African Journal of Biotechnology Vol. 7 (22), pp. 4100-4104, 19 November, 2008
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2008 Academic Journals

Full Length Research Paper

Intercropping of corn with cowpea and bean: Biomass yield and silage quality

Hakan Geren*, Riza Avcioglu, Hikmet Soya, Behcet Kir

Ege University, Agriculture Faculty, Department of Field Crops, 35100 Izmir, Turkey.

Accepted 17 October, 2008

An experiment was carried out at the Bornova experimental fields of Field Crops Department of Agriculture Faculty., Ege Univ., Turkey during 2004-2005 growing season in order to determine biomass yield and silage quality of corn (*Zea mays indendata*) mixed with legumes such as various cowpea (*Vigna ungiuculata*) and bean (*Phaseolus vulgaris*) cultivars monocropped or intercropped in same or alternate-rows. Results indicated that intercropping system affected many characteristics such as plant height, fresh biomass and dry matter (DM) yield, pH level and crude protein (CP) content and yield of silage material. Intercropped corn with legumes were far more effective than monocrop corn to produce higher DM yield and roughage for silage with better quality. Practicing alternate-row sowings and benefiting from climbing types of legumes as component crop had better performances than same-row sowings and dwarf type legume.

Key words: Intercropping, corn, cowpea, bean, biomass, silage quality.

INTRODUCTION

Maize silage plays an important role as a winter feed in the livestock industries of many countries. The main reasons for the popularity of maize for silage are the high yield obtained in a single harvest, the simplicity for ensilaging and its high energy value as a feed. However, its major shortcoming is undoubtedly its low crude protein content, which, on a dry matter basis, is usually around 70 to 80 g kg^{-1} dry matter (DM) (Carruthers et al., 2000).

Intercropping is being advocated as a new and improved approach to farming. However, it has been avoided because of the complications of planting and harvesting. Intercropping involves competition for light, water and nutrients. However, intercropping usually benefits from increased light interception, root contact with more soil, increased microbial activity and can act as a deterrent to pests and weeds of the other crop. There is also evidence that suggests intercropping may benefit a non-legume which needs nitrogen if the other crop is a legume, since legumes will fix nitrogen in the soil (Portes, 1984; Avcioglu et al., 2003).

Intercropping of corn with legumes is an alternative to monocropping of corn and has a number of advantages such as lower inputs, lower cost of production, and better silage quality than monocropping systems. Several studies found that intercropping of soybean with corn resulted in increases in biomass yield (20-40%) (Singh et al., 1986) and crude protein (11-15%) (Putnam et al., 1986). Etebari and Tansi (1994) reported that when intercropping is used, yield parameters increased indicating that the current environmental conditions are used more efficiently. Altinok et al. (2005) pointed out that the use of corn grown for ensilaging and the seeding of soybean with corn in alternate-rows as 1 corn + 1 soybean or 1 corn + 2 soybeans highly increased the silage quality and crude protein (CP) content. Smith (2000) informed that the pole bean+corn mix provided more silage and protein yield than the monocrop corn, and soybean+corn mix generally yielded less dry matter and with significantly higher protein rich silage but, the total protein yield was similar.

This study was conducted to evaluate some agronomical properties and biomass yield and silage quality of corn mixed with cowpea and bean cv's, monocropped or intercropped in same or alternate-rows under Mediterranean climate conditions.

MATERIALS AND METHODS

The experiment was carried out during 2004 and 2005 growing season (Table 1) on a silty-clay loam soil with 7.8 pH (Table 2) at Bornova experimental area (38°27.236 N, 27°13.576 E) in Ege University, Izmir, Turkey, at about 2 m a.s.l. with typical Mediterranean climate characteris-

*Corresponding author. E-mail: hakan.geren@ege.edu.tr.

Table 1. Monthly average temperatures, total precipitations and average humidity recorded at Bornova-Turkey location during the 2004 and 2005 growing seasons.

