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Yield and Quality of Forage Produced in Intercropping of Maize (*Zea mays*) with Cowpea (*Vigna Sinensis*) and *Mungbean* (Vigna radiate) as Double Cropped

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ABSTRACT

An experiment was carried out in 2010 to investigate the effect of intercropping on forage quality and quantity. Maize sole cropped and its intercropping with cowpea and mungbean in replacement and additive design were compared in RCBD in three replications. The results showed that intercropping systems had a significant effect on the dry matter yield, crude protein (CP) yield, neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentration. The CP yield and dry matter of produced forage increased by intercropping as compared with the maize monoculture. Intercropping of legumes with maize significantly reduced NDF and ADF content, resulting increased forage digestibility. In all intercropping treatments, land equivalent ratios (LER) were well above 1 indicating yield advantages for intercropping. It can be concluded that maize-legumes intercrops could substantially increase forage quantity and quality and decrease requirements for protein supplements as compared with the maize monocultures.

KEY WORDS: Acid detergent fiber (ADF), crude protein, forage production, multiple cropping, neutral detergent fiber (NDF).

INTRODUCTION

Intercropping of cereals and legumes is important for the development of sustainable food production systems, particularly in cropping systems with limited external inputs [1]. This may be due to some of the potential benefits for intercropping systems such as high productivity and profitability [28]. improvement of soil fertility through the addition of N by fixation and excretion from the component legume [16], efficient use of resources [18], reducing damage caused by pests, diseases and weeds [5], control of legume root parasite infections [11] and improvement of forage quality through the complementary effects of two or more crops grown simultaneously on the same area of land [2, 3, 7].

High quality of forage has been notified as an important aspect of forage crop production. Although cereals are widespread used in livestock nutrition for their high dry matter production and low cost [14], they have low nutrition value due to their low forage quality. Forage quality of legumes is high but they have low dry matter production [21]. Thus, legume-cereal composition is considered as a management strategy in producing both high quality and quantity forage. Legumes, which are good source of protein, intercropped with cereals to compensate their quality shortage [13]. It is reported that all of the three intercrops (maize-sunflower, maize-kale, and maize-runner bean) significantly increased crude protein concentration when compared with maize silage [3]. Protein concentration was increased from 69-81 g kg-1 for maize monoculture to 88-108 g.kg^{-1} for the various intercropping patterns [12]. The addition of berseem clover to oat reduced the neutral detergent fiber (NDF) concentration by an average of 30 g.kg^{-1}DM, indicating potential for increasing forage intake [21]. Also according to [7] all of the mixtures of vetch and barley had significantly higher digestible DM and CP yield. NDF and acid detergent fiber (ADF) concentrations in clover were observed lower than in wheat and intermediate in mixtures [8]. These reports established that intercropping of grass with legume increase CP content and decrease NDF and ADF concentrations and consequently enhance the nutritive value of the forage. This research evaluated forage quantity and quality of maize-cow pea and maize-mungbean intercropping systems as compared to the maize monoculture.

MATERIALS AND METHODS

The field experiment was conducted at a Research farm in Ramhormoz, Iran (46º 36´ N, 31º 16´ E, altitude 150 m a.s.l) in 2009-2010 growing seasons. Soil texture was silt loam with pH 7.42 and 0.66% organic matter. The meteorological data were recorded from sowing date to the harvest of each treatment (Table 1).

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Table1: Meteorological data for maize-cowpea and maize- intercropping area in 2010.

Month	Minimum temp (°C)	Maximum temp (°C)	Relative humidity (%)	Rainfall (mm)
July	30.0	49.0	31.17	---
August	23.11	42.18	25.18	---
September	21.05	36.45	27.0	---
October	16.16	26.75	34.18	1.8

Five treatments (maize monoculture and four mixtures of maize with cowpea and mungbean) were included in the experiment as showed in Table 2. The experimental design was a randomized complete block (RCB) with three replications.

