Protein Productivity and Economic Feasibility of Dual-purpose Cowpea

K. Ahenkora¹, H.K. Adu-Dapaah, B. Asafo-Adjei, J.N. Asafu-Agyei, J. Adjei, and E.Y. Oppong Konadu

Crops Research Institute, P.O. Box 3785, Kumasi, Ghana

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Abstract. The effect of leaf harvest on the total protein yield and economic viability of cowpea [*Vigna unguiculata* (L.) Walp.] was evaluated under tropical field conditions. Productivity was measured as edible dry weight and protein yield in kg·ha⁻¹ dry-weight basis (dwb). Calculation of the economic feasibility of the dual-purpose cowpea (leaf and seed harvest) vs. seed-only harvest was based on the net income. Each cultivar was grown on four row plots, with rows 60 cm apart × 5 m long. Only the two central rows were harvested. Two treatments (leaf harvest and no leaf harvest) constituted the main plots, with the varieties as subplots. Leaf harvest was restricted to the most recent, fully expanded third and fourth trifoliate leaves from the apical bud, and extended from 28 days after planting until 50% flowering. Significant ($P < 0.05$) cultivar differences were observed for leaf yield, seed yield, maturity, and protein yield. Dual-purpose use extended mean time to maturity by 6 days. The mean seed yield across 12 cultivars was 1260 and 976 kg·ha⁻¹ for seed-only vs. dual-purpose, respectively. Leaf harvest reduced mean seed protein yield for six cultivars by 23%. The mean gross incomes from the dual-purpose and seed-only harvests were \$1092 and \$912, respectively, but the protein productivity and net income for the dual-purpose system were 1.4 and 1.5 times as great, respectively, as for the seed-only harvest system. Thus, the increased protein yield associated with the dual-purpose harvest was financially warranted.

The cowpea is important in world agriculture and is an economic source of significant amounts of proteins, calories, and some B-vitamins (Fery, 1981; Juneke et al., 1980). Although cowpea is grown most commonly for its edible seeds, young cowpea leaves are consumed in numerous African and Asian countries (Duke et al., 1981). Cowpea is among the top three or four leafy vegetables used in many parts of Africa (Barrett, 1990). In recent years, research to exploit cowpea as a leafy vegetable and grain source for human consumption has increased (Bubeinham and Mitchell, 1988). In Africa, the Crops Research Institute of Ghana has been collaborating with the International Institute of Tropical Agriculture (IITA) to develop cowpea for dual-pur-

pose, leaf, grain, and fodder harvest. In the United States, cowpea is a low-fat candidate legume species for inclusion in the controlled ecological life-support systems (CELSS). Vegetative harvest of cowpea provides an alternative to conventional cowpea seed harvest (Adu-Dapaah et al., 1997; Maeda, 1985).

Some researchers have reported that, within limits, cowpea leaves can be harvested without adversely affecting seed yield (Imungi and Potter, 1983; Oomen and Grubben, 1977). Other researchers have shown that even limited harvest of leaves has a detrimental effect on yield of cowpea seeds harvested at maturity (Bubeinham et al., 1990; Nielsen et al., 1994). Although some cultivars show adverse effects, leaf harvest does not appear to compromise seed yield of other cultivars (Bittenbender et al., 1984). Nielsen et al. (1994), based upon soilless greenhouse culture under a 13-h photoperiod, attributed these conflicting reports about the effect of leaf harvest on seed yield to differences between cultivars. Bubeinham et al. (1990) suggested that, in a CELSS, a given crop should be grown to supply either leaves or seeds, but not both. Other researchers also contend that decisions on any early leaf harvest plan must be based on when food is needed by the consumer and in what form the food is desired (Nielsen et al., 1994).

However, where cowpea seed is an important cash crop, as is the case for the African farmer, both producer and consumer concerns become equally important. Decisions on early leaf harvest depend on the productivity of the system and the ultimate economic returns. The objectives of this study, therefore, were to

determine the protein productivity and economic feasibility of dual-purpose cowpea production, in comparison with production of seed only.

