VII[th] Symposium of the International Society for Tropical Root Crops,
Gosier (Guadeloupe), 1-6 July 1985, Ed. INRA, Paris, 1988.

INTERCROPPING POTATO (SOLANUM SPP.) WITH MAIZE IN WARM CLIMATES

D.J. MIDMORE

International Potato Center (CIP)
APDO 5969, LIMA PERU

(La culture associée Pomme-De-Terre (Solanum spp) et Maïs en climat chaud)

SUMMARY

High soil temperature late in the crop season can lead to reductions in tuber yield ; therefore a series of experiments were run in which maize and potato were simultaneously planted at three warm sites (20/30°C average night/day temperatures) in Peru. The adjacent maize crop (ranging from 10-25 per cent of normal population) provided sparse shade in the season, which resulted in reduced soil temperatures. Yield of the intercropped potato (75-90 per cent of normal population) did not generally differ significantly from that the sole crop. However, maize grain yields were proportionnately greater than expected from their respective planting densities, hence land equivalent ratios exceeded unity. Percent dry matter in tubers was improved in the intercrop whereas insect damage to tubers and foliage was diminished. The results are discussed in view of the increased light use efficiency by potato when grown adjacent to maize.

RESUME

Les fortes températures à la fin de la culture peuvent conduire à des réductions de récolte de pommes de terre. On a donc conduit une série d'expériences dans lesquelles Maïs et Pommes de terre étaient plantés ensemble dans trois situations chaudes du Pérou (températures nuit-jour 20° - 30° en moyenne). Les plants de Maïs, répartis à raison de 10 à 25 pour cent de la densité normale fournissaient une ombre légère en fin de saison, avec pour conséquence une réduction de la température du sol. Les rendements des Pommes de terre, plantées à 75 à 90 pour cent de la densité normale n'ont pas en général différé significativement de ceux obtenus en culture homogène, et les rendements en Maïs ont été supérieurs à ce qu'on aurait pu attendre en fonction des densités, donc le rendement proportionnel en culture associée a *dépassé l'unité. La teneur en matière sèche des tubercules a été augmentée en culture associée et les dégâts d'insectes sur tubercules et sur feuillages diminués. Les résultats sont interprétés en termes d'efficacité accrue de l'utilisation de la lumière par la Pomme de terre cultivée au voisinage du maïs.*

INTRODUCTION

High temperature represents a serious limitation to the extension of potato production, traditionally in temperate climates, to warmer areas where consumer demand for potato is great (VANDER ZAAG and HORTON, 1983). Efforts are underway at the International Potato Center (CIP) to identify practical modifications of the micro-environment in the warm tropics that would favour potato production.

One way of cooling the micro-environment is to capitalize on the shade of associate crops represents. Previous studies by MIDMORE et al, (1983) have reported on the use of maize or coconut as the source of shade. With maize, a relay cropping system was tested in which potato was planted into a senescing maize crop the latter at commercial density and intercepting up to 80 per cent of incident light. When potato was planted beneath coconut palms, 15 per cent of incident light was intercepted by the palms and 85 per cent reached the potato. With both cropping systems, improvement of potato emergence and establishment in shaded plots was attributed to reduced soil temperatures and conservation of soil moisture.

High soil temperature late in the potato crop is also detrimental to tuber yield, particularly when haulms lodge and expose the soil to incoming radiation. Reduction in soil temperature during the latter part of bulking in warm environments, by means of soil reflectans, leads to yield improvements of up to 50 per cent (MIDMORE, 1984). Attemps to reduce soil temperature during bulking by a single application of mulch at planting have been largely unsuccessful, since the reflective and insulatory characters of mulches, important for soil cooling, degenerate as the season progresses (MIDMORE et al., 1985). As an alternative, the potato can be planted at the same time with a companion crop, which intercepts radiation excessive to the needs of the potato crop and, simultaneously reduces soil and air temperature favouring the potato.

