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Effect of Intercropping Maize (*Zea mays* L.) With Cow Pea (*Vigna unguiculata* L.) on Green Forage Yield and Quality Evaluation

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Abstract: In this study effect of different planting ratios and harvest time of intercropping maize and cowpea on economical and biological yield and quality of maize forage (*Zea mays* L.) was evaluated in the Department of Agronomy, University of Zabol, during 2007. The planting ratios of maize to bean was 100:100, 50:100, 100:50, 25:75, 75:25, 50:50 , 0:100 and 100:0, respectively. The intercropped of maize and bean in different planting ratio significantly affected the quantitative and qualitative characters of the forage. The highest yield of green fodder (65.7 t ha^{-1}) was obtained by sowing the crops in ratio of 100:100. The highest grain yield (9.0 t ha^{-1}) for maize was recorded from 75+25% ratio, maize and cowpea and the highest grain yield for cowpea (3.9 t ha^{-1}) was recorded from 50+100% ratio, maize and cowpea, respectively. The highest crude protein (19.65%) was produced by the cowpea sole cropping and the lowest from the maize plots sole cropping (12.11%). The highest land equivalent ratio (2.26) was obtained by sowing the crops in ratio of 100:100 and the highest crude protein was obtained by harvest time in milky stage (15.2%).

Key words: Cowpea (*Vigna unguiculata* L.), intercropping, crude protein, land equivalent ratio

INTRODUCTION

Maize (*Zea maize* L.) is the third most important cereal crop of the world. It is used as food, feed and forage. Maize fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum or fodders. Maize is the most suitable fodder crop for making silage. Therefore, it is called the king of crops suitable for silage (Muhammad *et al*., 1990). Intercropping of legumes and cereals is an old practice in tropical agriculture that dates back to ancient civilization. The main objective of intercropping has been to maximize use of resources such as space, light and nutrients (Li *et al*., 2003), as well as to improve crop quality and quantity (Mpairwe *et al*., 2002; Moreira, 1989). The current trend in global agriculture is to search for highly productive, sustainable and environmentally friendly cropping systems (Crew and Peoples, 2004). When two crops are planted together, inter specific competition or facilitation between plants may occur (Zhang and Li, 2003).

Production of good quality fodder is of a great importance for the economical ruminant production. Both quality and quantity of fodder are influenced due to plant species (Kaiser and Piltz, 2002), stage of growth (Ghanbari and Lee, 2003) and agronomic practices (Rehman and Khan, 2003; Ghanbari and Lee, 2002). The growing of fodder crops in mixture with legumes enhanced fodder palatability and digestibility (Chaudhary and Husain, 1985). For example, studies have shown that intercropping of cereals and legumes produce higher grain yields than either sole crop (Mpairwe *et al*., 2002). In such intercropping, the yield increases were not only due to improved nitrogen nutrition of the cereal component, but also to other unknown causes (Connolly *et al*., 2001). Mixing of legumes in cereals is a better choice to increase the quality of cereal fodders. It has been reported that dry matter yields of maize sown alone were greater than soybean intercropping. However, intercropping gave higher crude protein yields than maize alone (Khandaker, 1994). The efficiency of cereal-legume intercrop systems, expressed as Land Equivalent Ratio (LER) increases, remains unchanged or decreases under application of increasing levels of N fertilizer (Ghanbari and Lee, 2002). Therefore, it is on considerable value to carry out an experiment on green fodder yield and fodder quality of maize in relation to different planting ratio and harvest time. For obtaining a good fodder of improved quality, an accurate balance of legumes and non-legumes in a mixture is very essential. The present experiment was carried out to study the growth, fodder yield and quality of maize and cowpea sown alone and mixture with each other in different proportions.

MATERIALS AND METHODS

The field experiment was carried out on the University of Zabol farm, Iran (61° 41'E, 30° 54'N, above

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Table 1: Monthly average temperature, relative humidity and wind speed recorded at Zabol, Iran location during the 2007 growing seasons (Agricultural Climatology Research Station of Zahak)

Month (2007)	Temperature (°C)	Relative humidity (%)	Wind speed (m sec^{-1})
March	10.8	50.2	4.5
April	24.2	42.5	3.3
May	34.3	30.2	7.2
June	34.7	24.3	8.5
July	37.2	24.1	10.2

Table 2: Soil characteristics of the experiment area during the 2008 growing seasons (Agricultural Research Center of Sistan)