Materials and Methods

Expt. 1. In the first part of the experiment, 12 local and improved cowpea cultivars differing in morphological and phenological characteristics were selected for evaluation. Field trials were conducted at two locations in Kumasi (6°43'N, 1°36'W), Kwadaso, and Fumesua during the major and minor seasons of 1995. The soil series has been classified as Ferric Acrisol (FAO/UNESCO Legend) and Paleustult (U.S. Dept. of Agriculture Soil Taxonomy). A split-plot design with two blocks and three replications was used. Two treatments (leaf harvest and no leaf harvest) constituted the main plots, with the 12 varieties as subplots. Each plot consisted of four rows, spaced 60 cm apart × 5 m long. Three seeds were planted in each hill, 20 cm apart within rows, giving 25 plants/row. The seedlings were thinned to two per hill, 2 weeks after emergence. Three sprays of Karate (Lambda-cyhalothrin) (15 g·ha⁻¹ a.i.) and Cymbush Super (Dimethoate) (400 g·ha⁻¹ a.i.) were applied to control insect pests during the growing season. The first spray was applied just before flowering and the second and third were applied when necessary. Leaves were picked using the practice normally adopted by farmers in the Upper West and Upper East regions of Ghana. The most recent, fully expanded, third and fourth trifoliate leaves from the apical bud were picked from all plants. Leaves were picked at weekly intervals from 28 d after planting until 50% flowering. Depending on the variety, two or three pickings were made.

Expt. 2. In the second experiment, conducted in the major and minor seasons of 1996, six cultivars of similar maturity period were selected. The experiments were conducted in Fumesua and Wa (10°52'N, 1°59'W). The soil series in Wa has been classified as Oxisols. The experimental design was the same as for the first experiment. However, only two leaf pickings were made for each cultivar. In both experiments, the planting date was determined according to the incidence of local rainfall, which totals 1140–1750 and 1100 mm annually for Kumasi and Wa, respectively.

All plant materials were dried at 70 °C in a forced-air oven. Dry weight and protein content were determined for leaves and seeds. Total N was determined in triplicate by the Kjeldahl method (Association of Official Analytical Chemists, 1984). No reduction step was used to include nitrate-N, and crude protein was calculated as N × 6.25. Protein yield was obtained by multiplying the total leaf or seed yield (dwb) by the percent protein. Data were analyzed using standard analysis of variance procedures.

Calculation of the economics of the two systems was based on the gross and net incomes. Prevailing market prices for leaves and seed at the time of the experiment were used.

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¹To whom correspondence should be addressed.

Results and Discussion

Expt. 1. Significant ($P < 0.05$) cultivar differences were observed for leaf yield, seed yield and maturity (Table 1). Leaf yield ranged from 322 to 896 kg·ha⁻¹. In general, mean maturity was extended by 6 d when cultivars were evaluated for dual-purpose. This may have been due to removal of younger, photosynthetically more active leaves, leaving older leaves that required more time to produce enough photosynthate to fill the seeds. On the other hand, the later a variety flowers, the greater the number of leaf harvests possible (Akundabweni et al., 1990). Reduction in seed yield among some cowpea cultivars has been attributed to the loss of new leaves (Brown et al., 1966). Ezedinma (1973) also reported that leaf harvest up to 50% flowering when plants were growing more vigorously and needed more assimilate and nutrients, promoted abscission of flowers and pods, and subsequently reduced seed yield.

Cultivars differed significantly in response to leaf removal (Table 2). The increase in protein yield among cultivars due to leaf harvest ranged from 14% ('Soronko') to 54% (IT87D-556-6). Across all cultivars, however, leaf harvest significantly reduced seed protein by 23%. Leaf protein (mean = 240 kg·ha⁻¹) represented 46% of the total protein yield in the dual-purpose harvest system, and the total protein produced was 41% greater than for the seed-only harvest system. Previous researchers reported that the protein productivity of a leaf-only harvest system was 15 times that for cowpea seeds, because leaves are produced earlier and in much greater quantity than are seeds (Barrett, 1990; Bittenbender et al., 1984). In the dual-purpose system, however, early leaf harvest was restricted to two pickings of selected leaves.

The total production cost of the dual-purpose system was slightly higher than that of the seed-only system (Table 3). On a fresh-weight basis, cowpea leaf yield was 6 times as great as the seed (Table 4). Leaf removal reduced mean seed yield and gross income from the seed by 23% and 23.1%, respectively, but the gross income from sale of the leaves was 36% of the total gross income. The mean gross income from the dual-purpose and seed-only harvests were \$1092 and \$912 per hectare, respectively. Although more weight of leaves than seed were marketed in the dual-purpose system, the seed contributed more to the gross income than did the leaf. The mean net income from the dual-purpose and seed-only harvests were \$510 and \$330 per hectare, respectively, or \$180 per hectare, representing a 54.5% increase.

