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Effects of Intercropping Maize (*Zea mays* L.) with Jack Beans (*Canavalia ensiformis* L.) at Different Spacing and Weeding Regimes on Crops Productivity

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***Abstract*—**A field experiment was conducted at Ido town in Ido Local Government Area of Oyo state, Nigeria to determine the effects of intercropping maize (*Zea mays* L.) with Jack bean (*Canavalia ensiformis* L.) at different spacing and weeding regimes on crops productivity. The treatments were 2 x 2 x 3 factorial arrangement involving two spatial crop arrangements. Spacing of 75 cm x 50 cm and 90 cm x 42 cm (41.667 cm) with two plants per stand resulted in plant population of approximately 53,000 plants/hectare. Also, Randomized Complete Block Design (RCBD) with two cropping patterns (sole and intercrop), three weeding regimes (weedy check, weeds once, and weed twice) with three replicates was used. Data were analyzed with SAS (Statistical Analysis System) and statistical means separated using Least Significant Difference (LSD) ($P \leq 0.05$). Intercropping and crop spacing did not have significant influence on the growth parameters and yield parameters. The maize grain yield of 1.11 t/ha obtained under sole maize was comparable to 1.05 t/ha from maize/jack beans. Weeding regime significantly influenced growth and yields of maize in intercropping with Jack beans. Weeding twice resulted in significantly higher growth than that of the other weeding regimes. Plant height at 6 Weeks After Sowing (WAS) under weeding twice regime (3 and 6 WAS) was 83.9 cm which was significantly different from 67.75 cm and 53.47 cm for weeding once (3 WAS) and no weeding regimes respectively. Moreover, maize grain yield of 1.3 t/ha obtained from plots weeded twice was comparable to that of 1.23 t/ha from single weeding and both were significantly higher than 0.71 t/ha maize grain yield obtained from the no weeding control. The dry matter production of Jack beans reduced at some growth stages due to intercropping of maize with Jack beans though with no significance effect on the other growth parameters of the crop. There was no effect on the growth parameters of Jack beans in maize/jack beans intercrop based on cropping spacing while comparable growth and dry matter production in Jack beans were produced in maize/Jack beans mixture with single weeding.

***Keywords*—**Crop spacing, intercropping, growth parameter, weeding regime, sole cropping, week after sowing.

I. Introduction

JACK bean is botanically known as *Canavalia ensiformis* and the plant is known in different countries with different names. It is called 'Jack bean' in South Africa and Zimbabwe; 'Sword bean' in Australia, 'One eye bean' in West Indices and 'Feijaode porco' in Brazil [16]. Jack bean belongs to the kingdom Plantae, division Magnoloiphyta, order Fabales, family Fabaceae, genus Canavalia and species *Canavalia ensiformis* [22]. The genus Canavalia comprises 48 species of underutilized annual legumes widely distributed and indigenous to the tropics. Jack bean is an incredibly drought-resistant, hardy legume that grows well in extremely poor, droughty soils (and apparently less well in fairly fertile soils) [6].

It is agronomically sown as an annual cover crop. Strong durable support crops such as millet, sorghum, sugarcane, coffee, cocoa among others can be intercropped when planted as a perennial crop [4]. Canavalia seeds (mostly seed coats) are known with presence of several endogenous toxic anti-nutritional factors [6]. Jack bean seed is known to be nearly oblong in shape and usually white in colour with coat that shoud not be eaten. Total yield of dry seeds can reach up to 2.5 tons/hectare [17]. If planted in a maize or sorghum field, it should be seeded within 15-30 days of the primary crop, depending on climate, speed of growth of the other crops etc. [8]. Presently in Nigeria, it is crystal clear there are no farms where the Jack bean is being cultivated commercially, although many Nigerians are known with planting of Jack beans both around and at homes as a flowering plant while some grow wild. It is also planted in several homes as anti-snake. It is generally cultivated for forage or green manuring purposes. Jack beans are scientifically known as soil nitrogen fixers as leguminous plants and therefore need atmospheric nitrogen. It can also be used in grain fields, under orchard trees or to shorten fallow periods [8].

