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Effect of Intercropping of Zea Maize with Potato *Solanum tuberosum*, L. on Potato Growth and on the Productivity and Land Equivalent Ratio of Potato and Zea Maize

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Abstract: This research was carried out during two growing seasons of 2006/2007-2007/2008 in order to determine the effect of intercropping of zea maize (*Miert cultivar*) with potato (*Marfona cultivar*) on potato growth and on the productivity and Land Equivalent Ratio (LER) of potato and maize. The results of this research showed that intercropping of maize with potato in the case of equal plant densities (4.76 plant m^{-2}) of both crops caused an increase in the mean length of potato stems, which reached 27.45 cm. Moreover, intercropping of maize of 2.38 plant m^{-2} led into the increase of the mean weight of potato shoots (fresh and dry) to 227 and 21.28 g $plant^{-1}$ for fresh and dry weight, respectively, besides the increase of the mean weight of potato tubers, which reached 101 g $tuber^{-1}$. Results also, showed that the number of potato stems and formed tubers were not affected by intercropping of maize with potato. As for productivity, results indicated that the total productivity of each unit area using intercropping system was higher than the productivity of the sole crop, with superiority of treatments with 2.38 plant m^{-2} of maize and 4.76 plant m^{-2} of potato where mean yield of 44 ton ha^{-1}, while, the productivity in the other treatments were 36 and 37.8 ton ha^{-1}. LER showed positive influence using the intercropping system compared to the sole cropping, as it shown in the LER values, which were higher (1.43-1.55) in intercropping compared to (1) in the sole cropping.

Key words: Intercropping, land equivalent ratio, potato, productivity, zea maize

INTRODUCTION

Food problem is one of the most important problems world is enduring nowadays, attributed to the drastically growing numbers of population and limited cultivation areas, implying the immense need for more extensive research in order to accommodate the problem. Agriculture is the key to solve famine problem, a lot of researches conducted around the globe expressed the possibility of increasing the yield by many means and cultivation innovative techniques, which is not limited to the use of genetically modified and disease resistance plants, finding a new cultivars with a good quantity and quality, or the use and implementation of cutting edge technologies, but also in utilizing the utmost of existing resources in countries (Boras *et al*., 2006).

The use of agricultural intercropping system is one method of increasing productivity and intensity of plants (Chaudhary and Singh, 1996). Field productivity in intercropping system depends on many factors including planting seasons, plants density, used cultivars and agricultural practices like irrigation, fertilization etc. (Tsubo *et al*., 2003).

Intercropping system proved achieving many advantages, such the perfect utilization of environmental factors, soil protection and variety of food resources (Beets, 1982). On the other hand, Ofori and Gamedoaghao (2005) indicated that intercropping system causes a decrease of yield due to the problems of harmfull grasses, pets and diseases, in addition to the difficulties of harvestation.

Most of the intercropping system researches have concentrated on field crops, like Soya been, zea maize, Negro bean which are searched by Galal (1998), Santalla *et al*. (2001), Kunchinda *et al*. (2003) and Ghosh *et al*. (2006). Also, there is a number of studies on intercropping system about potato and zea maize. In Latin America, Midmore *et al*. (1988) studied a combination of potato and zea maize, also Liu and Midmore (1990) in Asia and Ifenkwe *et al*. (1989) and Bouwe *et al*. (2000) in Africa.

In combining of potato and zea maize together in an intercropping system, where the growth pattern of potato and zea maize leaves differs, the light competition decreases the growth and affects leaves formation (Pellerin, 1991). Other results for Aerts *et al*. (1991) and

Cahill (1999) showed that root competition in the first stages of plant's life cycle leads into weak growth and decreases plant light interception another study conducted by Moorby (1978), explained that little competition between potato and zea maize plants offer suitable biological domain for potato plants, which is necessary for (what)?? Ebwongu *et al.* (2001) results showed that productivity of the potato crop decreased when intercropped with zea maize compared to the plantation of sole potato, while, it increased by increasing plant density during intercropping treatments. In addition to that researches results done by Dutta *et al.* (1994) indicated that land equivalent ratio was highest under intercropping system compared with sole cropping.