In Ghana, the system for postharvest handling of cowpea seed is better developed than that for leaves (Ahenkora et al., 1997). Handling and storage of cowpea leaves have received little research attention (Bittenbender, 1992). Cowpea seed, therefore, has a wider market and larger consumer acceptability than the leaf. This difference may partially explain why the protein productivity of the dual-purpose system is 41% greater and the net income

Table 1. Leaf and seed yield of cowpea cultivars evaluated for seed-only and dual-purpose harvests. Expt. 1.

Cultivar	Seed-only harvest		Dual-purpose harvest			Seed yield reduction by dual-purpose harvest (%)
	Maturity (days)	Seed yield (kg·ha ⁻¹) ^z	Maturity (days)	Leaf yield (kg·ha ⁻¹) ^z	Seed yield (kg·ha ⁻¹) ^z	
Ex-Adidome	70	985	66	322	714	28
Legon Prolific	82	894	80	520	716	20
IT85F-867-5	68	984	60	432	716	27
IT87D-453-2	75	1160	67	881	890	23
Amantin	70	1253	65	896	895	29
TVX 1948-01F	69	1253	62	835	983	22
IT86D-1038	72	1522	65	806	1071	30
IT87D-556-6	75	1164	68	567	1083	7
IT87D-1931	74	1342	68	768	1159	14
Ejura Erect	75	1427	69	551	1160	19
IT87D-551-1	67	1522	59	814	1163	24
Soronko	71	611	63	678	1164	28
Mean	66	1260	72	673	976	23
SE	2	18	2	35	29	

^zDry-weight basis.

Table 2. Protein yield of cowpea cultivars evaluated for seed-only and dual-purpose harvests. Expt. 2.

Cultivar	Seed-only harvest		Dual-purpose harvest		Increase in protein yield by dual-purpose harvest (%)
	Seed protein yield (kg·ha ⁻¹)	Leaf protein yield (L) (kg·ha ⁻¹)	Seed protein yield (S) (kg·ha ⁻¹)	Total (L+S) (kg·ha ⁻¹)	
Soronko	434	226	313	540	24
TVX 1948-01F	448	263	313	575	28
IT87D-1931	339	226	291	518	53
Amantin	322	279	230	509	58
IT86D-1038	395	270	289	559	41
IT87D-556-6	293	173	279	426	45
Mean	372	240	286	525	41
SE	10	8	5	5	

is 54% greater than that of the seed-only harvest system, and yet the increased protein production may not be used for consumption. Therefore, postharvest research on cowpea leaves should parallel breeding efforts for dual-purpose cultivars to ensure practical economic viability.

Conclusion

While previous studies have indicated that decisions to introduce early leaf harvest must be based on when food is needed by the consumer and in what form the food is desired, the present study shows that decisions on early leaf harvest must take into account the financial needs of the producer and in what form the income is maximized.

Literature Cited

- Adu-Dapaah, H.K., B. Asafo-Adjei, J. Adjei, and K. Ahenkora. 1997. Cowpea, edible leaves. Coraf Action 3:2-3.
- Ahenkora K., H.K. Adu-Dapaah, F. Ansere-Bioh, and J. Adjei. 1997. Breaking hunger with dual-purpose cowpeas in Ghana. African Crop Sci. Conf. Proc. 3:1421-1426.
- Akundabweni, L.S., C. Peter-Paul, and B.B. Singh. 1990. Evaluation of elite lines of cowpea [*Vigna unguiculata* (L.) Walp.] for leaf/fodder plus grain (i.e., dual-purpose). Trop. Agr. (Trinidad) 67(2):133-136.
- Association of Official Analytical Chemists. 1984.

Table 3. Production costs² for cowpeas evaluated for dual-purpose and seed-only harvests.

Item	Cost/ha (U.S. \$)	
	Dual-purpose	Seed-only
Seed for planting	16.50	16.50
Land preparation	50.00	50.00
Planting	30.00	30.00
Weeding	37.50	37.50
Application of insecticide	90.00	90.00
Harvesting		
Grain	160.00	187.50
Leaves	50.00	
Threshing of seed	115.00	150.00
Transportation		
Grain	15.00	20.00
Leaves	20.00	
Total	584.00	581.50

²Labor cost was US \$2.50/person-day.