There are few published studies on shading and intercropping of the potato. A study done in Kenya at 1 800 m, reports that the yields (on a per plant basis) of potato planted three weeks after maize (FISHER, 1977) ranged from 25 per cent to 75 per cent of the yields of the sole potato crop. The reduction in potato yield was not, however, compensated by equivalent increases in maize yield, hence the land equivalent ratios (LER) did not exceed one. Artificial shade

(34 per cent of full sunlight) applied throughout the season in a high-radiation environment also reduced potato yield, by 25-40 per cent (Sale 1973). Separate shading, however, at the same intensity either prior to or after late tuber initiation resulted in yields intermediate to those of the plots that were shaded or unshaded throughout the cropping cycle (SALE, 1976). Shade can be beneficial for the potato crop by reducing soil and air temperatures in warm climates, but if excessive it will cause reduced potato yields that may not be compensated by equivalent increases in the yields of a companion crop. Careful consideration should therefore be given to the relative densities of the component crops in a mixture to achieve a balance of competitive effects between such crops when planted together. This was one of the objectives of the series of experiments reported herein. Light interception and soil temperature data assisted in interpreting the influence of intercropping on component crop yields.

Reduction of insect pest damage an additional benefit of intercropping has been documented for mixed crops (LITSINGER & MOODY, 1976), and specifically for crop associations that include the potato (RAYMUNDO and ALCAZAR, 1984). Stability through diversity has been cited as one of the major incentives for the perpetuation of intercropping by subsistence farmers lacking capital for investments in chemical pest control (LITSINGER & MOODY, 1976). A second objective of the present study was to quantify the possible benefits of various maize-potato mixtures on reducing pest damage, particularly to the potato.

MATERIALS AND METHODS

Five experiments were set up in Peru, two at Lima (LIM, planted 30-1-85--Expts 1 and 2), one at San Ramon (SR, planted 8-5-84--Expt 3), and two at Yurimaguas (YUR, planted 14-6-84 and 21-6-84--Expts 4 and 5, respectively). Representative weather and site data are presented in Table 1. The potato was planted in pure stands and mixtures ; the clone DTO-33 in Expt 1, the clone LT-1 in Expts 2 and 3, and the variety Desirée in Expts 4 and 5. The double hybrid maize PM 701 was planted at LIM and SR, and the local maize cultivar Planta Amarilla Baja at YUR, again in pure stands and mixtures. Plot size for both sole (pure stands) and mixed stands in all but Expt 4 was 5 m x 3.5 m with spacing between rows at 0.7 m and within rows spacing at 0.3 m. Plots of 7.7 m x 5 m with the same between -and within- row spacing, were employed in Expt 4.

Fertilizer was applied at the rate of 80:160:160:50 kg of N, P_2O_5, K_2O, and MG_2O per hectare at planting ; and additional 80 kg of N was applied to the potato at hilling. Two t/ha of lime was applied to the soil before planting Expt 4 to raise the soil pH from 4.3 to 5.5. At SR and YUR no chemical crop protection was practiced ; however, at Lima,

Table 1. Meteorological and environmental data for three CIP Stations within Peru

Site :	Lima-La Molina	San Ramon	Yurimaguas
Latitude :	12°05'S	11°08'S	5°41'S
Altitude :	240 m	800 m	180 m
Growing season :	Jan-Mar	May-Aug	May-Aug
Air max (°C)	29.3	28.5	30.4
Air min (°C)	20.3	16.1	20.6
Evaporation (total mm)	600.5	550.8	247.7
Rainfall (total mm)	1.4	545.3	633.8
Radiation (daily MJ/m²)	19.14	17.32	14.01

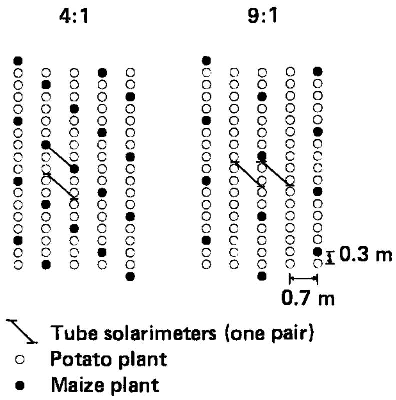

Fig. 1. Distribution of potato and maize plants, and tube solarimeters (one at top and one at base of potato canopy in each pair) in 4:1 and 9:1 mixtures.

Lannate (Methomyl) and Morestan (Quinomethionate) were applied once at the commercial rates to control serious outbreaks of *Phthorimaea operculella*, and *Polyphagotarsonemus latus*, respectively.

Mixtures of potato-maize in Expts 1, 3 and 5 were at a proportion of 9 : 1 (42,800 and 4,800 plants/ha, as illustrated in Fig. 1) within randomized complete block designs replicated 3, 5, and 4 times. In Expt 2, mixtures of potato-maize were at proportions of 9:1 and 4:1 (Fig. 1) replicated 3 times. For Expt 4, plant arrangement of 9:1 mixtures was as in Figure 1 ; 4:1 mixtures, however, comprised four rows of potato to one of maize--all treatments were replicated four times.

Early in the season, the crop cover of all plots was measured weekly at four positions within each plot by using the grid method as described by BURSTALL and HARRIS (1983) ; later, as the maize grew taller than the potato, the potato cover was measured only by this methods. Tube solarimeters (Delta-T, Cambridge, UK) were positioned within plots with maize as indicated in Figure 1 and light interception by maize was calculated against a control tube placed in the open. A pyranometer (LICOR Inc.) at the meteorological station at each site provided daily values for total incident light energy. During the latter part of tuber bulking in Expts 1 and 2, soil temperature, 7 cm depth within the plot ridge, was recorded hourly throughout 24 h periods with a thermistor recorder (Grant Instruments, Cambridge, UK). Foliar insect damage of the potato crop was visually quantified throughout Expts 1, 2 and 4 and at harvest damage to tubers and maize ears was recorded.

Bordered areas within the central 2 two rows of each plot were harvested at crop maturity. Tubers were sorted according to those greater or smaller than 3.5 cm, weighed, and counted. A tuber sample from each plot was dried at 70°C to a constant weight for per cent dry matter determinations. At maize harvest stems and ears were counted, the ears weighed and samples of grain from 5 to 10 ears were dried to a constant weight. The yields and yields components of mixed and sole crops were analysed using an analysis of variance. Land equivalent ratios, i.e., the relative land area under sole crops required to produce the yields achieved in intercropping, were computed as outlined by WILLEY (1979).

RESULTS

Crop Cover, Light Interception, and Soil Temperature

Data collected from Expts 1 and 2 illustrate the progenies over time for crop cover of sole and mixed crops (Fig. 2). The rate of achievement of maximum cover was greater for potato than maize ; however, the potato crop cover, once

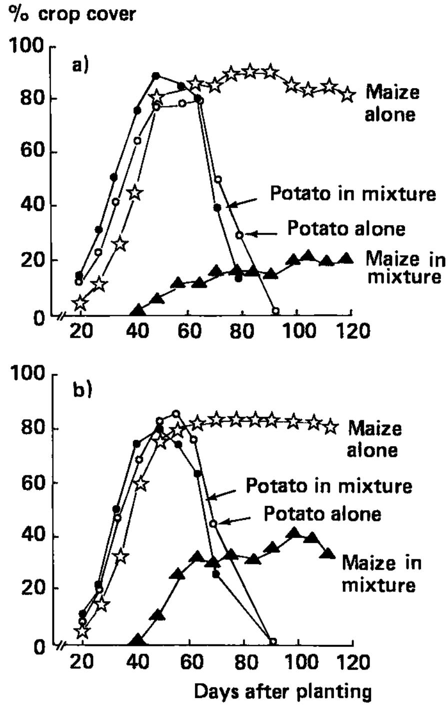

Fig 2. Crop cover for sole and mixed crops, a) 9:1 mixture in Expt 1; b) 4:1 mixture in Expt 2.

it reached a peak, soon declined whereas both sole and mixed maize maintained their maximum cover almost until maturity. Crop cover of the potato component in the mixtures was similar to that of sole plots-potato adjacent to maize effectively occupied all available space. Light interception by maize in mixtures was not evident until 45 days after planting. After this time, maize planted in the 9:1 mixture (10 per cent of normal population) intercepted between 10-20 per cent of incoming light, whereas maize planted in the 4:1 mixture (20 per cent of normal population) intercepted between 30-40 per cent (Fig. 2). In the other three experiments, maize at 10 per cent of normal population intercepted up to 25 per cent of incoming light.

Once the potato cover started to senesce, approximately 60 days after planting (Fig. 2) soil cooling during the day by maize in mixtures became effective. Maize shade reduced daytime soil temperatures by up to 5°C compared to soil temperature of non-shaded potato plots (Fig. 3). Little further reduction in soil temperature was effected in the sole maize plots (intercepting 85 per cent of incoming light).

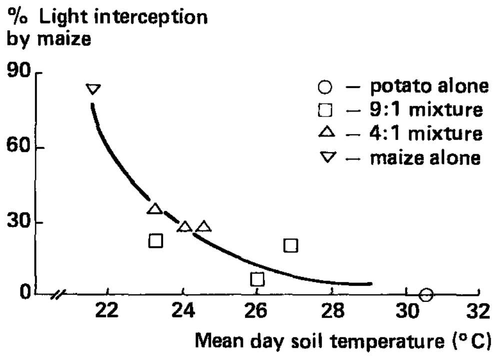

Fig. 3. Mean day soil temperature (7 cm depth) as a function of light interception by maize 70 days after planting of Expt 2.

Insect Damage

Less foliage and tuber damage to the potato was observed in mixed than sole potato plots (Table 2). At LIM (Expt 1), the number of potato tuber moth larvae (*P. operculella*) and their mining damage to leaves, particularly to tubers, was less in potato mixed with maize. Mixtures of 9:1 or 4:1 were equally effective in reducing foliar damage due to *P. operculella* in Expt 2 (27.3 vs. 25.1 larvae per 10 plants, respectively). Feeding damage due to *Colaspis cholorotis* Erickson in Expt 4 at YUR was also reduced in mixed plots, the beneficial effect was more evident when maize was systematically positioned throughout the plot rather than alternating it with every four rows of potato.

Table 2. Influence of mixed cropping with maize on incident of pest damage of potato, Expts 1 and 4.

Treatment	Expt 1		Expt 4		
	No. larvae per 10 plants[1]	% tubers damaged[1]	% damage, leaves per plant[2]	No. feeding holes per 25 leaflets[2]	% tubers damaged
Potato alone	38.4	34.0	43.35	73.25	23.01
Potato : maize (9:1)	25.4	9.9	38.11	55.50	15.78
Potato : maize (4 rows : 1 row)	-	-	40.30	38.75	19.34
SED[3]	4.2	2.3	2.69	10.47	2.30

[1] Phthorimae operculella

[2] Colaspis chloritis Erikson

[3] SED - Standard error of the different between two means

Table 3. Tuber and grain yields and their components in Expts 1 and 2, Lima

Treatment	Total fresh tuber yield (g/m^2)	Wt/plant (g)	% commercial size tubers (> 3.5 cm)	% dry matter in tubers	Maize grain (g/m^2)	Maize stems (per m^2)	Ears (per m^2)	Grain weight (g/ear)
Expt. 1								
Potato alone	1498	365	68.9	16.15	-	-	-	-
Potato : maize	1612	454	72.5	16.06	123	1.08	1.37	93
Maize alone	-	-	-	-	490	8.70	6.16	77
SED	ns[1]	ns	ns	ns	97	2.16	1.28	6
Expt. 2								
Potato alone	2435	543	87.3	16.01	-	-	-	-
Potato maize (9:1)	1777	433	81.8	18.01	148	1.47	2.01	66
Potato : maize (4:1)	1252	359	81.2	17.43	313	2.44	3.25	97
Maize alone	-	-	-	-	590	9.74	7.31	78
SED	265	42	ns	ns	90	0.42	0.51	ns

[1] ns = non-significant

Insect damage of maize ears attributed to *Euxesta* sp. and *Spodoptera* sp. was similar in mixed and sole plots.

Potato and Maize Yields and Components

In general, tuber yields from mixed plots did not differ significantly from those of sole potato plots, and on some occasions (Expts 1 and 5) yields exceeded those of sole potato plots (Table 3 and 5). In Expt 2, potato yields at both 9:1 and 4:1 were significantly less than those of sole potato. Yields on a per plant basis followed the tendency of yields expressed on a per unit area of land ; some differences, however, between initial and final potato plant populations influenced, in varying degrees, the yield differences between treatments. for example, in Expts 2 and 5, the final population of sole potato plots was 9 per cent less than the population planted, compared to 1 per cent reduction in potato plant population of 9:1 mixed plots.

The proportion by weight of tubers greater than 3.5 cm diameter did not differ significantly between mixed or sole plots of potato. Similarly, tuber number per plant did not differ between mixed and sole plots (data not presented), but there was a tendency for percent matter of tubers to be greater in mixed than sole plots.

Maize yield in mixed plots, except for Expt 3, was significantly less than of maize alone. Grain yield in mixed plots however was proportionately greater than that expected, based on the relative populations planted in mixed and sole plots. When planted at 10 per cent of normal population, maize produced from 20 per cent (Expts 4 and 5) to 47 per cent (Expt 3) of sole crop yield, and when planted at 20 per cent of normal population, maize yielded from 36 per cent (Expt 4) to 53 per cent (Expt 2) of sole maize. Altough maize stem population per unit area correlated well with the maize population planted, heavier grain weight per ear and more ears per stem were responsible for the proportionately greater maize grain yields in mixed plots.

The relative importance of either heavier grain weight per ear or improved survival of ears at low maize planting populations varied across sites ; the contribution of heavier grain weights per ear were greater at SR (Table 4), that of improved survival of ears at LIM (Table 3), and both components of equal importance at YUR (Table 5).

DISCUSSION

Intercropping maize with potato, planted simultaneously, effected reductions in soil temperature later in the potato season and reduced insect pest damage, to both potato foliage and tubers.

Table 4. Tuber grain yields, and their components in Expt 3, San Ramon

Treatment	Total fresh tuber yield (g/m^2)	Wt/plant (g)	% commercial size tubers (> 3.5 cm)	% dry matter in tubers	Maize grain (g/m^2)	Maize stem (per m^2)	Eears (per m^2)	Grain weight
Potato alone	2271	518	91.5	15.73	-	-	-	-
Potato : maize (9:1)	1957	468	87.1	17.01	203	0.73	1.40	148
Maize alone	-	-	-	-	426	10.20	7.31	57
SED	ns	ns	ns	ns	ns	3.02	0.94	20

Table 5. Tuber and grain yields, and their components in Expts 4 and 5, Yurimaguas

Treatment	Total fresh tuber yield (g/m^2)	Wt/plant (g)	% commercial size tubers (> 3.5 cm)	% dry matter in tubers	Maize grain (g/m^2)	Eear (per m^2)	Grain weight (g/ear)
Expt. 4							
Potato alone	299	67	0[1]	-[2]	-	-	-
Potato : maize (9:1)	222	67	0	-	46	0.47	94
Potato : maize (4:1)[3]	169	57	0	-	80	0.72	112
Maize alone	-	-	-	-	221	2.66	88
SED	ns	ns	-	-	18	0.33	ns
Expt. 5							
Potato alone	329	85	52.6	12.88	-	-	-
Potato maize (9:1)	429	109	61.7	13.10	64	0.69	94
Maize alone	-	-	-	-	296	3.80	76
SED	ns	ns	ns	ns	70	0.38	ns

[1] All tubers 3.5 cm

[2] No data collected

[3] Four rows of potato to one row of maize

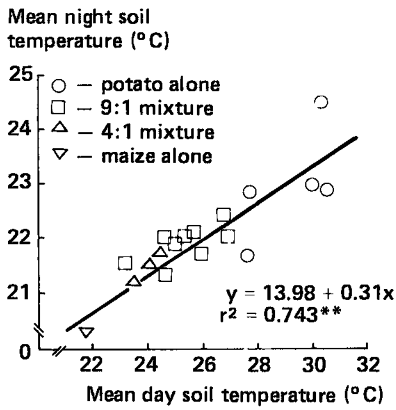

Fig. 4. Relationship between mean day (08.00 - 18.00 h) and night (18.00 - 08.00 h) soil temperatures at 7 cm depth as modified by shade treatments in Expt 2 on two successive days.

Cool shaded plots during the day were also the coolest at night, since loss of soil heat at night through back-radiation was not impeded by the maize crop, neither in mixed nor sole plots. This contrasts with the use of mulch as a soil coolant ; mulch although reducing daytime soil temperature often leads to a greater maintenance of heat at night through reduced loss of sensible heat (MIDMORE, et al., 1985). Maintenance of a cooler soil environment in mixed rather than sole plots during the night may have contributed to the slight but consistent improvement in tuber percent dry matter, perhaps as a result of lower rates of tubeer respiration (BURTON, 1966).

Shade provided by maize in mixed plots was negligible until 50 days after planting, by which time tuber initiation was complete ; consequently, tuber number per plant was unaffected by crop mixtures. Seventy days after planting, shade was greater than predicted on the basis of proportion of total planted population ; incoming radiation in 9:1 and 4:1 mixtures was 15 per cent and 30 per cent less than that of sole potato plots due to shade by the associated maize. Potato, with a crop cover of 40 per cent at that time (Fig. 2), therefore intercepted 35 per cent or 28 per cent of total incoming light energy in 9:1 or 4:1 mixtures, respectively, compared to 40 per cent of total light energy late in the season was apparently dependent upon the interaction between site and clone. Presentation of results expressed on the basis of LER's (Fig. 5) assists in the interpretation of the interaction. At LIM, shade of the 9:1 mixture increased yield of DTO-33 in Expt 1 and reduced that of LT-1 in Expt 2, the latter even more so at the 4:1 mixture (Tables 3 and 4). The

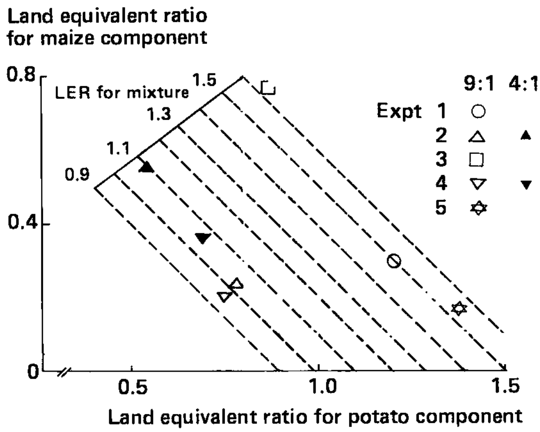

Fig. 5. Land equivalent ratios for maize, potato and the mixtures,

clone DTO-33 has been shown to close its stomates during the afternoon and is reasonably insensitive to reductions in light energy up to 25 per cent (Sattlemacher, unpublished)--a possible explanation for its good performance when mixed with maize. Grain yields of maize at LIM were proportionately greater than expected on a planted population basis due in part to proportionately more light interception (Fig. 2) and improved harvest index (Table 3). The response of the clone LT-1 to shade at SR (Expt 3) was similar to the response at LIM, its yield being slightly less than expected from the planted population. In contrast, however, grain yield of mixed maize at SR was greatly favoured for reasons similar to chose at LIM, resulting in a mixture LER of 1.64. At YUR, individual plant yields of the variety Desirée in 9:1 or 4:1 mixtures of Expt 4 were not markedly less than those of sole plots (Tables 5) and maize yields in mixtures were only marginally greater than predicted on the basis of planted population. Nevertheless, in Expt 5 potato yields per unit area were greater in mixed than sole plots, due to improved survival of plants to *Pseudomonas solanacearum* within the mixed plots. Autrique (unpublished) has observed a similar reduction in the spread of *P. solanacearum* in potato crop when intercropped with maize.

Computation of LER's, although useful for interpreting yields on a quantitative basis, has little bearing on the qualitative aspects of mixed cropping. For example, in Expts 1 and 4, the tuber damage due to insects was significantly decreased, enhancing the value of the harvested tubers from mixed plots.

The amount of light energy intercepted by potato up to maturity was greater by sole potato than by potato in mixed plots, e.g., in Expt 2, 628.9, 555.2 and 471.1 MJ/m^2, for sole potato, 9:1, and 4:1 mixtures, respectively. With the inclusion of the light energy intercepted by maize up to potato maturity, the values for 9:1 and 4:1 mixtures became 652.8 and 714/MJm^2 representing a more efficient interception than by the sole potato crop. An analysis of light use efficiency by potato foliage and conversion to tuber dry matter suggested a nonsignificant advantage of mixed potato in Expt 1 (0.69 g tuber/MJ vs. 0.42 g tuber/MJ for sole potato) and Expt 3 (1.02 g vs. 0.89 g tuber/MJ), but no apparent difference existed between mixed and sole potato plots in Expt 2. Light energy receipts in the tropics are normally non-limiting for photosynthesis even under 34 per cent shade (SALE, 1976). It is therefore conceivable that sparse shade provided by maize at different periods during the day, as in the present experiments, may permit a more efficient use of light energy by the potato mixed plants. Soil cooling and the probable reduction of tuber respiration may also contribute to the apparent greater light use efficiency.

Following potato harvest, maize remained standing for a further 20 to 30 days prior to its harvest. Strictly, LER's should be calculated on a unit area per unit time basis when the two crops are not harvested simultaneously and the crop that remains is of lesser importance. During the period between potato and maize harvest, however, the soil was shaded (Fig. 2), providing a suitable cool environment (Fig. 3) for the establisment of a further crop of potato (MIDMORE, et al. 1983) or other temperate crops (VILLAREAL and LAI, 1981). In addition, the maintenance of some cover over the soil between successive crops reduces erosion (GREENLAND, 1975) and weeds (LITSINGER and MOODY, 1976).

Given the promising results from the present experiments, further studies should concentrate on quantifying potato genotype response to maize shade and potatoes. Clones currently available for study were originally developed for monocropping, but if increasing emphasis is to be placed on the role of intercropping potato in warm climated, the question of whether to select clones under such conditions should be addressed.

In summary, mixing potato and maize in warm tropical environments has certain benefits for both crops. At a 9:1 ratio, apart from suffering less insect damage, potato yields were not significantly less and on a number of occasions they were greater than sole crop yields. The conversion efficiency of light to tuber dry matter by the potato in crop mixtures was equal to or greater than that of sole potato. Light excessive to the needs of the potato was used to advantage by the maize in crop mixtures, maize intercepted more light and yielded more grain than predicted on the basis of the population planted. At a 4:1 ratio, maize competed with potato for light energy and mixture land equivalent ratios barely exceeded unity.

ACKNOWLEDGEMENTS

Thanks are due to ingenieros JORGE ROCA, DONALD BERRIOS, PEDRO RUIZ, and JORGE ALCAZAR for assistance with collection of field data.

REFERENCES

BURSTALL L. and HARRIS P.M. (1983).- The estimation of percentage light interception from leaf area index and percentage ground cover in potatoes. J. agric. Sci. Camb. 100, 241-244.

BURTON W.G. (1966).- The potato. 2nd Ed. Holland, Veenman and Zonen. 382 pp.

FISHER N.M. (1977).- Studies in mixed cropping. I. Seasonal differences in relative productivity of crop mixtures and pure stands in the Kenya highlands. Expl. Agric. 13, 177-184.

GREENLAND D.J. (1975). Bringing the green revolution to the shifting cultivator. Science 190, 841-844.

LITSINGER J.A. and MOODY K. (1976).- Integrated pest management in multiplied cropping systems, in : Multiple Cropping. ASA Special Publication N° 27. Madison, U.S.A. 293-316.

MIDMORE D.J. ; ACCATINO P. and BERRIOS D. (1983).- Potato production under shade in hot climates. in : Potato for the Year 2000, Proc. Int. Conf. Ed. W. J. Hooker, Feb. 1982, CIP, Lima, Peru. 130-131.

MIDMORE D.J. (1984).- Potato (*Solanum* spp.) in the hot tropics I. Soil temperature effects on emergence, plant development and yield. Field Crops Res. 8, 255-271.

MIDMORE D.J. ; BERRIOS D. and ROCA J. (1985). Potato (*Solanum* spp.) in the hot tropics II. Soil temperature and moisture modification by mulch in contrasting environments. Submitted.

RAYMUNDO S.A. and ALCAZAR J. (1984).- Control of potato tubermoth (*Phthorimaea operculella*) through crop association, in : 6th Symp. Int. Soc. Trop. Root & Crops, Lima, 1983. CIP, Lima, Peru. 517-521.

SALE P.J.M. (1973).- Productivity of vegetable crops in a region of high solar input. I. Growth and development of the potato (*Solanum tuberosum* L.). Aust. J. agri. Res. 24, 733-749.

SALE P.J.M. (1976). Effect of shade at different times on the growth and yield of potato. Aust. J. agric. Res. 27, 557-566.

VANDER ZAAG, D.E. and HORTON D. (1983). Potato Production and utilization in world perspectives with special reference to the tropics and sub-tropics, in : Potato for the Year 2000, Proc. Int. Conf. Ed. W. J. Hooker, Feb. 1982, CIP Lima, Peru. 44-58.

VILLAREAL R.L. and LAI S.H. (1981).- Cultivar response of tomatoes to relay cropping. Hort. Sci. 16, 552-553.

WILLEY R.W. (1979).- Intercropping--its importance and research needs. Part I. Competition and yield advantages. Field Crops. Abstr. 31, 1-10.