In Jordan, a country witnessing a growing population with a limited planted lands and scarce irrigation water resources, causing shortage of potato and zea maize quantities produced locally in Jordan's, especially, in winter time, there are very few previous studies on intercropping system for such crops. Therefore, this study was designed to determine the effect of intercropping of zea maize with potato on potato growth, as well as to measure the productivity and land equivalent ratio of potato and zea maize.

MATERIALS AND METHODS

Site description: This research was carried out in the South region of the Dead sea, in the Jordan valley (350 m below sea level), for the period of two growing seasons of 2006/2007, 2007/2008. The soil of this site is loamy sand, consists of 86.1% sand, 3.74% silt, 10.16 clay and it's pH is 7.4.

Plants cultivars: Potato cultivar used in this research is Marfona, produced by AGRICO company, this cultivar is of medium maturity (100-105 days after planting date), has a short stand stem, good vegetative growth, an oval tubers with yellow pare and kernel of high yield and low dry matter.

Zea maize cultivar used is Miert, which is produced by AGRICO company and suitable to be grown in the Jordan valley environmental context.

Experimental design and treatments: A complete randomized-blocks design was used in this study, including 5 treatments with 4 replicates for each one. The replicate is an experimental slot 25.20 m^2, consisting of 6 rows, 6 m in length for each row, with an inter-row distance of 0.7 m. Potato tubers planted in pits with 0.3 m distance in between, while zea maize planted in pits with (0.3-0.45-0.6 m). Planting date in the first season was on 1/11/2006 and on 5/11/2007 in the second season for both crops. The soil was prepared by adding 3 kg m^{-2} of fermented organic fertilizers, 30 g m^{-2} of super phosphate 46% and also, 30 g m^{-2} of potassium sulphate 50%, in addition to (UREA 46%), which was added in 3 doses, 10 g m^{-2} for each stage, first dose was delivered at the soil preparation stage, the second was added after a week of germination, while the third dose was added a month after of the second dose.

Treatment: The plant density of potato in both sole cropping and intercropping treatments was 4.76 m^2 plant. The intercropping treatments were as following:

- Potato sole crop
- Zea maize sole crop (plant density = 4.76 m^{-2})
- Potato and zea maize in the same row (zea maize plants density = 4.76 plant m^{-2})
- Potato and zea maize in the same row (zea maize plants density = 3.57 plant m^{-2})
- Potato and zea maize in the same row (zea maize plants density = 2.38 plant m^{-2})

Measurements:

- Mean number of potato stems (stem/plant)
- Mean length of potato stems (cm/plant)
- Mean weight of fresh and dry shoots (g/plant)
- Mean number of potato tubers (tuber/plant)
- Mean weight of potato tubers (g/tuber)
- Mean productivity of potato tuber per unit area (ton/ha)
- Mean productivity of zea maize in unit area (ton/ha)
- Land Equivalent Ratio (LER) according to (Mead and Willey, 1980).

As the following equation:

$$LER = ERs\ (potato) + LERs\ (maize)$$

$$LER = \text{Total land equivalent ratio}$$

$$LERs = \text{Relative Land Equivalent Ratio}$$

$$LERs = YP/YM$$

$$YP = \text{Crop Yield Under Intercropping System}$$

$$YM = \text{Crop Yield Under Sole Cropping}$$

Data analysis: SPSS program used in the statistical analysis, where the significant differences were calculated in the level of (0.5) and the coefficient of variance used among treatments and its value was determined.

RESULTS AND DISCUSSION

Effects of intercropping system on potato (*Marfona cultivar*) on: Stems length, mean weight of fresh and dry shoots, number of stems and tubers and tuber mean weight (means of two growing seasons).

The results indicated as presented in Table 1, so that intercropping system influences the mean of stem length of potato plants. All intercropping treatments excelled the sole cropping and when comparing the intercropping treatments, we notice that treatment (3) of (27.45 cm) has superiority among all treatments in plant stem lenght of potato and this increase in the height is due to the competition between potato and zea maize plants on light. The growth pattern of zea maize resulted to be higher than potato plants which reduces the sun rays reaching, potato plants, which caused an enhanced stem elongation of potato, in order to obtain the needed light amounts. This result is consistent with Gawronska and Dwelle (1989) results. The data presented in Table 1 also, shows that intercropping affected the weight of shoots (fresh and dry), which was higher in the case of sole potato (227 g fresh weight, 21.28 g dry weight) compared with intercropped potato. It's clearly that treatment (1) of (212 and 19.57 g) fresh and dry weight, respectively, has a greater significant increase among intercropping treatments. This increase is attributed to the lowest plant density of maize plants (2.38 plant m^{-2}), which reduced the competition between the plants and helped potato plants to benefit more from light radiation, which resulted in a positive increase in the dry and fresh weight of potato plants.

Similar results Monteith and Mass (1977) insure that the total biological yield of plants, depends directly on the quantum of light intercepted by green foliage of plants.

There were no significant differences in the number of stems and tubers of potato plant as shown in Table 1. In both sole cropping and intercropping, similar observations by Allen and Warr (1992) indicated that the number of stems formed, depends on tuber size and variety. Furthermore, O'Brien *et al.* (1998) explained thatshading of potato plants before or after a period of tuber initiation had no effect on the number of tubers.

Also, intercropping had a negative influence on the mean weight of potato tuber, which resulted in a lower weight tubers compared to sole potato, which reached to 122.5 g $tuber^{-1}$. While, the best result obtained from intercropping treatments was in treatment (5) in which tubers weight reached to 101.0 g $tuber^{-1}$. But, in treatments (3) and (4), the mean weights were 62.0 and 81.0 g $tuber^{-1}$, respectively; this significant reduction in both of those treatments might be attributed to the weakness of potato plants, which have failed in assuming a suitable amount of light, which in return have reduced the organic matters transferred to the tubers resulting in small size tubers, which conforms with the observation by Sale (1976) and Menzel (1985).

Effect of intercropping system on the percent of dry matter and starch of potato tubers (*Marfona cultivar*) (means of two growing seasons): The results of calculating the percent of dry matter and starch of tubers presented in Table 2, showed a noticeable reduction in the percentage of the dried matter in the case of intercropped potato compared with the sole cropped, but when comparing the intercropping treatment with each other, treatment 5 was significantly the best (16%) dry matter compared with (14.7%) in treatment 3 and (15.6%) in treatment 4.

The same results about starch percentage obtained from Table 2 shows that tuber starch content in the intercropped potato have decreased, compared with sole cropped 1 and treatment 5 was significantly the best amongst intercropping treatments and because starch represents the gross percent of the dry matter in potato tubers, which indicates a strong relative relation between dry matter and starch percentage, then any reduction in dry matter percent is followed by reduction of starch percent.

Table 1: Effect of intercropping system on potato (*Marfona cultivar*) on: mean length of stems, mean weight of fresh and dry shoots, number of stems and tubers and tuber mean weight (means of two growing seasons (2006/2007-2007/2008)

Treatments	Mean length of stems (cm)	Mean weight: Fresh shoots (g $plant^{-1}$)	Mean weight: Dry shoots (g $plant^{-1}$)	No. stems (stem $plant^{-1}$)	No. tubers (tuber $plant^{-1}$)	Mean weight of tubers (g $tuber^{-1}$)
Potato sole crop 4.76 plant m^{-2}	23.55	227.0	21.28	4.30	6.10	122.50
Potato 4.76 and zea maize 4.76 plant m^{-2}	27.45	164.0	15.43	4.00	5.90	62.00
Potato 4.76 and zea maize 3.57 plant m^{-2}	25.90	193.0	17.45	4.10	6.00	81.00
Potato 4.76 and zea maize 2.38 plant m^{-2}	24.85	212.0	19.57	4.00	6.20	101.00
LSD 5%	02.98	29.72	02.58	0.83	0.57	6.44
CV (%)	12.68	18.14	14.12	11.52	8.96	5.82

Treatment (2) is zea maize sole crop

The effect of intercropping system on the productivity (ton/ha) (Mean of two growing seasons)

Effect of intercropping system on potato productivity: As shown in Table 3, there is a significant increase in productivity of sole cropped potato (35.5 ton ha^{-1}) compared with the intercropped, except to intercropped potato in treatment 5 (29.5 ton ha^{-1}). The reduction ratio of potato productivity in the third treatment 3 (where, the plant density of zea maize plants was high) is 53% compared to the sole cropped potato. A study by Sharaiha *et al.* (2004) confirmed this result by indicating to the potato productivity, which have reduced 61%, when it was intercropped with zea maize plants, compared to the sole cropped potato, this reduction is related to the low solar radiation intercepted by potato plants and its small leaf area. As shown in Table 3, there is a superiority of treatment 5 amongst other intercropping treatments according to the productivity of potato plants, which reached 29.5 ton ha^{-1}, compared with 16.7 ton ha^{-1} in treatment 3 and (21.0) to main treatment 4 and this significant increase in treatment 5 is attributed to the decreased qualitative competition between potato and maize plants, which resulted from low density of maize plants in unit area that allowed potato plants to get a greater domain, which is needed for large biological activity compared with potato under other intercropping treatments, were there was a high plant density of zea maize plants. So, low density of maize plants in the unit area as in treatment 5 resulted in a bigger size tubers, attributed to carbon allocation to potato tubers by its leaves, those results agree with study of Cutter (1978) and Begum *et al.* (1999), which indicated to the reduction of potato productivity when intercropped with zea maize.

Effect of intercropping system on zea maize productivity: Table 3 shows a decrease in maize productivity (8-31%) under intercropping system compared to the sole cropped maize 21 ton ha^{-1}, but according to the intercropping treatments, we found that treatment 3 (19.3 ton h^{-1}) have significantly excelled treatment 5 at the level of (14.5 ton ha^{-1}) and this increase of productivity in treatment 3 is linked to its high plants density, those results agree with Yilmaz *et al.* (2001). When comparing the reduction of productivity of both crops under intercropping system, the reduction in potato 17-53% is higher than that in zea maize 8-31%. This difference is possibly attributed to the great competition feature of maize plants, which allows it to intercept more light and benefit from CO_2 gas resulting from potato respiration. All that makes maize plants more effective than potato. Similar results done by Mayer and Anderson (1965).

Effects of intercropping system on overall productivity: From Table 3 that the total productivity in the intercropping system is higher than the productivity of each sole crop, with an increase ratio of 1-24% compared with the productivity of sole potato and 71-109% compared with the productivity of sole zea maize and when, we compared intercropping treatments with each other, we found superiority in treatment 5, with significant difference, because of its total productivity 44 ton ha^{-1}, while, the productivity of treatments 3 and 4 is (30.7, 32.2 ton ha^{-1}), respectively. This superiority of treatment 5 is attributed to low competition between potato plants, resulting from the low plants density of zea maize that give opportunity for potato and maize plants to get nutrient elements and light with out high competition and this is noticed through little decrease of productivity

Table 2: Effect of intercropping system on the percent of dry matter and starch of potato tubers (*Marfons cultivar*) (mean of two growing seasons 2006/2007- 2007/2008)

Treatments	Dry matter	Starch
Potato sole crop 4.76 plant m^{-2}	16.20	11.30
Potato 4.76 and zea maize 4.76 plant m^{-2}	14.70	09.90
Potato 4.76 and zea maize 3.57 plant m^{-2}	15.60	10.50
Potato 4.76 and zea maize 2.38 plant m^{-2}	16.00	10.80
LSD 5%	0.46	0.58
CV (%)	4.80	03.70

Treatment (2) is zea maize sole crop

Table 3: Effect of intercropping system on productivity (ton/ha) (means of two growing seasons 2006/2007-2007/2008)

Treatments	Productivity of potato crop 1	Productivity of Zea maize crop	Reduction of productivity of each crop (%)		Total productivity /unit area	Increase of productivity per unit area (%)	
			Potato	Zea maize		Potato productivity	Zea maize productivity
Potato sole crop 4.76 plant m^{-2}	03	-	-	-	35.50	-	-
Zea maize sole crop 4.76 plant m^{-2}	04	21.0	-	-	21.00	-	-
Potato 4.76 and zea maize 4.76 plant m^{-2}	05	19.3	53.0	08.0	36.00	01.0	71.0
Potato 4.76 and zea maize 3.57 plant m^{-2}	21.0	16.8	41.0	20.0	37.80	06.0	80.0
Potato 4.76 and zea maize 2.38 plant m^{-2}	29.5	14.5	17.0	31.0	44.00	24.0	109.0
LSD 5%	05.46	03.1	-	-	05.47	-	-
CV (%)	19.15	11.6	-	-	18.87	-	-