Year	Depth of soil (cm)	pH	Ec (mmohs cm^{-1})	N (%)	P (ppm)	K (ppm)	Sand	Silt	Clay
2007	0-20	8	7.8	0.053	7.8	190	63	20	17

Table 3: The description of experimental treatments

Factor	Description
A	
M	Sole maize (100% maize+0% cowpea)
C	Sole cowpea (100% cowpea+0%maize)
MC	Intercrop of maize 100%+cowpea 100%
Mc	Intercrop of maize 100%+cowpea 50%
mC	Intercrop of maize 50%+cowpea 100%
mc	Intercrop of maize 50%+cowpea 50 %
M'c'	Intercrop of maize 75%+cowpea 25%
m'C'	Intercrop of maize 25%+cowpea 75%
B	
H_1	Harvest at milky stage
H_2	Harvest at doughy stage

sea level 483 m), average 30 years rainfall was 49 mm. The experiment was carried out during 2007 growing season (Table 1) on a sandy-loam soil (Table 2). All phosphorus (150 g m^{-2}) and potassium (100 g m^{-2}) and half nitrogen (50 g m^{-2}) were applied at sowing, while balance of nitrogen was applied at stem elongation stage. All other cultural practices including (irrigation, thinning and weeding) were kept normal and uniform for all the treatments.

The treatments were compared in a factorial design with eight levels of planting ratios 100:100 (M:C), 50:100 (m:C), 100:50 (M:c), 50:50 (m:c), 75:25 (M":c"), 25:75 (m":C"), 0:100 (C) and 100:0 (M) and two levels of maturity stages (milky stage and doughy stage) in four replication. The treatments used for this experiment is shown in Table 3. The treatment comprising the individual plot size was (7×4 m) 28 m^2. Maize variety K.s.c 704 and cowpea (*Vigna unguiculata* L.) variety cv 29005 was sown on year 2007. For this experiment, the density of maize and cowpea are expressed, sole crop densities being 20 and 8 plant m^{-2} maize and bean, respectively. Inter-row spacing was 25 and 10 cm in the sole crops of maize and bean were used with a between-row spacing of 50 cm. Initially 2-3 seeds were sown per hill. Twenty five days after sowing (25 March) at seedling were thinned to retain one healthy seedling per hill. Three hand weeding procedures were applied 20, 30 and 40 days after sowing. Quality parameters like CP (Crude Protein), ADF (Acid Detergent Fiber), NDF (Neutral Detergent Fiber), WSC (Water Soluble Carbohydrate), DMD (Dry Matter Digestibility) and Ash (Ashes) were determined using the NIR (Near Infra-red Spectrophotometer) Model 8600, PERTEC Co (Roberts *et al*., 2004).

Statistical analysis: The data on growth, yield and quality parameters were analyzed by Fisher's analysis of variance technique and Duncan test at 0.05 probability level to compare the treatment means (Steel and Torrie, 1984). Data analysis were conducted using of SAS (SAS Institute, 2004) as a Factorial Experiment 8×2 with four replicates.

RESULTS

Maximum economical yield for maize (9.0 kg/10 m^2) was recorded in plots where M'c' were sown. Minimum economical yield for maize (2.2 kg/10 m^2) was recorded in plots of maize and bean sown ratio m'C' (Table 4), Maximum biological yield for maize (19.6 kg/10 m^2) was recorded in plots where MC but maximum biological yield for bean (14.8 kg/10 m^2) was recorded in plots where mC were sown. The highest LER (Land Equivalent Ratio) was obtained by sowing the crop in additive design in a ratio of MC (2.26) and the lowest LER was obtained by sowing the crops in replacement design of mc (1.27).

LER (Land Equivalent Ratio) values were greater than one in all intercropping systems with different planting ratios which indicated yield advantage of intercropping over sole cropping of maize. Bean (HF 465) LER increased with increases in bean population (Luiz and Willey, 2008). This might be attributed to the fact that bean plants possibly benefited from the nitrogen applied to maize rows. The results indicated that intercropping of maize+bean gave higher land use efficiency than mono cropping of maize. Various experiments have documented the best time to harvest corn f or silage to optimize yield and quality (Philippeau and Michalet Doreau, 1997; Bal *et al*., 1997). Total biomass yield of intercropped maize per unit area tended to increase with increasing maize population (Luiz and Willey, 2008). Grain yield per unit area of intercropped beans decreased as maize population increased (Mutungamiri *et al*., 2001). The cowpea sown alone produced the lowest green fodder (37.9 kg/10 m^2). Similar results have been reported earlier by Khandaker (1994). The data in Table 5 revealed that green fodder yield and quality forage were significantly affected by planting ratios and harvest time. DMD was significantly ($p<0.01$) affected by the harvest time. The highest DMD was achieved at H_1 (61.5%) that which was greater than at H_2. DMD was affected ($p<0.01$) by planting ratios. The intercrops Mc (100% maize+50% cowpea) produced the