Table 2: The description of experimental treatments.

treatment	Description
C	Sole maize
M_1	Within-row intercrop of maize and cowpea (replacement design)
M_2	Within-row intercrop of maize and mungbean (replacement design)
M_3	Within-row intercrop of maize and cowpea (additive design)
M_4	Within-row intercrop of maize and mungbean (additive design)

The seed-bed of experimental site was well prepared through two perpendicular plowing and removing residual of the previous crop (wheat) and weeds. Prior to planting, seeds were treated with mancozeb at 0.2% (wt/wt) in order to protect them from soil-borne pathogens. The additive and replacement method was used for intercropping systems. In replacement design one maize was replaced by three cowpea and three mungbean plants. Total population of intercrop components in replacement designs were half of their sole crops. The plots size was 15m^2 consist of six rows of 5m long. The rows located 50 cm apart. Treatments were separated by a 2m buffer zone. All plots were fertilized with the same amount of fertilizer. The fertilizers containing 70 kg of N ha^{-1}, 70 kg of P_2O_5 ha^{-1} and 70 kg of K_2O were broadcasted before sowing. Maize, cow pea and mungbean seeds were simultaneously sown in July 28, 2010. The seeds were sown at high density to ensure adequate emergence. After seedling establishment, the plots were thinned to 6.7, 20 and 25 plants/m^2, respectively.

Maize and legumes were harvested at the milk and flowering stages, respectively. At the stages of harvest an area of 3.0 m^2 for the monoculture maize and intercropping treatments were harvested from the center of each plot and weighed fresh biomass was determined as g of DM per m^2. Thereafter, forage dry matter was measured after drying at 105°C for 24 h. The dried forage samples of both experiments were ground in a cyclone mill to pass a 1 mm screen for chemical analysis. The samples were analyzed for DM, crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF). The N concentration was measured using the Kjeldahl method and the CP was achieved by N multiplied to 6.25. Acid and neutral detergent fiber (ADF and NDF) were determined using the procedure of Van Soest [27]. The protein yield (CP content × DM yield) was also calculated. The concept of land equivalent ratio (LER) is used as an index of combined yield for evaluating the effectiveness of all forms of intercropping [14]. LER is defined as the total land area required under sole cropping giving the yields obtained in the intercropping mixture. It is expressed as:

$$LER = (Yij/Yii) + (Yji / Yjj)$$

Where Y is the yield per unit area, Yii and Yjj are sole crop yields of the component crops i and j, respectively and Yij and Yji are intercrop yields. When LER = 1, there is no advantage to intercropping as compared with sole cropping. When LER is higher than one, a large area of land is needed to produce the same yield of sole crop of each component than with an intercropping.

Data were subjected to analysis of variance (ANOVA), using MSTATC software. The differences among means were tested using the least significant difference (LSD) method.

RESULTS AND DISCUSSION

The analyses of variance showed that the intercropping of maize with legumes significantly affected all the characters investigated (Table 3). Dry matter yield (t.ha^{-1}) of all intercropping treatments was significantly higher than maize monoculture (Table 4). The largest dry matter yield was obtained from intercropped maize-mungbean with additive design. On the other hand, the lowest dry matter yield was achieved from maize monoculture. A similar result from cereal-legume intercrops has been reported by other researchers (14, 17, and 19]. It was reported that wheat-bean intercrops produced less DM yield than either species alone [6]. One possible explanation for the higher yields of intercrops is the ability of the component crops to exploit different soil layers without competing with each other. There is probably better use of resources such as (i) light, because the presence of maize ensured good early interception of light in above layer of canopy and legume in below layer of canopy intercept diffused light as stated [10], (ii) nutrients and water [18]. When components are not competing for the same ecological niches interspecific competition is weaker than intraspecific competition for a given variable [25].

Table 3: Analysis of variance of maize - legumes intercropping all traits under study.