- Official methods of analysis. 14th ed. Assn. Offic. Anal. Chemists, Arlington, Va.
- Barrett, R.P. 1990. Legume species as leafy vegetables. p. 391-396. In: J. Janick and J.E. Simon (eds.). Advances in new crops. Proc. 1st Natl. Symp. New Crops. Timber Press, Portland, Ore.
- Bittenbender, H.C. 1992. Handling and storage of cowpea *Vigna unguiculata* (L.) Walp. as a leafy vegetable. Trop. Agr. (Trinidad) 69:197-199.
- Bittenbender, H.C., R.P. Barrett, and B.N. Indire-Lavusa. 1984. Beans and cowpea as leafy vegetables and grain legumes. Monograph No. 1. Bean/Cowpea Collaborative Res. Support Prog., East Lansing, Mich.

Table 4. Yield, income, and financial benefit per hectare from cowpea evaluated for dual-purpose and seed-only harvest.

Cultivar	Income (U.S. \$1000) ^z									Financial benefit ^y (U.S.\$ 1000)
	Yield (kg-ha ⁻¹)			Gross				Net		
	Dual-purpose			Dual-purpose				Dual-		
	Leaves ^x	Seed ^w	Seed-only	Leaves	Seed	Total	Seed-only	purpose	Seed-only	
Soronko	6000	1300	1800	370	780	1150	1080	570	500	70
TVX 1948-01F	6900	1101	1400	420	660	1080	840	500	260	240
IT87D-1931	6800	1300	1500	410	770	1180	900	600	320	280
Amantin	7000	1000	1400	430	600	1030	850	450	270	180
IT86D-1038	6500	1200	1700	400	720	1120	1020	540	440	100
IT87D-556-6	5400	1105	1300	330	660	990	780	410	200	210
Mean	6433	1168	1517	390	700	1092	912	510	330	180

^zFarm gate price of seed = U.S. \$0.60/kg; price of leaves = U.S. \$0.062/kg fresh weight. Price is identical for dual-purpose and seed-only harvest.

^yDual-purpose minus seed-only harvest.

^xFresh weight.

^wDry weight.

- Brown, R.H., R.B. Cooper, and R.E. Balster. 1966. Effects of leaf age on efficiency. *Crop Sci.* 6:206–207.
- Bubeinham, D.L. and C.A. Mitchell. 1988. Cowpea harvest strategies and yield efficiency for space food production. *HortScience* 23:106. (Abstr.)
- Bubeinham, D.L., C.A. Mitchell, and S.S. Nielsen. 1990. Utility of cowpea foliage in a crop production system for space, p. 535–528. In: J. Janick and J.E. Simon (eds.). *Advances in new crops*. Proc. 1st Natl. Symp. New Crops. Timber Press, Portland, Ore.
- Duke, J., C. Reed, K. Rachie, and R. Summerfield. 1981. *Vigna unguiculata* (L.) Walp. sp. unguiculata, p.302–306. In: J. Duke (ed.). *Handbook of legumes of world economic importance*. Plenum, New York.
- Ezedinma, F.O.C. 1973. Effects of defoliation and topping on semi-upright cowpea [*Vigna unguiculata* (L.) Walp.] in a humid tropical environment. *Expt. Agr.* 9:203–207.
- Fery, R.L. 1981. Cowpea production in the United States. *HortScience* 16:4–6.
- Imungi, J.K and N.N. Potter. 1983. Nutritional contents of raw and cooked cowpea leaves. *J. Food Sci.* 48:1252–1254.
- Junek, J.J., W.A. Sistrunk, and M.B. Neely. 1980. Influence of processing methodology on quality attributes of canned dry beans. *J. Food Sci.* 45:821–823.
- Maeda, E.E. 1985. Effect of solar dehydration on amino acid and available lysine content in four tropical leafy vegetables. *Ecol. Food Nutr.* 16:273–279.
- Nielsen, S.S., C.I. Osuala, and W.E. Brandt. 1994. Early leaf harvest reduces yield but not protein concentration of cowpea seeds. *J. Hort. Sci.* 29: 631–632.
- Oomen, H.A.P.C. and G.J.H. Grubben. 1997. Tropical leaf vegetables in human nutrition. Dept. Agr. Res. Commun. 69, Kononklijk Tropen. Amsterdam, The Netherlands.