Table 4: Mean values of economical and biological yield and LER of maize and cowpea as influenced by different planting ratios and harvest time based on Duncan test

Planting ratio	Economical yield (kg/10 m^2)		Biological yield (kg/10 m^2)		LER		
Maize:Cowpea	Maize	Bean	Maize	Bean	Maize	Bean	Total LER
100:100	8.2c	3.3b	19.6a	10.7b	1.17b	1.09b	2.26a
100:50	8.5b	1.1e	19.2a	4.1e	1.21b	0.41d	1.62c
50:100	4.5e	3.9a	12.1d	14.8a	0.64c	1.32a	1.96b
50:50	4.4e	1.9d	10.7e	7.1d	0.63c	0.64c	1.27e
25:75	2.2f	3.1b	5.8f	9.8c	0.31d	1.07b	1.38d
75:25	9.0a	9.2e	18.5b	3.3f	1.28a	0.32d	1.6c
100:0	7.0d	----------	15.4c	---------	-------	--------	--------
0:100	--------	2.9c	---------	10.3b	-------	--------	--------
Harvest time							
Milky stage	6.2b	2.0b	1.5a	7.2b	0.86a	0.81a	1.67a
Doughy stage	6.3a	2.9a	1.3b	9.9a	0.88a	0.81a	1.69a
CV (%)	4.98	6.59	9.48	5.25	5.7	13.2	6.19

Any two Mean values not sharing a common letter differ significantly from each other at 5% probability; LER: Land Equivalent Ratio, CV: Coefficient of variation

Table 5: Means of green fodder yield and quality parameters as influenced by different planting ratios and harvest time of intercropping maize and bean based on Duncan test

Planting ratio	Green fodder	Quality parameter (%)					
Maize: Cowpea	yield (kg/10 m^2)	DMD	Ash	NDF	ADF	WSC	CP
100:100	65.7a	60.2ab	7.25bc	55.55a	27.11bc	18.15bc	13.3bc
100:50	49.2b	62.50a	7.29b	54.25a	25.89c	20.04ab	13.04bc
50:100	46.3bc	57.8ab	7.35b	57.95a	29.88ab	18.16bc	13.62b
50:50	43.9dc	60.6ab	9.82c	55.34a	26.33c	20.5a	12.23c
25:75	38.0e	56.30b	7.44b	54.44a	31.04a	18.25bc	13.94b
75:25	43.8dc	60.5ab	7.04bc	55.39a	26.87bc	20.46a	12.22c
100:0	41.9d	61.1ab	7.00bc	55.86a	31.85a	20.69a	12.11c
0:100	37.9e	57.40b	10.1a	54.46a	26.53c	16.65c	19.65a
Harvest time							
Milky stage	27.5b	61.5a	7.75a	57.09a	29.82a	18.42b	15.2a
Doughy stage	64.2a	57.6b	7.32b	53.72b	26.56b	19.83a	12.3b
CV (%)	7.17	7.69	5.930	8.28	11.30	9.08	7.91

Any two Mean values not sharing a common letter differ significantly from each other at 5% probability; DMD: Dry Matter Digestibility, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, WSC: Water Soluble Carbohydrate, CP: Crude Protein, Ash: Ashes, CV: Coefficient of variation

highest of DMD (62.5%) and the intercrop m'C' (maize 25%+cowpea 75%) produced the lowest of DMD. The DMD of the intercrop was between the sole maize and higher than that for sole cowpea (Table 5).