Maize (*Zea mays* L.) is a cereal plant belonging to the family Poaceae commonly referred to as the grass family which today constitute the most widely distributed food crops in the world [7]. Maize is a versatile crop growing across a range of ecological zones and every part of it has economic values; the grains, leaves, stalk, tassel and non-food products of the plant [12]. Though maize is the most important cereal food crops in Nigeria, it comes after wheat and rice in terms of world importance [19]. Maize is a basic staple food for large population groups particularly in developing countries [10]. Maize is also an important livestock feed both as silage and as crop residue, grain and is also used industrially for starch and oil extraction [12]. The low yield of maize recorded in Africa can be attributed to some limitations encountered. The constraints include insect pests, diseases and in particular weeds. In Nigeria, weed infestation which seems to be one of the major factors responsible for low yield can be associated with low maize grain yield. Maize production has increased in Nigeria. This rapid growth in maize production occurred mainly through expansion of areas under cultivation [3]. Weed

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is also a major constraint to maize production and is also regarded as the most deleterious to maize production causing between 69 and 92% loss in grain yield in Nigeria Savanna ecological zone [13]. Maize is susceptible to competitions from many annual weeds in the first 6-8 weeks after planting and the extent of the infestation varies from one ecological zone to another. Weeding during the critical period of 10-30 days after crop emergence greatly enhances grain production, while an uncontrolled weed growth during this period could reduce yield by 40-60% [2]. Maize requires minimum weed invasion to exhibit its yield potential. Heavy weed interference results in competition for essential resources and consequently yields loss. Weeds are the most persisted of all crop pests. The major weed control techniques in maize are hand weeding, use of mulches, cover crops and herbicides; the choice depends on the demands for erosion control, type of soil, soil fertility and moisture conservation.

Mixed cropping is the practice of growing more than one particular crop in a field at a given period of time. Intercropping is known as a practice of growing more than one crop at same time in alternating rows of a field [5]. Intercropping can therefore be regarded as a type of mixed cropping. Cereal-legume intercropping is often employed as a basis for enhancing resources use and the sustainability of tropical smallholder farming systems [21]. In Africa, maize does well when intercropped with beans or other legumes. Productivity of mixture of maize and legumes often exceeds that of sole crops due to synergistic effects that favour the growth and yield components of both crops [1]. Legume and cereal usually work together when intercropped while the legume fixes the nitrogen level in the soil to supply it back to the cereal in order to maximize the crop yield. Intercropping of maize and cowpea (*Vigna unguiculata*) is especially beneficial on nitrogen poor soils [23]. Cowpeas do not compete with maize for soil nitrogen as they obtain majority of their nitrogen from the atmosphere. Research shows that maize yields were insignificantly unaffected when intercropped with cowpeas [23]. Legumes can however compete with associated crop for soil nitrogen, and consequently reduce grain yield of the crop being competed with.

II. Materials and Methods

The field experiments were conducted between April to October 2013. The experimental site was situated at Ido town in Ido Local Government Area of Oyo state, Nigeria. Ibadan lies in the derived savannah zone of south-west Nigeria with an annual rainfall from 1200 to 1450 mm. Generally, the monthly rainfall distribution pattern for Ibadan is bi-modal and there are two growing seasons. The first is from March to July and the second from August to November. The vegetation cover was mainly annual weeds with very few stands of perennial weeds.

Maize seeds (Oba Super II) were obtained from Ido, Ibadan, Nigeria while jack beans seeds were obtained from previously harvested jack beans on the same farm. The experimental design was a RCBD. The treatments were 2 x 2 x 3 factorial arrangement involving two spatial crop arrangements with spacing of 75 cm x 50 cm and 90 cm x 42 cm (41.667 cm), 2 plants per stand resulting in plant population of approximately 53,000 plants/hectare; two cropping pattern (sole and intercrop) and three weeding regimes (weedy check, weeds once, and weed twice) with three replications.

Four maize seeds (Oba Super II) were sown per hole and later thinned to two plants per stand to achieve the desired planting density while the missing stands for both maize and jack beans were supplied. Jack beans seeds were sown using the same spacing for maize but maintained at one plant per stand resulting in plant population density of 26,666 plants/ha. Weeding was done manually at 3 and 6 weeks for treatments meant for 'weeding twice' and once at 3 weeks for treatments to be weeded once. The plots were also sprayed with insecticide Magic Force© (Lamdacyhalothrin 15 g/l + dimethoate 300 g/l) at the rate of 1.5 l/ha prior to harvesting.

Data were collected on number of weed species and density at 7 WAS and dry weed biomass. Weed count (species and density) was done by quadrant size of 50 cm x 50 cm. Dry matter of the quadrant was obtained by cutting off the roots of the weeds and oven drying of the fresh weeds at 800 ^{o}C until constant weight is obtained. Data collected on maize were plant height, stem diameter, numbers of tasseled plants to determine number of days to 50% tasseling and economic and biological weight after harvesting at 20 WAS. Plant height was taken using measuring tape and stem diameter using digital vernier callipers. Data collected on Jack beans included number of leaves and height per plant at 4, 6 and 11 WAS, weight of fresh and oven dry samples at 6 WAS, number of flowered plants between 7 and 9 WAS, number of podded plants at 9 WAS, number of pods and flowers per plant at 9 WAS, number of branches per plant at 11 WAS and weight of harvested beans at 21 WAS.

The data obtained from the field experiments were analyzed with SAS and means separated using LSD (P = 0.05).

III. Results and Discussion

A. Effects of Cropping Systems on Growth and Yield Parameters of Maize in Maize/Jack Beans Intercrop

Table I shows the effects of cropping systems (sole and intercrop) on growth and yield parameters (plant height, plant diameter and grain yield) on maize in Maize-Jack beans intercrop. The table shows that the cropping pattern significantly influenced maize plant height at 4 weeks after planting. At 6 weeks after planting, the difference was not significant on maize plant height and the other growth parameters collected on maize. Maize grain yield at harvest was also not significantly influenced by intercropping though lower yields were recorded for the plots that had intercrop. This was also reported by [9]-[24] that legumes can compete for soil nitrogen with the associated crop and reduce its grain yield.

The absence of significant influence of weeding regime on maize growth parameters except on plant height at 4 WAS (early stage of growth) may be as a result of increase in Jack

beans production which competes with maize for soil N. In another study the harvest index of maize intercropped with crotalaria was lower than that of the monoculture in all seasons with the conclusion from long-term studies that there can be possible reduction in yield of a more competitive green manure (legume) such as crotalaria intercrop with maize [18].

B. Effects of Crop Spacing on Growth and Yield Parameters of Maize in Maize/Jack Beans Intercrop

Table II shows the effect of crop spacing (75 cm x 50 cm and 90 cm x 42 cm) on growth and yield parameters of maize in Maize-Jack beans intercrop. The crop spacing had no significant influence on growth parameters collected on maize in maize/Jack beans intercrop. Also, the crop spacing has no significant influence on grain yield of maize at harvest.

The plant population was based on earlier studies where optimum density 53,000 – 66,000 plants/ha gave optimum grain yield [14]. Some of the collected parameters; maize plant height at 6 WAS, maize stem diameter at 4 and 6 WAS with grain yield at harvest under crop spacing of 90 cm x 42 cm were slightly higher than that of 75 cm x 50 cm crop spacing but not significantly different. This can be attributed to increase in the equidistant spacing of the plants at 90 cm x 42 cm and reduction in plant density. According to [18], plants spaced equidistantly from each other compete minimally for nutrient, light and other growth factors. Maize is the most sensitive to variation in plant density among members of the grass family. Plant density affects plant architecture, alters growth developmental patterns and influences carbohydrate production and partition [7].

TABLE I
EFFECTS OF CROPPING SYSTEMS ON GROWTH AND YIELD PARAMETERS OF MAIZE IN MAIZE/JACK BEANS INTERCROP

Cropping system	Plant height (cm)		Stem diameter (cm)			MGY (t/ha)
	Weeks after planting					
	4	6	4	6	9	
Sole maize	32.19	69.64	1.43	1.9	1.95	1.11
Maize/Jack beans	28.72	67.10	1.28	1.83	1.85	1.05
LSD	2.60	ns	ns	ns	ns	ns

MYG = Maize grain yield; ns = not significant ($P \leq 0.05$)

TABLE II
EFFECTS OF CROP SPACING ON GROWTH AND YIELD PARAMETERS OF MAIZE IN MAIZE/JACK BEANS INTERCROP

Crop spacing (cm)	Plant height(cm)		Stem diameter (cm)			MGY (t/ha)
	Weeks after planting					
	4	6	4	6	9	
75 x 50	30.46	63.07	1.35	1.84	1.93	1.07
90 x 42	30.45	73.67	1.36	1.89	1.88	1.09
LSD	ns	ns	ns	ns	ns	ns

MYG = Maize grain yield; ns = not significant ($P \leq 0.05$)

C. Effects of Weeding Regimes on Growth and Yield Parameters of Maize in Maize/Jack Beans Intercrop

Table III shows the effect of weeding regimes on growth parameters of Maize in Maize-Jack beans intercrop. Plant height (4 and 6 WAS) was significantly influenced by (3 and 6 WAS) weeding regime while there was no significant difference in the plant height at 4 WAS under no weeding and when weeded once at 3 WAS. Stem diameter and maize grain yield at no weeding regime are significantly lower than when the maize was weeded at 4 WAS and also at 3 and 6 WAS. Weeding during the critical period of 10-30 days after crop emergence greatly enhances grain production, while an uncontrolled weed growth during this period could reduce yield by 40-60% [2].

Grain yields of maize obtained at no weeding regime and once weeding (3 WAS) regimes were lower than that of weeding twice (3 and 6 WAS) regime. Reference [11] observed that unless weeds are controlled, they either choke or eliminate the desired plants or reduce yields and any competition by weeds significantly reduces yield or prevent crop harvest.

TABLE III
EFFECTS OF WEEDING REGIME ON GROWTH AND YIELD PARAMETERS OF MAIZE IN MAIZE/JACK BEANS INTERCROP

Number of weeding	Plant height (cm)		Stem diameter (cm)			MGY (t/ha)
	Weeks after planting					
	4	6	4	6	9	
Twice (3 and 6 WAS)	34.23	83.9	1.53	2.03	2.02	1.3
Once (3 WAS)	27.83	67.75	1.42	1.95	1.95	1.23
No weeding	29.31	53.47	1.12	1.61	1.75	0.71
LSD	3.18	16.15	0.2	0.23	0.19	0.23

MYG = Maize grain yield; ns = not significant ($P \leq 0.05$)

D. Effects of Cropping Systems on Growth and Yield Parameters of Jack Beans in Maize/Jack Beans Intercrop

Table IV shows that the cropping system has no significant influence on growth parameters collected on Jack beans in maize/Jack beans intercrop. The dry matter yield of jack beans at harvest was significantly influenced by cropping systems. In [25], the results showed that the sole cropping of legumes yielded higher than all the maize-legume combinations did although such mixture indeed increased the seed yield of maize with (13.3 mg ha^{-1}) in 2-row planting for intercrop and (13.4 mg ha^{-1}) in single-row planting for sole legume. According to [20], *Stylosanthes hamata* yield was greatest as a monoculture and, as the intercrop, was significantly increased with increasing row spacing of maize. Low nitrogen requirement of maize may be responsible for the absence of significant effect on parameters of jack beans in maize/jack beans intercrop.

E. Effects of Crop Spacing on Growth and Yield Parameters of Jack Beans in Maize/Jack Beans Intercrop

Table V shows that crop spacing has no significant influence on growth parameters collected on Jack beans in maize/Jack beans intercrop. Also, dry matter yield at harvest was not significantly influenced by cropping spacing. Some of the growth parameters collected on jack beans at 90 cm x 42 cm crop spacing were greater than that of the 75 cm x 50 cm crop spacing but with no significant difference. Reference [20] also showed that the yield of the legume increased with wider row spacing due to increased space availability, resulting in

reduced shading by the maize plants and perhaps reduced competition for nutrients. Similarly, the reduction in crude protein concentration of *Stylosanthes hamata* with increased row spacing may result from increased *Stylosanthes* growth and hence stem content.

F. Effects of Weeding Regime on Growth and Yield Parameters of Jack Beans in Maize/Jack Beans Intercrop

Table VI shows that at 4 and 6 WAS plant height of Jack beans was not significantly influenced although plant height at 6 WAS under twice weeding regime is 57 cm tall while that of once weeding regime and no weeding regime are 49 cm and 57 cm respectively.

TABLE IV
EFFECTS OF CROPPING SYSTEMS ON GROWTH AND YIELD PARAMETERS OF JACK BEANS IN MAIZE/JACK BEANS INTERCROP

Cropping system	Plant height (cm)		Number of leaves		Dry matter yield (kg/ha)
	Weeks after planting				
	4	6	4	6	6
Sole Jack beans	40.58	57.38	6.07	13.54	24.85
Maize/Jack beans	35.64	51.51	5.82	12.06	21.37
LSD	ns	ns	ns	ns	3.47

MYG = Maize grain yield; ns = not significant ($P \leq 0.05$)

TABLE V
EFFECTS OF CROP SPACING ON GROWTH AND YIELD PARAMETERS OF JACK BEANS IN MAIZE/JACK BEANS INTERCROP

Cropping spacing	Plant height(cm)		Number of leaves		Dry matter yield (kg/ha)
	Weeks after planting				
	4	6	4	6	6
75 x 50	35.33	53.86	5.74	13.29	23.36
90 x 42	40.89	55.04	6.14	12.31	22.86
LSD	ns	ns	ns	ns	ns

ns = not significant ($P \leq 0.05$)

TABLE VI
EFFECTS OF WEEDING REGIME ON GROWTH AND YIELD PARAMETERS OF JACK BEANS IN MAIZE/JACK BEANS INTERCROP

Cropping spacing	Plant height (cm)		Number of leaves		Dry matter yield
	Weeks after planting				
	4	6	4	6	6
Twice (3 and 6 WAS)	37.63	57.37	7.1	14.83	25.87
Once (3 WAS)	36.93	48.78	5.49	12.76	23.91
No weeding	39.78	57.19	5.24	10.81	19.56
LSD	ns	ns	1.05	2.79	4.25

ns = not significant ($P \leq 0.05$)

The number of leaves at weeding twice (3 and 6 WAS) resulted in higher number of leaves which was significantly different from other weeding regimes. Although at 6 WAS, weeding twice resulted in the number of leaves that is not significantly different from weeding once but significantly different from that of no weeding. Dry matter yield at harvest was significantly influenced by weeding regimes. At weeding twice regime (3 and 6), dry matter yield of Jack beans at harvest was significantly different from that of no weeding regime. Reference [15] evaluated the effect of weed period on sesame (*Sesamum indicum*). Decreased sesame seed yield can be associated to the increased duration of weed interference and occur mainly through reduction in number of capsules or plants and number of seeds/capsules which is related to loss in grain yield of legumes.

IV. CONCLUSION

In this study, intercropping and crop spacing did not have significant influence on the growth parameters and yield of maize while the weeding regime significantly influenced growth and yields of maize in maize/jack beans intercropping. The effect of weeding twice on plant height is significantly higher than that of the other weeding regimes. Intercropping of maize with Jack beans reduced the dry matter production of Jack beans at some growth stages whereas it has no significance effect on the other growth parameters. Cropping spacing has no effect on the growth parameters of jack beans in maize/jack beans intercrop. Single weeding in maize/jack beans intercrop produced a comparable growth in plant heights at 4 and 6 WAS of maize and dry matter in Jack beans.

Since crop spacing has no significant influence on growth parameters and grain yield of maize, any of the two crops spacing can be used. Wider spacing may however be adopted so that the amount of sun radiant energy captured by the jack beans in intercrop, can be improved. Jack beans may not be intercropped with maize for the purposes of yield maximization of maize except for other reasons such as soil conservation, control of soil erosion, mulching, land maximization, production of two crops at a time since results show that intercropping maize with Jack beans did not have significant influence on the growth parameters and yield of maize. Twice weeding regime (3 and 6 WAS) is also suitable and can be adopted. Moreover, other weeding regimes and cropping system can be evaluated further.

REFERENCES

[1] Agegnehu, G., Ghisaw, A. and Sinebo, W. (2010). Yield potential and land use efficiency of wheat and faba bean mixed intercropping. *Agronomy Sust Development* 28: 257-263.
[2] Akobundu, I.O. (1987). Weed science in the tropics; Principles and practices. John Waley and son Chichester, New York; 522pp.
[3] Ajala, S.O., A. Menkir and J.G.King (1999).Fertilizer requirement of open-pollinated and hybrid maize genotype. Paper presented at Sasakawa global 2000 national maize workshop, ABU, Zaria, Nigeria.
[4] Annon, 2007; http://www.hdra.org.uk/ HDRA's booklet, Green Manures, No. TGM2 Jack bean. Accessed on 22/05/2013.
[5] Beets, W.C. (1990). Raising and sustaining productivity of smallholder farming systems in the tropics. Alkmaar, Holland; AgBe Publishing.
[6] Carlini, C.R. and Gumaraes, I. (1981). Isolation and characterization of toxic protein from *Canavalia ensiformis* (Jack bean) seeds distinct from Con A. Toxicon 19: 667-675.
[7] Casal, J.J. and V.A. Deregibus (1985). Variation in tiller dynamics and morphology in *Lolium multiflorum* Lam. Vegetative and reproductive plants as affected by differences in red/far red irradiation. Annals of Botany V.56, p.533-559.
[8] Echo 2006 (Roland Bunch, 1985). Green manure crops, Echo technical note; http://echonet.org/ Accessed on 09/06/2013.
[9] Enyi, B.A.C. (1973). Effect of intercropping maize or sorghum with cowpeas, pigeon peas or beans. Exp. Agric. 9:83-90.
[10] FAO and ILO (1997). Maize in human nutrition intermediate level handbook. FAO and ILO Publication, Rome, Italy.
[11] Hartmann, H.T. Kofranet, A.M. Rubatzky, V.I. and Flocker, W.I. (1981). Plant science growth, development and utilization of cultivated

plants (2nd Est.) Prentice-Hall, Inc. Simon and Schuelet, Englewood, New Jersey, Pp. 57-72.
[12] IITA (2007). Maize overview, http://www.iita.org/details/researchsummary.aspx/ Accessed on 24/06/2013.
[13] Lagoke, S.T.O. Chondhary A.H. and Yanko Y.M. (1981). Weed control in rainfall groundnut in the Guinea Savanna Zones of Nigeria. Weed Research (21):11-25.
[14] Lucas, E.O. (1981). The growth of two maize varieties in farmers' plots located at two ecological zones in Nigeria. Journal of Agricultural Science 26: 1017-1022.
[15] Mukhtar, A.M. and Suhair, M.E. (2013). Critical Period of Weed Interference in Sesame (*Sesamum indicum* L.) in Dongola Locality, Northern State, Sudan. Faculty of Agricultural Sciences, El Selaim, Dongola University-Sudan.
[16] Odetokun, S.M. (2000). Effect of fermentation on physiochemical properties, anti-nutrient and *in-vitro* multi-enzymes digestibility of selected legumes. PhD thesis, Chemistry Department, Federal University of Technology, Akure, Ondo State, Nigeria.
[17] Okonkwo, J.C. and Udedibie, A.B.I. (1991). Preliminary observations on the yield performance of Jack bean (*Canavalia ensiformis*) and Sword bean (*Canavalia gladiata*) in the Guinea Savanna of Nigeria. Paper presented at the 27th annual Conference of Agricultural Society of Nigeria, Minna, Nigeria. 1-4 September 1991.
[18] Richner, W., Sangakkara, U.R., Schneider, M.K., and Stamp, P. (2003). Impact of intercropping beans (*Phaseolus vulgaris* L.) and sunhemp (*Crotalaria juncea* L.) on growth, yields and nitrogen uptake of maize (*Zea mays* L.) grown in humid tropics during the minor rainy season. Maydica 48 (2003): 233-238.
[19] Rouannent, G. (1987). The tropical agriculturist Ed: Macmillan Publisher Ltd, Malaysia, 102p.
[20] Shehu,Y., Alhassan, W.S. and Phillips, C.J.C. (1997). The effect of intercropping maize with *Stylosanthes hamata* at different row spacings on grain and fodder yields and chemical composition. Tropical Grasslands (1997) Volume 31, 227–231.
[21] Tsubo, M. Walker, S. Ogindo, H.O. (2005). A simulation model of cereal-legume intercropping systems for semi-arid regions.Model Application. Field Crop Research. 93: 23-33.
[22] USDA, (2005). United State Department of Agriculture (USDA), *Canavalia ensiformis* (L) DC. Germplasm Resources Information Network, 2005.
[23] Vesterager, J.M., N.E., Nielsen, and H. Hogh-Jensen (2008). Effects of cropping history and Phosphorus source on yield and Nitrogen fixation insole and intercropped cowpea-maize systems. Nutrient Cycling in Agroecosystems. 80(1); 61-73.
[24] Wahua, T.A.T. (1983). Nutrient uptake by intercropped maize and cowpeas and a concept of nutrient supplementation index (NSI). Exp. Agric. 19:263-275.
[25] Yilmaz, F., Atak, M., and Erayman, M. (2007). Identification of advantages of maize-legume intercropping over Solitary Cropping through Competition Indices in the East Mediterranean Region. Turk Journal Agric For.32 (2008); pp. 111-119.