S.V	df	Mean Squares			
		DM Yield	CP Yield	NDF	ADF
Replication	2	1389711.13	182031.31	56181.9	**392.45**
Treatment	6	185819.11**	57311.31**	29587.30**	**1088.04****
Error	12	22303.96	11740.03	2341.6	**666.87**
CV (%)		**6.06**	**11.04**	**3.3**	**7.4**

**Significant at the 0.01 probability level DM: Dry matter, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber.

Table 4: Mean values of dry matter yield, crude protein (CP) yield, neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations in maize monoculture and mixtures of maize with cowpea and mungbean.

treatment	DM Yield ($g.m^{-2}$)	CP($kg.ha^{-1}$)	NDF ($g.kg^{-1}$ DM)	ADF($g.kg^{-1}$ DM)
C	780.14 c	730.0 b	641.4 c	**381.14 b**
M_1	1088.23 b	918.1 a	421.2 a	**306.9 a**
M_2	1101.52 b	923.0 a	460.4 a	**262.2 a**
M_3	1308.18 a	944.0 a	512.6 b	**286.1 a**
M_4	1315.59 a	951.1 a	514.2 a	**292.4 a**
LSD (1%)	**105**	**22.1**	**51.4**	**38.0**

C: Sole maize; M_1: maize-cowpea intercrop (replacement design); M_2: maize-mungbean intercrop (replacement design); M_3: maize-cowpea intercrop (additive design); M_4: maize-mungbean intercrop (additive design).

The CP yield was significantly affected (Table 3) and increased by the intercropping system (Table 4). The highest CP yield was for the intercropping maize with mungbean (additive design) which was not significantly different with the other intercrop systems. The CP per hectare was lowest for maize sole crop. Similar results have been reported by others where legumes included in the intercropping systems significantly increased the CP per hectare [10, 14, 20]. The higher total protein yield produced by intercropping was attributed to higher forage production by intercrops and also protein content. Legumes supply nitrogen to grass-legume mixtures, so it may produce more forage yield than grasses grown alone. Grasses grown in intercropping with legumes also contain a higher percentage of protein. The NDF and ADF content are important in ration formulation because they reflect the amount of forage that can be consumed by animals [20]. As NDF and ADF percentage increases, dry matter intake generally decreases [26]. Monoculture maize had the highest values of NDF and ADF (Table 4). Forage quality in terms of NDF and ADF content of dry forage was improved by intercropping as compared with sole maize (Table 4). It was noted that intercropping with winter pea decreased NDF in all cereal forage-legume intercrops compared with their monocultures [19]. Thus addition of legumes to forage maize reduced the NDF and ADF concentrations, indicating potential for increasing forage intake. According to [22] NDF concentrations more than 550 g kg-1 DM could severely reduce voluntary intake. Similar results from cereal-legume intercrops have been reported [7, 20].

Results indicated that LER was higher than one in all of the mixtures indicating a yield advantage over sole crops (Table 5). LER ranged from 1.28 to 1.33. Therefore, 28 to 33% more land should be used in sole cropping in order to obtain the same yield of intercropping, which indicates the superiority of the intercrops over pure stand in terms of the use of environmental resources for plant growth [9]. The highest LER values were obtained from intercrops of maize with cowpea and mungbean in additive designs (Table 5). The LER greater than 1.0 has been reported 15, 23, 28].

Table 5: Land equivalent ratio (LER) values of different maize-legume intercropping systems.

	Relative Yield		
Intercropping	**Maize**	**Legume**	**LER**
M_1	0.93	0.38	**1.31**
M_2	0.87	0.41	**1.28**
M_3	0.81	0.52	**1.33**
M_4	**0.84**	**0.49**	**1.33**

M_1: maize-cowpea intercrop (replacement design); M_2: maize-mungbean intercrop (replacement design); M_3: maize-cowpea intercrop (additive design); M_4: maize-mungbean intercrop (additive design).

CONCLUSION

Results indicated that maize-legume intercrops produced greater dry matter yield than maize sole crop. Also intercropping of maize with legume enhanced the forage quality in terms of CP yield, NDF and ADF concentrations as compared with the sole cropping of maize. Mixtures of maize-legume showed advantages in land use efficiency expressed as LER. The greater LER of the intercrops was mainly due to a greater resource use and resource complementarity, when the species were grown alone. Thus, it can be suggested that maize-legume intercropping (with additive design) can be used as a good management for production of high quality and quantity of forage.

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