The increase in mixed green forage yield compared to maize grown alone mainly ascribed to more production of vegetation and biomass of component legume crops. DMD was greatly (p<0.01) affected by the harvest time. The mean of DMD over the harvest time at H_1 (61.5%). The intercrops Mc (100% maize+50% cowpea) produced the highest of DMD (62.5%) and the intercrop m'C' (maize 25%+cowpea 75%) produced the lowest of DMD (Table 5). The production of crude protein was also affected significantly by planting ratios and harvest time of maize and bean. The results (Table 5) revealed that an increased proportion of bean in seed mixture increased the crude protein contents. The bean sown alone produced more crude protein (19.65%). Maize sown alone produced minimum crude protein (12.11%). Primitive effect of legume intercrops on protein concentration of main crop has also been reported by Mpairwe *et al.* (2002) and Azraf-ul-Haq *et al.* (2007).

Maximum crude protein (15.2%) was obtained in H_1 and minimum crude protein (12.3%) was obtained in H_2. Crude protein has previously been shown to decline with increasing maturities (Shepherd and Kung, 1996). Armstrong *et al.* (2008) reported that intercropping climbing beans with corn increased CP in the mixture, but also increased neutral detergent fiber concentration and decreased digestibility compared to monoculture corn. Dawo *et al.* (2007) reported that CP concentration increased 22% in the mixture when corn proportion in the mixture decreased by 50%. The results are in agreement with other studies where legumes also increased CP concentration when in mixture with corn (Anil *et al.*, 2000; Dawo *et al.*, 2007). Maximum ADF (31.85%) was recorded by sowing maize alone. Harvest time was also affected significantly on ADF; Maximum ADF was recorded by H_1. A decline in fiber concentration with increasing maturity can be attributed to the dilution effect created by the increasing content of grain as corn matures (Coors *et al.*, 1997). Maximum WSC was recorded Maize sown alone and bean sown alone produce minimum WSC. In maize WSC in H_1 lowest content and H_2 was highest content.

An increase in WSC with increasing maturity can be attributed to the dilution effect created by the increasing content ratio of grain to fodder as corn matures. Johnson and McClure (1968) reported increased soluble carbohydrate in stalks from tasseling to the milk stage and a decline thereafter plots were established at the University Of Wisconsin Ag- with advancing maturity. Decrease in the ash concentration with maturity could results from dilution of minerals within increased the DMD.

DISCUSSION

Obtained results shown that an increased proportion of bean in intercrops increased the crude protein contents. Primitive effect of legume intercrops on protein concentration of main crop has also been reported by Mpairwe *et al.* (2002) and Azraf-ul-Haq (2007). The mean intercrop CP concentration, across H_1 and H_2, were (15.2 and 12.3%) for this experiment. These were greater than maize but less than cowpea, similarly results have been given for maize. Maximum crude protein percentage (15.2%) was obtained in milky stage and minimum crude protein (12.3%) was obtained in doughty stage, the decrease of CP content with maturity reported by Ghanbari and Lee (2003). Crude protein has previously been shown to decline with increasing maturities (Shepard and Kung, 1996). Armstrong *et al.* (2008) reported that intercropping climbing beans with corn an increased of neutral detergent fiber concentration and decreased digestibility compared to monoculture corn. Dawo *et al.* (2007), reported that CP concentration increased 22% in the mixture when corn proportion in the mixture decreased by 50%. Present results are in agreement with other studies where legumes also increased CP concentration when in mixture with corn (Anil *et al.*, 2000; Dawo *et al.*, 2007). Reduction in NDF and ADF concentration of forage from H_2 compared with H_1 can be attributed to increasing of grain to whole biomass ratio. Harvest time was also affected significantly on ADF; maximum ADF was recorded by milk stage. A decline in fiber concentration with increasing maturity can be attributed to the dilution effect created by the increasing content of grain as corn matures (Coors *et al.*, 1997). WSC concentration increased in intercrops compared with that in sole cowpea. The highest WSC was recorded for sole maize and sole crop of cowpea produce the lowest WSC and dry matter digestibility. Johnson and McClure (1968) reported increased soluble carbohydrate in stalks from tasseling to the milk stage and a decline thereafter Plots were established at the University Of Wisconsin Ag-with advancing maturity. Decrease in ash concentration with maturity could results from dilution of minerals as crop mature and agree with Ghanbari and Lee (2003).

CONCLUSION

This study has thus clearly brought out the beneficial effects of maize-cowpea intercropping for forage yield and quality. As a conclusion, intercropping is more productive than sole cropping. Maize-cowpea intercropping increasing green fodder yield and forage quality of maize. Therefore, it can conclude that this initial investigation show results of maize/climbing cowpea mixture were advantageous compared to both sole crops of maize and cowpea.

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