.93c	3.60c
T6 Grass + Fertilizer	2.41 c	2.50 i	2.20e	3.22d
T7 Legume + Fertilizer	2.71 b	2.63 i	1.80g	3.07de
T8 Intercropping 33%+ Fertilizer	3.00 a	3.10 d	2.94c	3.67bc
T9 Intercropping 50% + Fertilizer	3.03 a	4.02 d	3.91b	3.84b
T10 Intercropping 67% + Fertilizer	3.47 a	5.60 a	4.51a	4.14a
LSD	0.5715	0.7780	0.2878	0.2385

Dry weight included grass and respective legume together

proved more economical and caused significant increase in biomass over monoculture of grass or legumes. The combination of 67% intercropping and fertilization proved the most beneficial and produced maximum biomass that was significantly higher than all the other treatments of the experiment (Fig.1). The increasing biomass yield of mixture forages of the present protocol is similar to that reported by Kumar *et al.* (2001) who indicated that the green forage yield increased significantly ($P<0.05$) with increase level of nitrogen fertilizer. The increasing trend of forage yield in response to increasing level of N fertilization was also observed Sultana *et al.,* 2005. The overall production of biomass of fodder from four crops during two years was 13.35 and 17.72 t ha^{-1} due to intercropping of grass-legumes by 67% alone (without fertilizer) and coupled with fertilizer application as against 7.9 t ha^{-1} of grass alone. The increases in biomass production due to this treatment was calculated as 122, 195, 141 and 61% over grass alone in the first, second, third and forth crop, respectively indicating more effectiveness of legumes in earlier stage because an increasing quantum of grass alone was recorded as well with time due to establishment of grass being of perennial habit. The increases were computed as 82, 206, 199 and 53% over monoculture legumes in case of first, second, third and fourth crop, respectively.

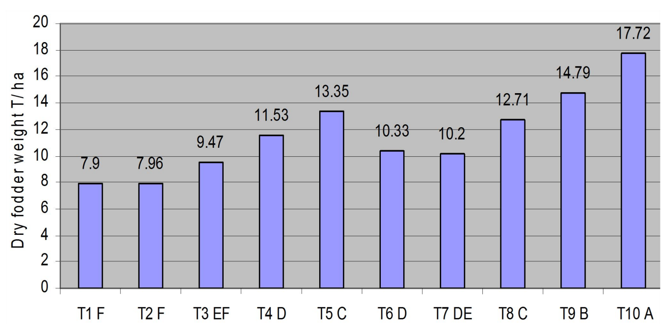

Figure 1. Effect of grass-legumes intercropping and fertilizer application on dry weight of Fodder.

Growth of plants is mainly affected by the soil, water and environmental factors. No stresses were provided under this experiment and there was only factor of intercropping that might create space problem and light competition due to more plant population. Intercropping 67% did not show negative trend due to which increased biomass was recorded. This was further resulted that competition of crops did not disturb plant growth of each other. Therefore, conditions of plant growth remained favorable and produced maximum biomass. Fertilization of crops also remained beneficial and its combination with intercropping further increased forage yield (Fig. 2&3).

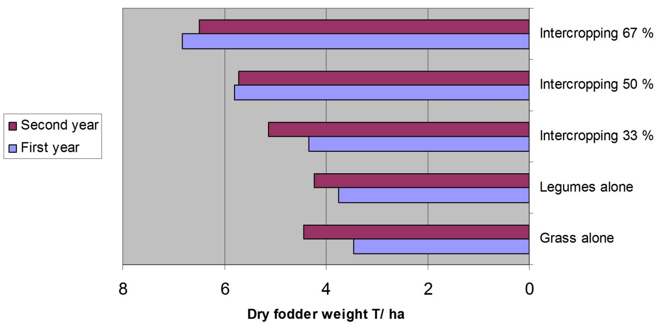

Figure 2. Year wise effect of intercropping on dry fodder weight of fodder.

Figure 3. Year wise comparison of fodder production due to fertilizer application.

The biomass and grain yields of the legumes more than doubled with the application of P. Webster and Wezi (2003) concluded that intercropping of maize/ pigeon pea has proved successful. This may be due to more establishments of forage grass and legumes by root nodulation. Elessesser (2004) also noted significant increase in dry matter yield in lucerne varieties with 4 cuts due to more assimilation of nitrogen in legume root's nodule. These results are in conformity with other investigations as well because Shisaya (2005), Hoffmann *et al.* (2004), Vasilev (2004), Giacomini *et al.* (2003), Kuzeev (2002), Odhiambo and Bomke (2001), Mohaptra *et al.* (2001), Turk (2000), Ibewiro *et al.* (2002), Elessesser (2004) and Malhi *et al.* (2004) also recorded higher fresh/dry biomass when different leguminous crops were intercropped with non-leguminous crops or grasses. Nitrogen fixation is relatively low in response to high inorganic N supply that was estimated less than 20% of the harvested N in alfalfa. Where forage yield was high and inorganic N supply was low, N_2 fixation by alfalfa appeared to be greater than 400 kg Nha^{-1}. Biological nitrogen fixation occurs mainly through symbiotic association of legumes and some woody species with certain N_2-fixing microorganisms that convert elemental nitrogen into ammonia (Shiferaw *et al.*, 2004).

***Conclusions*:** Biomass production of blue panic grass (*Panicum maximum*) can be increased significantly by intercropping of legumes (*Vicia sativa* or cowpeas) with levels of 33, 50 or 67%; the last one proved to be the most effective. Fertilizer application (25, 75 and 50 kg ha^{-1} N, P_2O_5 and K_2O respectively) also increased biomass production.

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