Response of *Solanum Macrocarpon* to Irrigation and Organic Matter

Jimmy Akinfemi Osunbitan and Toyese Friday Oyewusi
Department of Agricultural Engineering, Adeleke University, Nigeria

Abstract: **The study was conducted to examine the effect of irrigation scheduling (irrigation depth and interval) and organic matter on the growth and yield of *Solanum macrocarpon*. A replicated 3 × 3 × 4 factorial arrangement with treatments consisting of irrigation depth (4, 6 and 8 mm), irrigation interval (1, 3 and 5 days) and percent organic matter incorporation (0%, 2%, 4% and 6% by weight) was used for experiment pot in a screen house. The mixed soil and poultry litters was left for 14 days to allow for decomposition of the manure. Ten viable seeds of *Solanum macrocarpon* were planted per pot and were thinned to three stands of plant per pot two weeks after germination then irrigation water at the above-mentioned depths and intervals were applied. The result of the experiment showed that irrigation depth, irrigation interval and percent organic matter incorporation influenced the vegetable yield. The maximum fresh yield (78.73 kg/ha) and dry matter yield (17.29 kg/ha) occurred when 4% poultry litter was incorporated into the soil while the minimum fresh yield (34.88 kg/ha) and dry matter yield (7.40 kg/ha) occurred when no organic matter was incorporated. Irrigation interval of three days as well as irrigation depth of 6 mm resulted in the highest growth and maximum yield of the vegetable. In conclusion, the factor combination of 4% organic matter incorporation with 6 mm irrigation depth applied at three days irrigation interval resulted in the highest plant growth and maximum yield of the vegetable.**

***Keywords: S. macrocarpon*, irrigation depth, irrigation interval, organic matter, plant yield**

I. INTRODUCTION

Fertilizers have been ascertained to be significant in *Solanum macrocarpon* growth [1]. Nitrogen is needed in the growth and development of leaves; phosphorus is crucial in stimulating the formation of flowers and fruits whereas potassium is required for seeds setting; for these reasons, fertilizer is required for optimum yield of *Solanum macrocarpon* [2]. However, the application of organic amendments has become more common for the improvement of soil organic matter in recent years. Incorporation of organic matter into the soil has been found to enhance soil structure, improve water holding capacity, soil porosity and low bulk density which is an indicator that the soil is completely aerated, very easy to till and enables root growth.

Furthermore, the role of water in crop growth and development cannot be exaggerated. Water is vital for plant growth because it is an agent which transports the nutrients from soil to plant [3]. So, availability of water in the roots zone is an important condition for plant nutrients uptake in soluble form from soil. In other word, the amount of water presented to plant through the soil delivers the nutrients needed for germination, growth and yield of the plant. In addition, the level of irrigation depth is a vital aspect that must be regarded in production of crop. There is a little information on optimum irrigation scheduling and poultry litters to be applied for the soil to be in good conditions to determine the growth and yield response of Solanum. Therefore, the study examines the effect of irrigation depth and interval, and organic matter on the growth and yield of *Solanum macrocarpon*.

II. MATERIALS AND METHODS

Pot experiments were conducted in a greenhouse of the Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria, on sandy loam soil classified as Alfisol. The mean annual rainfall of the study area was about 1,500 mm while the average daily minimum temperature ranged between 20 °C and 22 °C and the average maximum temperature between 27 °C and 35 °C. The soil is classified at series level as two series [4] and it was a derivative of granite and gneiss parent material. The sandy loam is 80% sand, 5% silt and 15% clay with organic matter content of 1.56%. The soil samples were collected from the top 15 cm layer and taken to the laboratory for analysis of its physicochemical parameters. Plant residues and stones in the soil sample were removed by passing the soil through a 2 mm sieve in order to obtain a homogeneous soil sample.