Month	Temperature (ºC)			Precipitation (mm)			Relative Humidity (%)		
	2004	2005	1980- 2000	2004	2005	1980- 2000	2004	2005	1980-2000
June	26.5	24.9	25.0	1.6	40.0	8.2	40.4	45.1	50.0
July	29.0	29.1	27.6	1.8	0.3	3.6	37.3	45.1	47.0
August	27.8	28.5	27.0	-	0.5	2.1	45.6	45.6	50.0
September	23.8	23.5	22.2	-	5.5	17.0	49.0	50.9	56.0
$\bar{x}$ - Σ	26.8	26.5	25.5	3.4	46.3	30.9	44.3	45.5	50.8

Table 2. Soil characteristics of the experiment area.

Soil (20-40 cm)			
Sand (%)	32.7	pH	7.8
Clay (%)	30.6	OM (%)	1.1
Silt (%)	36.7	N (%)	0.1
$CaCO_3$ (%)	18.6	P (ppm)	0.4
Salt (%)	0.07	K (ppm)	400

tics. The experiment was carried out with a randomized complete block design with three replicates. Five large-seeded legumes (3 cowpea cv's [Karagoz, Akkiz and Endase], 1 pole bean cv [Alman Ayse] and 1 dwarf bean cv [Magnum]) were seeded as monocrop or intercropped with corn cv [Dracma] in same or alternate-rows (Table 3). The soil was harrowed 10 days before planting, after which 100 kg ha^{-1} of N, P and K, respectively, were broadcast and disked to produce a smooth seed bed. After 2 weeks of corn seeding, corn monocropping plots received an extra 100 kg N ha^{-1} by hand-broadcasting to give a total of 200 kg ha^{-1} in each plot. Corn and legumes were simultaneously seeded in June 27, 2004 and June 28, 2005, respectively into a field which had previously been cropped with *Lolium perenne*. Each plot was 7 m long in which corn was planted by hand in four rows with 70 cm row spacing (95238 corn ha^{-1}). Legumes were also sown by hand between each corn rows or on the corn rows in intercropped plots (285714 legumes+95238 corn ha^{-1}). None of the legume seeds were inoculated with *Rhizobium*. Neither herbicides nor insecticides were used. Hand weeding by hoe was done once when the corn was app. 20 cm in height. Plots were harvested at the doughy stage of corn, cutting mid-rows of plots in order to avoid border effects, by removing at 4-5 cm height on 9 Sept., 2004 and 12 Sept., 2005, respectively. Corn was harvested from the middle 5 m of the two centre rows, and the legumes from the middle 5 m of the three centre rows in intercrop plots. Harvested materials were counted, separated, weighed and dried to a constant weight at 80ºC during 48 h. In each plot 5-6 kg of fresh mixture samples were taken at this stage and were chopped mechanically then wilted for appr. 24 h. The samples without additives were pressed using a special apparatus (Petterson, 1988) into glass jars of 3 litres capacity. The jars were then tightly sealed and kept in storage without light for appr. 70 days for fermentation. Matured silage samples of each component were dried at 80ºC for 48 h and ground in a mill and passed through a 2 mm screen for protein analysis using the Kjeldahl method. pH value of silage samples was also determined (Alcicek and Ozkan, 1996). All data were statistically analyzed using analysis of variance (ANOVA) with the Statistical Analysis System (SAS 1990). Probabilities equal to or less than 0.05 were considered significant. If ANOVA indicated differences between treatment means a LSD test was performed to separate them.

RESULTS

Plant height

Corn plant height increased in the mixture with legumes and the corn mixed with cowpea had the highest value (227.3 cm) (Table 4), whereas plant height was lowest in the mixture with dwarf bean (215.1 cm). There was also significant difference between sowing treatments, same-row sowings having highest average plant height (222.7 cm). Year effect was also significant and average corn height of second year (222.2 cm) was found higher than the first year (218.0 cm) (Table 4).

Fresh biomass

Total fresh biomass yields increased in mixtures with legumes and corn mixed with cowpea and climbing bean had highest fresh biomass yields (94248 - 93193 kg ha^{-1}). Corn+dwarf bean mixture, however, yielded slightly limited biomass (91493 kg ha^{-1}). Least fresh biomass yield was obtained from monocropped corn (89210 kg ha^{-1}). Sowing techniques, also significantly affected biomass production and alternate-row sowings (95085 kg ha^{-1}) yielded better than same-row sowings (90201 kg ha^{-1}). There were also significant differences between the years in terms of fresh biomass yield and the average yield of second year (93580 kg ha^{-1}) was better than previous year (91709 kg ha^{-1}) (Table 4).

Dry matter (DM) yield

Any significant difference was not observed among the DM yields of tested mixtures and monocropped corn. On the contrary, difference between sowing techniques was signify-cant and alternate-rows (25052 kg ha^{-1}) yielded better than the same-row sowings (23131 kg ha^{-1}). Effect of years on DM yields were also significant. Second year average (24569 kg ha^{-1}) was found higher than first year (23614 kg ha^{-1}) (Table 4).

Silage pH

The mixtures tested were highly effective on silage pH compared to monocropped corn and most favourable pH level was provided by monocropped corn (3.22). Sowing techniques were also effective on silage pH and same-rows (3.50) had more favourable pH levels than alternate-row sow-ings (3.74). Significant effect of years on the silage pH were also recorded and average silage pH in first year was better

Table 3. Treatments of cropping systems and descriptions.

No.	on the same-rows	On the alternate-rows
1	C: Corn monocrop (control)	Corn monocrop (control)
2	C+Kr: Corn + cowpea (Karagoz cv)	Corn + cowpea (Karagoz cv)
3	C+Ak: Corn + cowpea (Akkiz cv)	Corn + cowpea (Akkiz cv)
4	C+End: Corn + cowpea (Endase cv)	Corn + cowpea (Endase cv)
5	C+Alm: Corn + bean (Alman Ayse cv)	Corn + bean (Alman Ayse cv)
6	C+Mg: Corn + dwarf bean (Magnum cv)	Corn + dwarf bean (Magnum cv)

Table 4. Corn plant height, fresh biomass, DM yield, pH level, CP concentration and yield of silage material as affected by mixtures and sowing systems at Bornova.

Mixtures	Corn plant height (cm)	Fresh biomass (kg ha^{-1})	Dry matter yield (kg ha^{-1})	Silage pH	Silage crude protein (g kg^{-1})	Silage protein yield (kg ha^{-1})
C	208.0	89210	23778	3.22	84	1974
C+Kr	227.3	94248	24664	3.71	111	2721
C+Ak	224.9	93193	24216	3.75	108	2606
C+End	224.8	94215	24157	3.70	110	2629
C+Alm	220.5	93500	23947	3.82	100	2386
C+Mag	215.1	91493	23787	3.56	95	2246
LSD	4.9	1250	ns	0.17	4.7	186
F-test	**	*	ns	**	**	*
Sowing techniques						
Same-rows	222.7	90201	23131	3.50	99	2285
Alternate-ro	217.5	95085	25052	3.74	103	2573
LSD	2.9	720	426	0.11	2.8	165
F-test	**	*	**	**	**	*
Year						
2004	218.0	91709	23614	3.55	100	2340
2005	222.2	93580	24569	3.70	103	2516
LSD	2.8	721	425	0.10	ns	167
F-test	**	*	**	**	ns	*

*Significant at P≤0.05; **significant at P≤0.01; ns = non-significant.

than the average of succeeding year (Table 4).

Silage crude protein (CP) content and yield

CP content and yields of silage increased noticeably in mixtures. Corn mixed with cowpea cultivars possessed better silage CP rates (108-111 g kg^{-1}) and CP yields (2246-2721 kg ha^{-1}) than the other treatments. Sowing techniques were also significantly effective on average CP rate and yield. Alternate-row provided better rate (103 g kg^{-1}) and yield (2573 kg ha^{-1}) than same-row sowing (99 g kg^{-1} and 2285 kg ha^{-1}), respectively. CP rates were not significantly different between the years, whereas average CP yield of second year (2516 kg ha^{-1}) was significantly higher than the first year.

DISCUSSION

Mixed grown cereal and legumes have many advantages in terms of growth and some other agronomical properties (Singh et al., 1986; Putnam et al., 1986). There are also significant handicaps of mixed grown component crops such as root competition for water and nutrients and competition for light (Ofori and Stern, 1987; Portes, 1984). In the study, although the light and nutrient competition created obstacles for corn and legumes in mixed vegetation, increases in corn heights can be attributed to the nitrogen provided by component legumes. Herbert et al. (1984) stated that the legume component of mixture fixing N from the atmosphere increased CP content and total yield and also enhanced the height and yield of the component crops. In this respect, cowpea cultivars were found to be more effective than beans due to their larger habitus. Similar observations were reported by Etebari and Tansi (1994). Average plant heights of crops sown in same-rows were higher than the crops in alternate-rows suggested that, N flow from legumes was also highly and positively effective on corn crops in same-rows. In a previous study, Singh et al. (1986) reported that legumes have a significant role on enrichment of soil nitrogen and N uptake of accompanying corn crop. It was also observed that year effect on plant height was significant and second year average was higher than the first year, most probably due to the average monthly temperatures in the study site was consistent with the 20-year average, providing better humidity and precipitation for the maturation of crops in 2005 compared to 2004 (Table 1).

Fresh biomass production of mixtures was higher than monocrop corn due to the contributions by legumes in the mixtures. Some researchers reported that, legume contribution to corn in mixtures was significant and increased the total biomass yields of mixtures (Martin et al., 1998; Smith, 2000). There were also significant differences in total biomass yields of different legumes mixed with corn. Cowpeas and climbing bean performed better than dwarf bean. It may also be suggested that climbing type of legumes with their higher biomass production contributed better than dwarf type to total yield of mixtures. Our results were in accordance with the indications of Smith (2000) who reported that climbing type of legumes as companion crop were superior than dwarf type legumes in mixtures with corn. Overall fresh biomass yields of surveyed crops indicated that total yield of mixtures sown in same-rows were limited compared to alternate-rows. It may be concluded that competition for water and plant nutrients in the soil decreased the yield of component crops densely populated in the same-rows compared to alternate-rows. In a previous study, Putnam et al. (1986) pointed out that the density of mixed crops per unit area was the factor most closely correlated with total yield of mixture and hence the factor was most affected by competition. Fresh biomass yield in second year was also higher than first year, most probably due to the favourable summer conditions including relatively high humidity in 2005.

DM yield characteristic is a very dependable parameter in agronomical studies (Herbert et al., 1984; Martin et al., 1990). Although the DM yields of mixtures were highly different, results in the experiment indicated that these variations were not significant statistically. Average DM yields of sowing techniques imposed in the study displayed a significant difference between alternate and same-row sowing. Former had better yield than other treatment. It may be concluded that this result may be due to reason of the negative effect of competition in same-row sowing. Our findings are in accordance with Avcioglu et al. (2007) results. They also stated that preferring crops with similar growth rhytmes in mixtures and sowing alternate-rows had better yield performances than same-row treatments. On the contrary, Essah and Stoskopf (2002) pointed out the superiority of same-row mixtures over alternate-row treatments. Average DM yield in second year was higher than the yields of the first year, probably because of the favourable climatic conditions of second year as discussed in biomass yield.

Corn or corn+legume mixtures are widely practiced and are important source of silage material in livestock husbandry (Smith, 2000). And also silage quality is many times more significant property than quantity. According to McDonald et al. (1991), in many cases silage pH and CP contents are most dependable parameters of silage material. Silage pH levels of mixtures were higher than corn silage which had favourable pH level. Although higher pH levels in silage are not preferred in feeding, these pH levels of samples in the experiment were also within acceptable limits (Petterson, 1988; Alcicek and Ozkan, 1996). It may be concluded that legumes in mixtures increased pH values of silage material and decreased the silage quality relatively. These results may also be attributed to the total yield increases in mixtures and higher CP contributions of legume components which are poor in terms of carbohydrate contents. Many researchers confirmed our findings reporting that legumes had limited advantages in ensilaging (Carter et al., 1991; Carruthers et al., 2000).

Some researchers also pointed out the significance of CP content in addition to the CP yield of silage in livestock farming (Ofori and Stern, 1987; McDonald et al., 1991; Avcioglu et al., 2003). Silage CP contents and yields of different mixtures and monocrop corn in the experiment were significantly different. Mixtures possessed higher CP contents and yields. These results suggested that the contributions provided by legume components in the mixtures increased the CP contents and yields of silages. Alternate-row sowing resulted in higher silage CP content and yield compared to the same-row treatment, resembling the results of other parameters tested in the experiment. It was concluded that higher average biomass and DM yields of alternate-row treatments resulted in higher CP yield. Some previous studies on soya beans and other legumes intercropped with corn also showed that sowing techniques are highly effective on silage CP content and yield which is closely related to biomass and DM yields of mixtures (Carruthers et al., 2000; Altinok et al., 2005).

As conclusion, intercropped corn with legumes are far more effective than monocrop corn to produce higher DM yield and silage material with better quality. Practicing alternate-rows and benefiting from climbing type of legumes as component have better performances than same-row sowings and dwarf type legumes.

REFERENCES

Alcicek A, Ozkan K (1996). Zur quantitativen Bestimmung von Milch-, Essig- und Buttersäuren in silage mit Hilfe eines Destillations verfahren, J. Agric. Fac. Ege Univ. 33(2-3): 191-198.

Altinok S, Genc A, Erdogdu I (2005) The determination of silage quality of the silages made by corn and soybean grown in different cropping systems, 6th Turkish National Field Crops Congress, 5-9 Sept. 2005, Antalya. (2): 1011-1016.

Avcioglu R, Boberfeld WO, Soya H, Geren H, Beckmann E (2003). Investigations on some yield and quality characteristics of second crops of *Vicia sativa* and *Trifolium resupinatum* and their mixtures with *Lolium multiflorum*, 7th Symposium Ergebnisse Deutsch-Türkischer Agrarforschung, 24-30 March 2003, Ankara, pp. 109-112.

Avcioglu R, Soya H, Geren H, Erekul O, Kir B, Demiroglu G, Kavut YT (2007). Performances of mixtures used in artificial pastures under grazing conditions for Mediterranean ecology, Ege Univ. Sci. Research Prj. No: 2003-ZRF-044, Izmir.

Carruthers K, Prithiviraj B, Fe Q, Cloutier D, Martin RC, Smith DL (2000). Intercropping of corn with soybean, lupin and forages: silage yield and quality, J. Agron. Crop Sci. 185: 177-185.

Carter PR, Oplinger ES, Undersander DJ (1991). Intercropping corn and soybean to increase protein concentration, (www.soybean.uwex.edu/library/soybean/grain/Planting /index)

Essah SYC, Stoskopf NC (2002). Mixture performance of phenotypically contrasting barley cultivars, Can. J. Plant Sci. 82: 1-6.

Etebari H, Tansi V (1994). Research on determining the effects of maize intercropped with vigna in Cukurova on the grain yield and some agricultural characters, 1st Turkish National Field Crops Congress, 25-29 April 1994, Izmir (3): 132-135.

Herbert SJ, Putnam DH, Poos-Floyd MI, Vargas A, Creighton JF (1984). Forage yield of intercropped corn and soybean in various planting patterns. Agron. J. 76(4): 507-510.

McDonald P, Henderson AR, Heron SJE (1991). The Biochemistry of Silage, 2nd Edition, Chalcombe Publications, Printed in Great Britain by Cambrian Printers Ltd, Aberystwyth, p. 327.

Martin RC, Astatkie T, Cooper JM (1998). The effect of soybean variety on corn-soybean intercrop biomass and protein yields, Can. J. Plant Sci. 78(2): 289-294.

Martin RC, Voldeng HC, Smith DL (1990). Intercropping corn and soybean in a cool temperate region: yield, protein and economic benefits. Field Crops Res. 23: 295-310.

Ofori F, Stern WR (1987). Cereal-legume intercropping systems. Adv. Agron. 41: 41-90.

Petterson K (1988). Ensiling of Forages: Factors affecting silage fermentation and quality, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, Uppsala, p. 46.

Portes TDA (1984). Profile of light interception and yields of six bean (*Phaseolus vulgaris* L.) cultivars of different growth habits intercropped with maize (*Zea mays* L.), Field Crop Abst. 37(6): 491.

Putnam DH, Herbert SJ, Vargas A (1986). Intercropped corn-soyabean density studies, II.Yield composition and protein. Exp. Agric. 22: 373-381.

SAS Institute (1990). SAS Users Guide:Statistics, Version 6. SAS Inst., Cary, NC.

Singh NB, Singh PP, Nair KPP (1986). Effect of legume intercropping on enrichment of soil nitrogen, bacterial activiy and productivity of associated maize crops. Exp. Agric. 22: 339-344.

Smith S (2000). Growing corn with companion crop legumes for high protein silage, Greenbook Energy and Sustainable Agriculture Program, Minnesota Dep. Agric. USA, pp. 68-70.