Table 4: Effect of intercropping system on Land Equivalent Ratio (LER) (mean of two growing seasons 2006/2007-2007/2008)

	Land Equivalent Ratio (LER)		
Treatments	Potato	Zea maize	Potato and zea maize
Potato sole crop 4.76 plant m^{-2}	1.00	-	1.00
Zea maize sole crop 4.76 plant m^{-2}	-	1.00	1.00
Potato 4.76 and zea maize 4.76 plant m^{-2}	0.47	0.91	1.38
Potato 4.76 and zea maize 3.57 plant m^{-2}	0.59	0.80	1.39
Potato 4.76 and zea maize 2.38 plant m^{-2}	0.83	0.69	1.52
LSD 5%	0.35	0.27	-
CV (%)	17.85	11.80	-

for both crops, which was not >17% of sole potato productivity and 31% of sole zea maize productivity, similar results explained by Roder *et al.* (1992). Studying, the coefficient of variance shows that it has a medium value with a range of 11.6-19.15%.

Effect of intercropping system on Land Equivalent Ratio (LER): Table 4 indicates the different values of LER of potato crop, which was 1.0 in sole cropping and between (0.47-0.83) under intercropping, where the highest value (0.83) resulted in treatment 5, with significant difference among the other treatments. Concerning zea maize, LER also decreased in intercropping treatments (0.91-0.69) compared with sole cropping and treatment 3 (0.91) has significantly excelled treatment 5 (0.69), but there is no significant difference between the first treatment 3 and treatment 4 (0.8). However, under the intercropping system where there is a combination between potato and maize, there is an increase in the LER values (1.38-1.52) compared to the case of sole cropping of each crop. Those results are consistent with the results of (Moseley, 1994), which indicated that intercropping system caused an increase in LER.

While, Reddy and Willey (1981) stated that the increase of LER under intercropping system is related to the increase of solar radiation. The coefficient of variance index among all treatments has a middle value ranging between (11.8-17.85%).

CONCLUSION

- The intercropping of potato with zea maize in the case of equal plants density of potato and maize (4.76 plant m^{-2}) resulted in the increase of mean length of potato stems
- The intercropping of potato of (4.76 plant m^{-2}) plant density with Zea Maize of (2.38 plant m^{-2}) plant density, led to the increase: in mean weight of shoots (fresh and dry), mean weight of potato tubers and dry matter and starch of potato plants
- It's noticed that the number of stems and tubers of potato was not affected by intercropping of potato with Zea Maize
- The intercropping of potato with Zea Maize in the case of 2.38 plant m^{-2} of maize contributed significantly to the increase in both; productivity of cultivated unit area and the value of LER compared with sole cropping

RECOMMENDATIONS

Based on the findings mentioned above, it highly indicates to the importance of applying intercropping system of potato with Zea Maize, in order to achieve higher productivity rates of the two crops, which lead us to favorably recommend the use and utilization of this system in the Jordan valley area, in order to cover market needs.

REFERENCES

Aerts, R., R.G.A. Boot and P.J.M. Vander Aart, 1991. The relation between above and below-ground biomass allocation patterns and mpetitive ability. J. Ecol., 87: 551-559. DOI: 10.1007/BF003-20419. http://www.springerlink.com/content/k3462w0502x83401.

Allen, E.J. and D.C.E. Warr, 1992. Plant Density. 2nd Edn. In: Harris, P. (Ed.). Chapman and Hall, London. The Potato Crop, pp: 292-330.

Beets, W.C., 1982. Multiple cropping and tropical farming systems, west view press Inc. Baulder Colorado; 8030 USA.

Begum, N., M.M. Ullah, M.F. Haq, M.A.R. Khatuna and S. Yasmin, 1999. Performance of potato intercropped with maize. Bang. J. Sci. Indust. Res., 34: 183-187. http://cat.inist.fr/?aModele=afficheN&cpsidt=16105443.

Boras, M., N. Roukia and R. Babilie, 2006. The effect of sweet corn intercropping on autumn potato in terms of productivity and land equivalent ratio. Tishreen University. J. Stud. Sci. Res., 28 (1): 175-184.

Bouwe, N.B., M. Walangululu and H.M. Kidanemariam, 2000. Performance de 4 cultivars de pomme de terre en culture associes avec le mais et le Haricot. Afr. Assoc. Conf. Proc., 5: 187-190. http://orton.catie.ac.cr/cgibin/wxis.exe/?IsisScript=TEMAS.xis&method=post&formato=2&cantidad=1&expresion=mfn=007666.

Cahill, J.F. Jr., 1999. Fertilization effects on interactions between above-and below-ground competition in old field. J. Ecol., 80: 466-480. DOI: 10.1890/00129658 (1999)080[0466:FEOIBA]2.0.CO;2. http://www.esajournals.org/doi/abs/10.1890/0012-9658%281999%29080%5B0466%3AFEOIBA%5D2.0.CO%3B2?journalCode=ecol.

Chaudhary, D.C. and S.N. Singh, 1996. Effect of intercropping maize varieties on autumn planted sugarcane. Ind. J. Agric. Sci., 41 (1): 30-34.

Cutter, E., 1978. Structure and Development of the Potato Plant in the Potato Plant in the Potato Crop. In: Harris, P.M. (Ed.). The Scientific Basis for Improvement. Chaman and Hall, London, pp: 70-152. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=19930760122.

Dutta, H., S.R. Baroova and D.J. Raikhowa, 1994. Feasibility and Economic profitability of wheat-based intercropping systems under rain fed conditions. Ind. J. Agron., 39 (3): 448-450.

Ebwongu, M., E. Adipala, C.K. Ssekabembe, S. Kyamanywa and A.S. Bhagsari, 2001. Effect of intercropping maize and Solanum potato on yield of the component crops in central Uganda. Afr. Crop Sci. J., 9: 83-96. http://www.bioline.org.br/request?cs01038.

Galal, A.H., 1998. Effect of different intercropping system on yield and yield components of maize (*Zea maize* L).and sun flower (*Hellianthis annus*). Assiut. J. Agric. Sci., 29 (1): 75-84.

Gawronska, H. and R.B. Dwelle, 1989. Partitioning of photoassimilates by potato plants (*Solanum tuberosum* L.) as influenced by irradiance: II. Partitioning patterns by four clones grown under high and low irradiance 1. Am. Potato J., 67: 163-176. DOI: 10.1007/BF02987069. http://www.springerlink.com/content/93xrk0m28h525340.

Ghosh, P.K., M. Mohanty, K.K. Bandyopadhyay, D.K. Painuli and A.K. Misra, 2006. Growth, competition, yield advantage and economics in soybean/pigeonpea intercropping system in semi-arid tropics of Ind. J. Field Crops Res. DOI: 10.1016/j.fcr.2005.05.010. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6M-4GJVB5Y-2&_user=4731503&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000064617&_version=1&_urlVersion=0&_userid=4731503&md5=d803dacb904a44c0cd0b17abd1689aa1.

Ifenkwe, O.P., S.O. Odurukwe, J.C. Okonkwo and H.N. Nwokocha, 1989. Effects of maize and potato populations on tuber and grain yields, net income and land equivalent ratio in potato/maize intercropping. J. Trop. Agric., 66: 329-333. http://cat.inist.fr/?aModele=afficheN&cpsidt=6701364.

Kunchinda, N.C.I., K.B.D. Tarfa, C. Shinggu and R. Omolehin, 2003. On farm evaluation of improved maize varieties intercropped with some legume in the control of striga in the Northern Guinea Savanna of Nigeria. Crop. Prot. J., 22: 533-538. DOI: 10.1016/S0261-2194(02)00206-5. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T5T-481MW6H2&_user=4731503&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000064617&_version=1&_urlVersion=0&_userid=4731503&md5=026abfb2fdc92c0c954f47cb2d42fbb2.

Liu, J. and D.J. Midmore, 1990. A review of potato intercropping practices in Western Hubei, China. Field Crops Res., 25: 41-50.

Menzel, C.M., 1985. Tuberization in potato at high temperatures: Interaction between temperature and irradiance between temperature and irradiance. Ann. Bot. J., 55: 35-39. http://aob.oxfordjournals.org/cgi/content/abstract/55/1/35.

Mayer, B.C. and D. Anderson, 1965. Respiration in Physiology, pp: 538-564.

Midmore, D.J., D. Berrios and J. Roca, 1988. Potato (*Solanum* sp.) in the tropics. IV. Intercropping with maize and influence of shade in micro environment and crop growth. Field Crop Res., 18: 141-157.

Monteith, J.L. and C.J. Moss, 1977. Climate and the efficiency of crop production in Britain. Proc. R. Soc., series B, 281: 277-294. DOI: 10.1098/rstb.1977.0140. http://rstb.royalsocietypublishing.org/content/281/980/277.short.

Moorby, J., 1978. The Physiology of Growth and Tuber Yield in the Potato Crop. In: Harris, P.M. (Eds.). The Scientific Basis For Improvement. Chaman and Hall, London, pp: 153-194. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=19780771935.

Moseley, W.G., 1994. An Equation for the Replacement Value of Agro Forestry Systems, 26: 47-52. DOI: 10.1007/BF00705151. http://deepblue.lib.umich.edu/handle/2027.42/41763.

Mead, R. and R.W.Willey, 1980. The concept of area land Equivalent ratio and advantages in yield from intercropping. Exp. Agric., 16: 217-228. DOI: 10.1017/S0014479700010978. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=1609532#.

O'Brien, P.J., D.M. Firman and E.J. Allen, 1998. Effects of shading and seed tuber spacing on initiation and number of tubers in potato crops (*Solanum tuberosum*). J. Agric. Sci., 130: 431-449. DOI.10.1017/S0021859698005541. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=7139#.

Ofori, K. and D.K. Gamedoaghao, 2005. Yield of scarlet eggplant (*Solanum aethiopicum* L.) as influenced by planting date of companion cowpea. Scientia Horticult., 105: 305-312. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=20053108109.

Pellerin, S., 1991. Effecte d, une reduction du rayonnement uncident sur I, emission. Desracines adventives du mais en debut du cycle. Agronomies, 11: 9-16. DOI: 10.1051/agro:19910102. http://www.agronomy-journal.org/index.php?option=article&access=standard&Itemid=129&url=/articles/agro/abs/1991/01/Agronomie_0249-5627_1991_11_1_ART0002/Agronomie_0249-5627_1991_11_1_ART0002.html.

Reddy, M.S. and R.S. Willey, 1981. Growth and resource use studies an intercrop of pearl millet/groundnut. Field Crop Abstr., 4: 13-24.

Roder, W., E. Anderhalden, P. Gurung and P. Dukpa, 1992. Potato intercropping systems with maize and faba bean. Am. J. Potato Res., 69 (3): 195-202. DOI: 10.1007/BF02856552. http://www.springerlink.com/content/k724553225452544.

Sale, P.J.M., 1976. Effect of ahade at different times of growth and yield of potato. Aust. J. Agric. Res., 27: 567-574. www.archive.org/stream/gardenerschroni00unkngoog/gardenerschroni00unkngoog_djvu.txt.

Sharaiha, R.K., H.M. Saoub and O. Kafawin, 2004. Varietal response of potato, bean and corn to intercropping. Dirasat-Agric. Sci., 31 (1): 1-11. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=20043033652.

Santalla, M.A.P., P.A. Rodino, Casquero and A.M. De Ron, 2001. Interaction of bush bean intercropped with field and sweet maize. Eur. J. Agron., 15: 185-196. DOI: 10.1016/S1161-0301(01)00104-6. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T67-44B20SW3&_user=4731503&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000064617&_version=1&_urlVersion=0&_userid=4731503&md5=f7bcb79f86de680a038a04597b1ec4f4.

Tsubo, M., E. Mukhala, H.O. Ogindo and S. Walker, 2003. Productivity of Maize-bean Intercropping in a Semi-arid Region of South Africa, 29: 381-388. DOI: 10.1016/j.fcr.2004.09.002. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6M-4DTKDSW1&_user=4731503&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000064617&_version=1&_urlVersion=0&_userid=4731503&md5=7cd7ec61220d6d7df1fa32a01c4cc0c3.

Yilmaz, G.S., M.A. Gokmen, I. Sakin and T. Gagatay, 2001. Intercropping potato with maize. Bull. USAMV-CN, 55: 42-47.