The experimental set up was a 3×3 × 4 factorial arrangement with three replicates. The factors were irrigation depth, irrigation interval and organic matter incorporation. The three levels of irrigation depth used were 4, 6 and 8 mm of water while the three levels of irrigation interval in the study were 1, 3 and 5 days. The treatment with organic matter comprised of four levels of poultry litter applied at the rate of 0, 16, 32 and 48 t/ha, respectively, in form of 0%, 2%, 4% and 6% by organic matter weight of poultry litter incorporation into the soil. The result of soil analysis indicated a soil pH of 5.74 (slightly acidic), organic carbon of 1.8%, nitrogen 0.07% which is considered to be very low, available phosphorus of 56.28 mg/kg and exchangeable potassium of 462.80 mg/kg. The result of poultry litter showed a pH of 7.87, organic carbon of 32%, nitrogen 1.24%, and available phosphorus of 15.09 g/kg and exchangeable potassium of 7.10 g/kg. The mixture of soil and poultry litter at different levels of poultry litter in corporation was compacted to bulk density of 1.5 g/cm^3 inside perforated plastic pots with surface area of 314.2

cm^2 and depth of 45 cm. The soil/poultry litters mixture was then left for 14 days to allow for some decomposition of the manure during which water was sprinkled into the pots. Ten seeds of *Solanum macrocarpon* plant were sown inside each of the pots. Two weeks after planting, thinning of germinated plants was done to three stands per pot after which irrigation water at the above-mentioned depths and intervals were applied using small watering cans as is done by the majority of small-scale farmers in the country. Growth parameters were measured once a week from the 5th week after sowing because leaves of the vegetable are sometimes plucked from five weeks after sowing for consumption and marketing by some farmers. The growth parameters were plant height which was measured from the ground level to the top most leaf and the leaf area which was measured by tracing the leaf on a white paper and measuring the traced area using a planimeter. The vegetable was harvested eight weeks after sowing and the yield parameters (fresh yield and dry matter weight) were determined. In determining the yield parameters, the vegetable roots were carefully washed with water after harvest to remove any adhering soil and the plant was weighed per stand to obtain the fresh weight. The dry weight was obtained by placing the plant in an oven at 70 °C for 24 h [5].

III. RESULTS AND DISCUSSION

The plant height, leaf area, fresh yield and dry matter weight as significantly affected by irrigation depth, irrigation interval and organic matter incorporation are shown in Table 1. Also, the mean effects of irrigation depth, irrigation interval and organic matter incorporation on plant height, leaf area, fresh yield and dry matter weight of *S. macrocarpon* are shown in Table 2.

Table 1: Analysis of Variance (ANOVA) for growth and yield of *Solanum macrocarpon*

Source	DF	*F* value			
		Plant Height (cm)	Leaf Area (cm^2)	Fresh Yield (kg/ha)	Dry Matter (kg/ha)
A- Irrigation Depth	2	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
B- Irrigation Interval	2	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
C- Organic Matter	3	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
AB	4	0.9162	0.0136*	< 0.0001*	< 0.0001*
AC	6	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
BC	6	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
ABC	12	< 0.0001*	< 0.0001*	0.0004*	< 0.0001*

* represented significant at P<0.05

Table 2: Mean Effect of irrigation depth, irrigation interval and organic matter incorporation on growth and yield of *Solanum macrocarpon*

	Plant Height (cm)	Leaf Area (cm^2)	Fresh Yield(kg/ha)	Dry Matter (kg/ha)
Irrigation Depth (mm)				
4	25.07^b	164.39^b	57.98^b	11.63^b
6	27.52^a	178.05^a	62.79^a	12.94^a
8	26.84^a	170.96^a	61.28^a	12.60^a
Irrigation Interval (Day)				
1	26.85^a	170.71^a	60.72^a	12.14^a
3	27.63^a	184.93^a	62.44^a	13.24^a
5	24.95^b	157.76^b	58.89^b	11.79^b
Organic Matter (%)				
0	15.10^d	66.66^d	37.73^d	8.43^d
2	28.05^c	182.62^c	61.75^c	11.11^c
4	32.31^a	227.77^a	74.55^a	16.01^a
6	30.44^b	207.49^b	68.70^b	13.99^b

Means with the same letters are not significantly different at 5% level using Duncan's multiple range test

A. Plant Height (cm)

The influence of depth of irrigation, irrigation interval and different organic matter incorporation into the soil on height of *Solanum macrocarpon* is shown in Figure 1. The plant height in this study varied significantly (P < 0.05) with irrigation depth, irrigation interval and organic matter incorporation (Table 1). [6] Saeed *et. al*. (2001) reported that to achieve sustainable plant production, plant height is a major determinant of plant yield especially in large scale vegetable production. On the average, 6 mm irrigation depth resulted in the highest plant height of 27.63 cm while 4 mm irrigation depth gave the lowest plant height of 24.95 cm. Also, the lowest plant height of 25.06 cm was observed when the irrigation interval was five days while the highest plant height of 27.52 cm was recorded when the irrigation interval was three days.

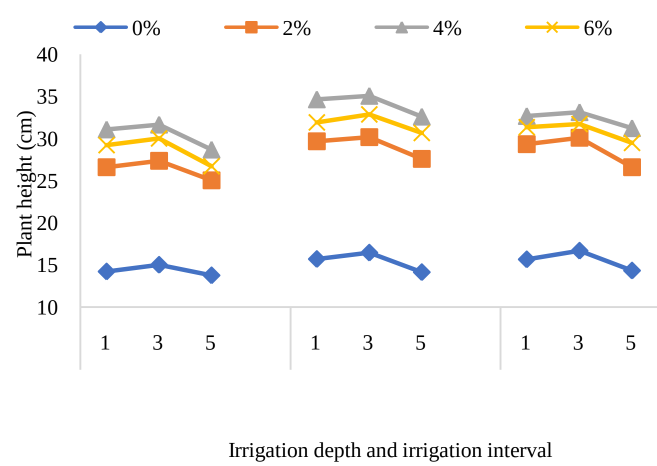

Figure 1: Plant height (cm) of *Solanum macrocarpon* as affected by the different irrigation depth, irrigation interval and organic matter incorporation

This is similar to what was observed by [7] and [8] that growth and yield were higher when irrigation was scheduled at 30% soil water depletion. Likewise, the highest plant height of 32.31 cm occurred when 4% organic matter was incorporated into the soil while the lowest plant height of 15.10 cm occurred with 0% organic matter incorporation. The better performance of *S. macrocarpon* height with organic matter application can be attributed to its higher nutrient composition and ability to provide enough nutrients for the plant growth. Poultry manure promotes vigorous growth, increase meristematic and physiological activities in the plant due to supply of plant nutrient and improvement in soil properties as reported by [9]. However, when all the factors were considered the highest plant height of 35.1 cm was recorded when 4% organic matter was incorporated under 6 mm of irrigation depth at 3 days irrigation interval while the lowest plant height of 13.75 cm was observed when no organic matter was incorporated under 4 mm of irrigation depth at 5 days irrigation interval. These differences in irrigation scheduling may be enough to cause water to be a limiting factor for yield of *S. macrocarpon*. Several researchers have reported that frequency of irrigation and quantity of nutrient in solution provided to plants affect yield [10, 11,12]. According to Duncan Multiple Range (DMR) test (Table 2), 6 mm irrigation depth resulted in the highest (27.52 cm) plant height on the average while 4 mm irrigation depth gave the lowest (25.07 cm) plant height. However, the 6 mm and 8 mm were not significantly different in their effects on the plant height while 4 mm irrigation depth was significantly different from the remaining two levels of irrigation depth. Moreover, the irrigation interval of three days gave the highest (27.63 cm) effect on plant height while irrigation depth of five days gave the lowest (24.95 cm). Yet, the irrigation intervals of one day and three days were not significantly different in their effects on the plant height while five days irrigation interval was significantly different from the remaining two levels of irrigation intervals. Then again, all the four levels of organic matter incorporation were significantly different in their effects on plant height with highest effect (32.31 cm) from 4% and the lowest (15.10 cm) from 0%.

A. *Leaf Area (cm^2)*

The effect of irrigation depth, irrigation interval and organic matter incorporation into the soil, on the leaf area is shown in Figure 2. The leaf area varied significantly ($P < 0.05$) with irrigation depth, irrigation interval and organic matter incorporation (Table 1). When all the factors were considered together, the maximum leaf area of 245.81 cm^2 occurred with 4% organic matter when 6 mm irrigation depth was applied every three days while the minimum leaf area of 53.98 cm^2 was observed when no organic matter was added with 8 mm of irrigation water applied every five days. The results obtained are in good harmony with those of [13] who found that increasing in irrigation scheduling with adequate nutrients caused an increase in growth of leaves of eggplant. However, on the average, the irrigation depth of 6 mm resulted in the maximum (184.92 cm^2) leaf area followed by 8 mm irrigation

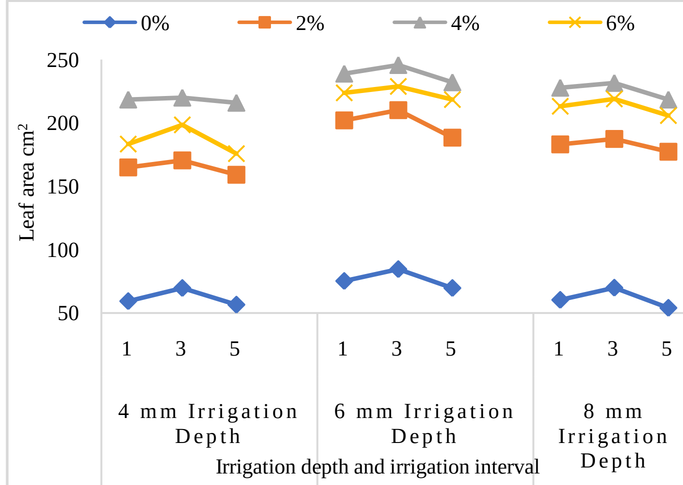

Figure 2: Leaf area (cm^2) of *Solanum macrocarpon* as affected by irrigation depth, irrigation interval and percent organic matter incorporation

Depth (170.71 cm^2) while the minimum leaf area (157.76 cm^2) occurred when the irrigation depth was 4 mm. Likewise, the minimum leaf area of 164.39 cm^2 was observed when the plant was irrigated every five while the maximum leaf area of 178.04 cm^2 was recorded when the irrigation interval was three days. Meanwhile, the maximum leaf area of 227.76 cm^2 occurred when 4% organic matter was incorporated into the soil while the lowest leaf area of 66.67 cm^2 occurred when no organic matter was incorporated. The increase in leaf area of *S. macrocarpon* in pots treated with poultry litter indicates that organic matter was able to release enough nutrients for the growth of the *S. macrocarpon*. [14] reported that poultry litter contains essential nutrients elements associated with high photosynthetic activities and thus promotes root and vegetative growth. According to Duncan Multiple Range (DMR) test (Table 2), 6 mm irrigation depth resulted in the highest (178.05 cm^2) leaf area on the average while 4 mm irrigation depth gave the lowest (164.39 cm^2) leaf area. However, the 6 mm and 8 mm were not significantly different in their effects on the leaf area while 4 mm irrigation depth was significantly different from the remaining two levels of irrigation depth. Likewise, the irrigation interval of three days gave the highest (184.93 cm^2) effect on leaf area while irrigation depth of five days gave the lowest (157.76 cm^2). Nevertheless, the irrigation intervals of one day and three days were not significantly different in their effects on the leaf area while five days irrigation interval was significantly different from the remaining two levels of irrigation intervals. Conversely, all the four levels of organic matter incorporation were significantly different in their effects on leaf area with highest effect (207.49 cm^2) from 4% and the lowest (66.66 cm^2) from 0%.

B. *Fresh Yield Weight (kg/ha)*

The effect of irrigation depth, irrigation interval and organic matter incorporation on *S. macrocarpon* fresh yield is shown in Figure 3.

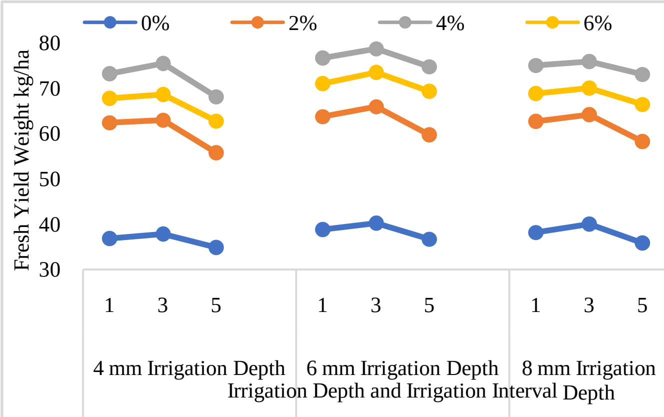

Figure 3: Fresh yield weight (kg/ha) of *S. macrocarpon* as affected by the different irrigation depth, irrigation interval and organic matter incorporation

The fresh yield weight varied significantly (P < 0.05) with irrigation depth, irrigation interval and organic matter (Table 1). On the overall, when all the factors were considered together, the maximum fresh yield of 78.73 kg/ha occurred with 4% organic matter incorporation when 6 mm irrigation depth was applied every three days while the minimum fresh yield of 34.88 kg/ha was observed when no organic matter was added with 4 mm of irrigation water applied every five days. Similar results were also reported by [15], the study found that yield was highest at increasing rates of applied farm yard manure under moderate irrigation scheduling which showed that irrigation and organic matter played a significant role in accelerating vegetable yield. However, when considering the irrigation effect, irrigation depth of 6 mm resulted in the maximum (62.44 kg/ha) fresh yield followed by 8 mm irrigation depth (60.72 kg/ha) while the minimum yield (58.89 kg/ha) occurred when the irrigation depth was 4 mm. Likewise, the minimum yield of 57.98 kg/ha was observed when the plant was irrigated at five days interval while the maximum yield of 62.79 kg/ha was recorded when the irrigation interval was three days. This is expected since plant reactions are affected directly or indirectly by the amount of soil water. [16] and [17] reported that all physiological processes like photosynthesis, transpiration, cell turgidity, cell and tissue growth and yield in plants is directly affected by water available in the soil. Moreover, the maximum yield of 74.55 kg/ha occurred when 4% organic matter was incorporated into the soil while the minimum yield of 37.73 kg/ha occurred when no organic matter was incorporated. This is expected because organic matter increased soil productivity and crop yield. [18] reported that organic matter has profound effect on the vegetative development of garden egg and it ensures vigorous growth of the crop hence, the increase in yield. According to Duncan Multiple Range (DMR) test (Table 2), 6 mm irrigation depth resulted in the highest (62 kg/ha) fresh yield weight on the average while 4 mm irrigation depth gave the lowest (57.98 kg/ha) fresh yield weight. However, the 6 mm and 8 mm were not significantly different in their effects on the fresh yield weight while 4 mm irrigation depth was significantly different from the remaining two levels of irrigation depth. Moreover, the irrigation interval of three days gave the highest (62.44 kg/ha) effect on fresh yield weight while irrigation depth of five days gave the lowest (58.89 kg/ha). Yet, the irrigation intervals of one day and three days were not significantly different in their effects on the fresh yield weight while five days irrigation interval was significantly different from the remaining two levels of irrigation intervals. On the other hand, all the four levels of organic matter incorporation were significantly different in their effects on fresh yield weight with highest effect (74.55 kg/ha) from 4% and the lowest (37.73 kg/ha) from 0%.

D. Dry Matter Weight (kg/ha)

The dry matter of *Solanum macrocarpon* in response to different organic matter incorporation into the soil, depth of irrigation and irrigation interval is shown in Figure 4.

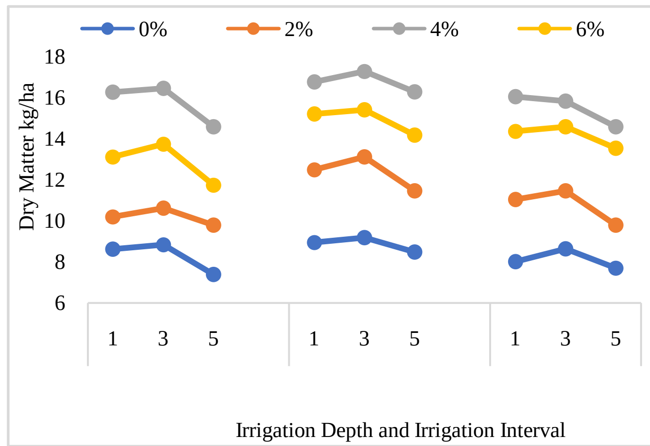

Figure 4: Dry matter weight (kg/ha) of *S. macrocarpon* as affected by the different irrigation depth, irrigation interval and organic matter incorporation

The dry matter weight in this study varied significantly (P < 0.05) with irrigation depth, irrigation interval and organic matter (Table 1). On the average, 6 mm irrigation depth resulted in the maximum dry matter weight of 13.24 kg/ha while 4 mm irrigation depth gave the minimum dry matter weight of 11.79 kg/ha. Similarly, the maximum dry matter weight of 12.94 kg/ha was recorded when the irrigation interval was three days while the minimum dry matter weight of 11.63 kg/ha was observed when the irrigation interval was five days. Also, the maximum dry matter weight of 16.01 kg/ha occurred when 4% organic matter was incorporated into the soil while the minimum dry matter weight of 8.43 kg/ha occurred when no organic matter was incorporated. The poultry litter application increased the dry matter yield of *Solanum* compared to the control (0%). The increase in the dry matter yield goes further to confirm that organic manure increased nutrient concentration in the soil, improve nutrient uptake by plants and increased crop yields [19, 20, 21]. Moreover, when all the factors were considered the maximum dry matter weight of 17.29 kg/ha was recorded when 4% organic matter was incorporated under 6 mm of irrigation depth at 3 days irrigation interval while the minimum dry matter weight of 7.40 kg/ha was observed when no organic matter was incorporated under 4 mm of irrigation depth at 5 days irrigation interval. According to Duncan Multiple Range (DMR) test (Table 2), 6 mm irrigation depth resulted in the highest (12.94 kg/ha) dry matter weight on the average while 4 mm irrigation depth gave the lowest (11.63 kg/ha) dry matter weight. However, the 6 mm and 8 mm were not significantly different in their effects on the dry matter weight while 4 mm irrigation depth was significantly different from the remaining two levels of irrigation depth. Moreover, the irrigation interval of three days gave the highest (13.24 kg/ha) effect on dry matter weight while irrigation depth of five days gave the lowest (11.79 kg/ha). Yet, the irrigation intervals of one day and three days were not significantly different in their effects on the dry matter weight while five days irrigation interval was significantly different from the remaining two levels of irrigation intervals. On the other hand, all the four levels of organic matter incorporation were significantly different in their effects on dry matter weight with highest effect (8.43 kg/ha) from 4% and the lowest (16.01 kg/ha) from 0%.

IV. CONCLUSION

The study examined the consequences of irrigation depth and interval along with poultry litter incorporation into soil on the yield of *Solanum macrocarpon*. The highest plant height occurred with 4% organic matter incorporation while the lowest plant height occurred when no organic matter was incorporated. Plant yield varied significantly with organic matter, depth of irrigation and irrigation interval. Also, the maximum leaf area occurred with 4% organic matter incorporation when 6 mm irrigation depth was applied every three days while the minimum leaf area was observed when no organic matter was added with 8 mm of irrigation water applied every five days. The maximum fresh and dry matter yield occurred with 4% organic matter incorporation when 6 mm irrigation depth was applied every three days. Organic fertilizer influence both yield, plant micronutrient contents, and help sustain crop productivity. In conclusion, the factor combination of 4% organic matter incorporation with 6 mm irrigation depth applied at three days irrigation interval resulted in better yield of the vegetable. It is therefore imperative that the nutrients uptake from the different levels of organic matter incorporated into the soil should be estimated.

REFERENCES

[1]. Olaniyan, A. B. and Nwachukwu, S.N. (2003). Response of Solanum macrocarpon to different sources of nitrogen fertilizer. In Proceedings of the 6th Biennial Conference of the African Crop Science Society, Hilton Hotel Nairobi, Kenya October 12th -17th.

[2]. Ojo, D.O. and Olufolaji, A.O., (1997). Optimum NPK fertilizer rates for growth and yield of *Solanum macrocarpon* (Igbagba). *Journal of Vegetable Environment and Ecology* 14(4): 834–836.

[3]. Schwab, G.O., Fangmeier, D.D., Elliot, W.J. and Frevert, R.K. (1993). Soil and Water Conservation Engineering. 4th Edition. John Wiley and sons, inc. New York.

[4]. Ojanuga, A.G. (1975). Morphology, Physical and chemical characteristics of Ife and Ondo areas. *Nigerian Journal of Soil Sci.* 9: 225-269.

[5]. AOAC, (1990). Official Methods of Analysis, 15th Edition. Association of Official Analytical Chemists, Washington, DC.

[6]. