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Investigating the effect of corn and mung intercropping on the yield and quality of *Vigna radiata* in the climate of Shoush city

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ABSTRACT:

Cultivating long grain such as sorghum and corn -with members of fabaceae is one of the most popular kinds of intercropping. The experiment was carried out in the form of split plot in a private farm in Shoush city, 8 Km away from Shoush – Dezful road, in 2013. The experimental design was a Randomized Complete Block Design (RCBD) with four replications. The maximum yield of wet forage in the treatment of C_{100} (pure corn + 100% normal density of mung without weeding) was 42.48 tons per hectare and the minimum of that treatment M_w was 13.85 tons per hectare in the intercropping treatment. The maximum yield of dry forage in the treatment of C_{100} was 9095 tons per hectare and the minimum of that treatment M_W was 2.67 tons per hectare. The lowest percent of digestibility in the treatment of M_0: pure mung with weeding was observed with the percent of 64.58%. The effect of intercropping was obvious in other studied features. The purpose of this study was to investigate the quality of forage of both crops and recommending its intercropping provided that it results in better performance and higher quality and protein.

Keywords:

Mung ,corn, intercropping, yield and quality

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INTRODUCTION

Intercropping means the growing of two or more crops in proximity which is very popular in developed countries because of the high yield (Park *et al.,* 2002). Intercropping is done in two forms namely alternative and additive; in additive form, some plants are added to the home agriculture and in alternative form a specified portion of plants of a species eliminated and substituted with its plant equivalent of second species (Mazaheri, 1998). The general experience of intercropping experiments is that the yield of forage of each plant in intercropping is less than the yield of the same plant in pure cropping, but the total production capacity per unit surface is more in intercropping than pure cropping (Nandi and Haque, 2008). The findings of different researchers shows that leguminous and non-leguminous intercropping are more beneficial than alternative series in all density of pure cropping (Neumann *et al.,* 2007)

The problem will be solved by maize intercropping with legumes. The rival between maize and legume is reduced in intercropping with legume and legume portion increases in producing the dry matter and protein (Saleem, 1995). The content of forage raw protein is one of the most important criteria in investigating the forage quality (Assefa and Ledin, 2001). Legume intercropping with non-legume plants often increases the degree of harvested raw protein in hectare per pure cropping of grains (Nadi and Haque, 2008). The degree of increase of quantity and quality of forage and its benefit depends on the type of chosen plants and suitable agriculture management. Similar to this study, grain has more digestive nutrients in the study of Lithourgidis *et al.* (2006) and it is reduced by increasing the ratio of legume in forage. Oveysi (2005) investigated the intercropping of two corn hybrids (SC604, SC704) and reported that the degree of yield in intercropping is more than mono-cropping of the two plants. Corn is one of the chosen plants for ensiling because of its high yield, the quality of fermentation and energy content (Maasdorp and Titerone, 1977).

But this plant lacks protein; thus, it is necessary to be intercropped with one of the plants of legume family for reinforcing the forage protein. Mung has the essential properties to be intercropped with corn such as tolerating shadow, good performance, the ability of quick vegetation development annual growth habit, non-rising growth, and high content of raw protein. Local mung is one of the legumes which is cultivated in the region in this regard. It is an early plant like corn and has a lot of leaves and also can increase the quality of the forage. Mung forage is delicious for animals and increases the milk of animals a lot in form of green, dry and ensiling. Mung forage is rich in protein and if it is harvested on time, the amount of its vitamin is about 10 to 20 percent. Nutritional value of mung is the same as *Trifolium*. All animals eat the mung forage with appetite when flowering. Maize is one of the chosen plants for ensiling because of high yield, fermentation quality and energy content (Maasdorp and Titerone, 1997).

Due to the biological properties of the plant and lack of organic materials in the soil of the country, using the plants for grains should gradually increase. On the other hand, in the region with short growth period, mung is used as the plant between the main plants, for example mung is cultivated between winter wheat and summer maize in Khozestan. Thus, cultivating the plant is necessary in the country. Mung varieties are mostly local which have a low production potential. Therefore, consuming high product varieties and supplying the needed nutrients by using manure and biological fertilizer is necessary. Plants compete for absorbing natural resources but they can live together successfully in the condition of needs and in different ecological nests. Leguminous and non-leguminous plants is one of the simple and normal examples in which non-leguminous plants get their nitrogen from the inorganic resources of the soil and legumes get the nitrogen by coexisting with special bacteria (Hauggaard-Nielsen *et* *al.,* 2002).

Using the forage, legume can stabilize a great amount of nitrogen and reduces the competition one of the main resources. Plants with different root pattern which use different layers of soil reduce the competition for food and water (Bitch, 2005). Type of intercropped plants can impact on the intercropping yield. Lauriault and Kirkesy (2004) observed that when wheat and triticale are intercropped with winter pea and *Vicia,* their yield decreased but still it is more than the pure culture of rey, barley and *Avena sativa* or their intercropping with pea and *Vicia*. Sometimes, intercropping does not show dominancy over the pure culture. Jahansooz *et al.* (2007) intercropped wheat and pea and they noticed that the yield of pea seed in intercropping equals to 29 percent of pea pure culture while wheat seed production in intercropping was 72 percent of wheat pure culture. In the intercropping of corn with *Lablab purpureus*, maize yield in simultaneous cropping reduced with delay in cultivation so that the product of maize was 1.7 ton per hectare in early culture and 1.3 ton per hectare in late culture. Delaying in cultivating *Lablab purpureus* led to the increase of corn yield (Gbaraneh *et al.,* 2004). The results of different researchers shows legume and non-legume intercropping in all density is more beneficial in comparison with alternative series of pure culture (Bulson *et al.,* 1997; Carr *et al.,* 1995). In intercropping of normal *Vicia* with *Avena sativa*, *Vicia's* forage yield was more than 34% in comparison with pure culture, but its yield was 57% lower than *Avena sativa* pure culture (Caballero *et al.,* 1995).

Although cultivating two plants next to each other force them to compete for absorbing the effective resources of growth such as water, light, nutrient and space, if these plants are chosen correctly, they use the resources effectively and increase the production. Success of intercropping depends heavily on optimal use of growth resources especially water and light by intercropped plants (Soetedjo *et al.,* 1998). Yield benefit is the main reason of choosing the intercropping which lead to use of more effective resources for growth by intercropping than pure culture, especially when legume and geramineae are cultivated together (Fukai and Trenbeth, 1993). Intercropping of legume and non-legume often leads to the effective use of limited resources of growth (Wilson, 1998). Ogindo (2003) noticed that intercropping uses water and resources optimally and also has a greater yield than pure culture. Plant components of intercropping have different needs; therefore, using fertilizer is complicated especially time, application and amount of fertilizers for obtaining the highest economical effect without biological unbalancing of legume in nitrogen economy is complicated (Ghosh 2004).

Producing dry matter and seed depend on the ability of the plant in absorbing the resources. Intensive farming especially multiple cropping in a year improve the absorption of resources and their production power. Double cropping has a greater effect on absorption of water than light (Caviglia *et al.,* 2004). Optimum use of resources in relation with seed yield in intercropping of wheat and pea and pure culture of wheat was at least double of pure culture of pea. Producing dry matter in intercropping is related with the development of vegetation and absorption of radiation (Jahansooz *et al.,* 2007). Kruger *et al.* (2008) investigated pure culture and mixture of corn, bean and squash (*Cucurbita*) and observed that pure culture of corn has the greatest index of leaf level; it may be because of the low internal competition of bottom coverage of maize for light. With the increase of leaf level in the system, the available light decreased in the ground level. In the research of Tsubu *et al.* (2001), quick development of vegetation by intercropping of corn and bean absorbed radiation 15 percent more than their pure culture. Intercropping usually increases the percent of seed nitrogen. In the research of Neumann *et al.* (2007), intercropping of pea and *Avena sativa* led to a meaningful increase of seed

Table 1. Physical and chemical features of soil (0-30 cm)

EC (deci Siemens on m)	pH	Percent of organic carbon	Total nitrogen percent	Presumable potassium (ppm)	Presumable phosphorus (ppm)	Texture	Saturation percent	TNV	Clay Percent	Silt Percent	Sand Percent
1.69	7.05	2.43	21	220	6.8	loam	45.5	38	14	37	49

nitrogen in comparison with pure culture. The density of pea did not effect on the nitrogen content of *A. sativa* seed. Nitrogen content of pea was not affected by its density, but its content was more than pure culture in intercropping with *A. sativa* and also with the increase of *A. sativa* density. Nitrogen content of *A. sativa* seed did was not affected by pea density but it is increased in intercropping with pea. More nitrogen yield in intercropping of pea and *A. sativa* was one of the benefits of intercropping of these two plants in comparison with pure culture of *A. sativa*.

Intercropping of forage gramineae and legume usually increases the content of forage nitrogen (Abbas *et al.,* 2001) and also the higher yield of forage protein in comparison with pure culture of gramineae (Koosla *et al.,* 2004, Nnadi *et al.,* 2008).

The purposes of this study include:

- Determining the yield and qualitative properties of pure culture and intercropping of mung and corn and their comparison.
- Investigating the possibility of simultaneous use of cultivating two forage crops in regard with the optimum use of the land.
- Investigating the forage quality of both crops and also recommending their intercropping ability to get more yield, quality and higher protein.

METHODS AND MATERIALS

The experiment was carried out in a private farm in the city of Shoush, 8 kilometers away from Shoush-Dezful road in 2013 with the geographical coordinates of 47º1' E and 32º 2' N and sea level to 87m.

Therefore, for determining some physical and chemical features of the soil, a portion of the farm's soil sampled by using Agar device before the start of experiment and treatments. Table 1 presents the results of studying the farm's soil.

Research Method and Statistical Plan

The experiment was carried out split plot. The experimental design was a Randomized Complete Block Design (RCBD) with four replications. Cultivars which are common in the region consisted of SC 704 corn and mung. The main factors of two figures and sub factors include:

C_0: Pure corn with weeding

C_W: Pure corn without weeding

C_{50}: Pure corn + 50% normal density of mung without weeding

C_{75}: Pure corn + 75% normal density of mung without weeding

C_{100}: Pure corn + 100% normal density of mung without weeding

M_0: Pure mung with weeding

M_w: Pure mung without weeding

After ploughing, the land and furrows with tractor, the intended land was divided into 4 replications (block). The distance between the two blocks was 5m to make two streams by tractor for water entry and exit. Each replication (block) includes two main plots (mung and SC 704 corn) in which different compounds of mung and corn seed quantities set accidently inside the main plots of each block. Thus, each main plot was divided into 7 subplots. Each subplot include 4 rows with defined amounts of mung and corn set in each subplot in the

Table 2. Results of analysis of variance of studied properties

Studied properties	Wet forage (Kg/ha)	Dry forage (Kg/ha)	Crude ash (%)	Digestive matter %	Digestibility (%)	Crude protein %
Replication	$1.92^{\times}$	0.14^{ns}	$0.85^{\times}$	0.12^{ns}	0.03^{ns}	$1.7^{\times\times}$
Error	0.37	0.14	0.001	0.04	0.11	1.86
Intercropping	$1224.2^{\times\times}$	$67.7^{\times\times}$	$67.1^{\times\times}$	$114.7^{\times\times}$	$425.2^{\times\times}$	$183.2^{\times\times}$
Change coefficient	21.16	25.3	0.34	10.4	13.4	20

ns: meaningless, × meaningful in the level of 5%, ×× meaningful in the level of 1%

form of intercropping or serial. The distance between rows was 50 cm and length of each row in each replication was 5 m. Thus, each plot was defined in the dimension of two valleys, so that there were four rows for cultivation and one row of uncultivated land between the subplots. As investigating the efficiency of water consumption was one of the purposes of the research, therefore, the distance between the main plots was 3m to prevent the impact of possible moisture of each main plot to the adjacent plot. Irrigation was done based on the mentioned treatments. Mixed sampling was carried out for obtaining the degree of low and high consuming elements of soil in the experimental area. Fertilizing the land was done at the same time with cultivation in stripped form based on soil test and according to the latest fertilizer recommendation. In addition to fertilizer, manure was also used at the time of cultivation. Sowing the seeds was done based on the aforementioned amounts in form of mixed and on a row in each 10 m^2 plot. Except weeding and irrigation, other actions were carried out for treatments simultaneously. Harvesting was for comparison of wet forage at the time of mung flowering and for the corn at the time of 10-20% of flowering in two crops (55 and 105 days after greening).

Forage harvest was done in the level of 7 m^2 by deleting the border of each plot. Finally, the sample distributed and wet forage yield was calculated for the level of one hectare. After harvesting each plot, a 1kg sample was provided for each treatment and dried for about 48 h in the oven at the temperature of 85^0Ċ. After drying, the samples were weighed again and the percent of dry matter and wet weight of each treatment was defined. Then, dry forage yield was calculated for one hectare per ton. Five shrubs were taken accidently, the number of seed calculated and the average number of shrub seeds were determined. Then seed weight was measured in 7 m^2 of harvested sample and was calculated for the level of one hectare per Kg.

A 2 Kg sample was taken for measuring the qualitative features of forage and then dried, milled and then measured by the National Internet Registry device for doing other experiments of forage qualitative features (Jafari *et al.,* 2003).

Statistical programs of MSTATC were used for statistical analysis of sampling data including simple and compound analysis of variance. Diploma in Medical Radiology Technology (DMRT) was used for the comparison of intended features and the effects of intended factors was determined after data analysis.

RESULTS AND DISCUSSION

The effect of intercropping methods on wet forage yield

According to Soetedjo *et al.* (1998), Fukai and Trenbath (1993) and Wilson (1998) intercropping of legume with non-legume often leads to effective use of limiting growth resources. In the treatment of intercropping, the maximum yield of wet forage was in the treatments of C_{100} (pure corn + 100% normal density of mung without weeding) which were 42.48 tons per hectare and the minimum was Mw with the average of 13.85 tons per hectare (Figure 2-4). Wet forage yield has a direct relation with total level of vegetation in which C_{100} (pure corn + 100% normal density of mung without

Table 3. Result of comparison of the average of studied properties

Properties	Wet forage (Kg/ha)	Dry forage (Kg/ha)	Crude ash (%)	Digestive matter (%)	Digestibility (%)	Crude protein (%)
	30.8[a]	7.11	7.3[a]	20.4[b]	74.5	13[a]

Means that have the same letters are not statistically significant

weeding) is in its maximum level in mentioned treatment (Figure 1). Mung improves the growth condition of sorghum by increasing the soil nitrogen by means of biological stabilization and as sorghum belongs to C_4 plants and has high growth rate and aboveground bulky organs, its presence in existing treatments increases the yield of wet forage (Javanshir *et al.,* 2004).

As Carr *et al.* (1998) and Jenson (1996) reported intercropping of legume with non-legume often increases the yield which is similar to our claim. In the treatment of intercropping, the maximum yield of wet forage was in the treatment of C_{100} with the amount of 28.24 tons per hectare and the minimum was in the treatment of Mw with the average of 16.11 tons per hectare (Figure 1).

According Ghosh (2004), wet forage yield in grains intercropping produced at least 20% wet forage more than pure culture; it was also proved in this experiment.

The effect of intercropping method on dry forage yield

Intercropping increases the yield more than pure culture because it competes for more growth and production (Assefa and Ledin, 2001). Neumann *et al.* (2007) reported that the maximum density of seed yield in the intercropping of pea and *Avena sativa* was more than the optimum density of pure culture. In other word, the optimum density of intercropping was more than the optimum density of pure culture, therefore, the two species did not compete for the same resources and thus, more resources was available for intercropping than pure culture. Triticale and *Avena sativa* had a rapid growth when cultured pure than when intercropped with normal *Vicia.* This was because of the competition of *Vicia* with them (Assefa and Ledin, 2001).

In intercropping treatments during first year, the maximum yield of dry forage was in the treatment of C_{100} with the amount of 9.59 tons per hectare and the minimum belonged to Mw with the average of 2.67 tons per hectare (Figure 2).

The maximum dry forage yield in intercropping treatments was in the treatment of C_0 with the amount of 6.93 tons per hectare and then C_{100} with the amount of 6.63 tons per hectare and the minimum was in the treatment of M_w with the average of 2.67 tons per hectare (Table 2).

The effect of intercropping methods on the percentage of crude ash

The maximum percentage of crude ash in intercropping treatment was in the treatments of C_0 with the amount of 10.41% and then C_w treatment with the amount of 10.36% and the minimum amount belonged to M_w with ash percentage of 4.58 (Table 3). Ash percentage depends on the total existing materials in cultivated plants. Thus, low or high amount of it does not effect on the quality of type of intercropping or pure culture but it is related to the plant impurities (Figure 3).

Effect of intercropping methods on the percentage of

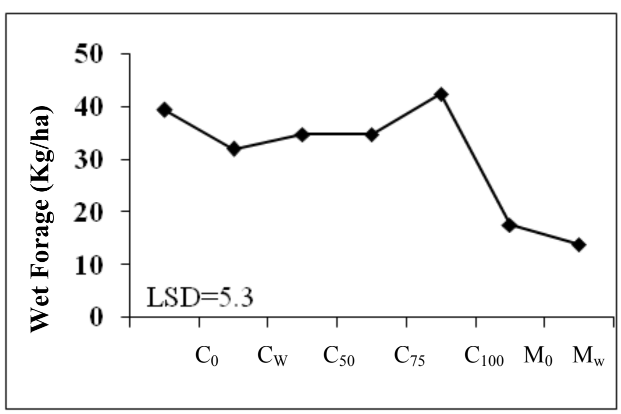

Figure 1. Comparing the average wet forage yield in intercropping treatments

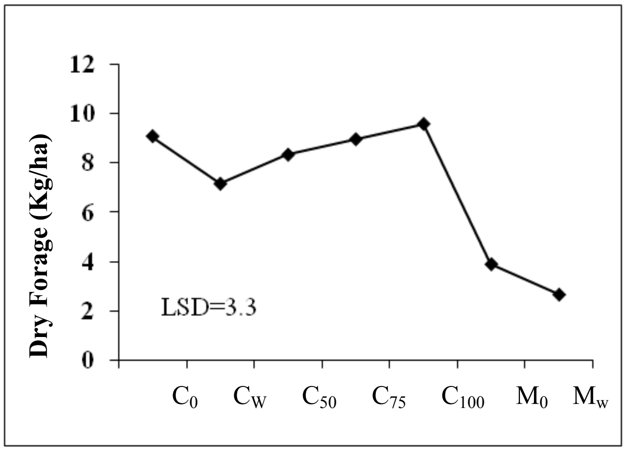

Figure 2. Comparing the average dry forage yield in intercropping treatments

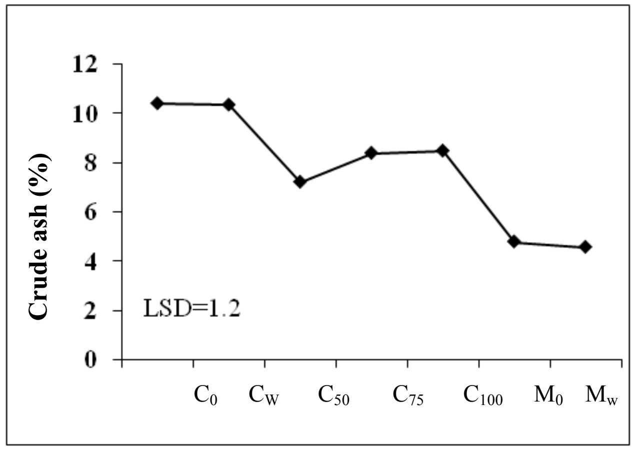

Figure 3. The mean percentage of crude ash in intercropping treatments

digestibility

In studying the effect of intercropping on the percentage of digestibility, the maximum result belonged to the treatment of C_0 with the amount of 80.08% and then C_w with the amount of 79.95% and the minimum percentage of digestibility was observed in the treatment of M_0 with the amount of 64.58% (Figure 4).

The yield of dry matter was low and digestibility is high before flowering, but at the stage of seed growing dry matter yield increases and digestibility decreases. In general, if the height of plant is more at time of harvest, dry matter yield is more and digestibility is lower (Muldoon, 1985).

In the methods of intercropping, the maximum percentage of digestibility was in the treatment of C_0 with the amount of 79.39% and the minimum was in M_w with the amount of 67.87% (Figure 4).

The effect of intercropping methods on the percentage of crude protein

The maximum percentage of crude protein in intercropping treatment in the first year belonged to the treatment of M_0 with the amount of 19.45% and then M_w with the amount of 19% and the minimum percentage of crude protein belonged to the treatment of C_w with the amount of 8.46% (Figure 5).

The maximum percentage of protein in intercropping treatments belonged to the treatment of M_0 with the amount of 18.62% and then Mw with the

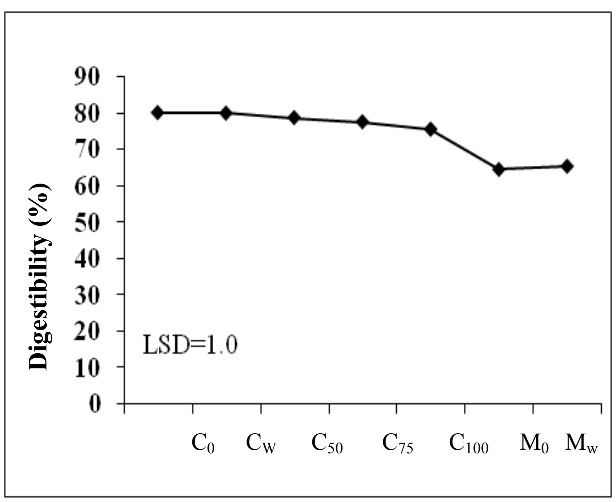

Figure 4. Comparing the mean digestible material in intercropping treatments

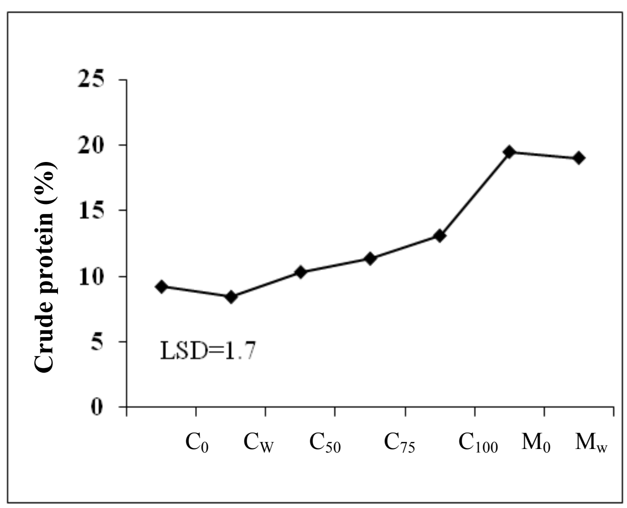

Figure 5. The mean percentage of Crude protein in intercropping treatments

amount of 18.45% and the minimum percentage of crude protein belonged to the treatment of C_w with the amount of 7.23% (Figure 5). The reduction of protein percentage in the treatment C_w is probably because of the reduction of leaf percentage and increase of stem percentage and cell walls over time.

Reed and Tedla (1987), Stallcup and York (1986), Hajiponuta *et al.* (1996) and Snyman and Joubert (1996) reported the same results and asserted that leaves and vegetative parts are effective in providing the needed protein. The percent of protein is high in fabaceae family which mung belongs to them. According to the Muldoon (1985) crude protein of forage sorghum was in the highest amount before and after the flowering, the amount decreases by increasing the plant age. Giacomini *et al.* (2003) studied the intercropping of *Vicia* and *Avena sativa* and observed that the content of crude protein increases with the increase of normal *Vicia* in intercropping. Pure culture of normal *Vicia* had the maximum content of crude protein and pure culture of *Avena sativa* has the minimum content. Lithourgidis (2006) also presented similar results about intercropping of normal *Vicia* with triticale and *Avena sativa.* Adding a plant rich in protein with gramineae is one of the methods of improving silage protein. This can be done with intercropping of gramineae with a legume or their single cropping and then mixing them at the time of ensiling (Titterton and Bareeba, 2008). Shirley *et al.* (2004) reported that the amount of clover protein was 40 to 55 gram on kilogram more than the grains in intercropping. The forage quality of second cut of clover was higher with the average protein of 209 gram on kilogram. The low difference of clover protein with grain shows the high amount of soil's nitrogen. In intercropping of corn with legumes, corn density and cropping time of each plant had a meaningful effect on the ratio of legume and content of silage crude protein.

CONCLUSION

The maximum yield of wet forage in the treatment of C_{100} was 42.48 tons per hectare and the minimum of that treatment M_w was 13.85 tons per hectare in the intercropping treatment. The maximum yield of dry forage in the treatment of C_{100} was 9095 tons per hectare and the minimum of that treatment MW was 2.67 tons per hectare. The lowest percent of digestibility in the treatment of M_0: pure mung with weeding was observed with the percent of 64.58%. The effect of intercropping was obvious in other studied features. The purpose of this study was to investigate the quality of forage of both crops and recommending its intercropping provided that it results in better performance and higher quality and protein.

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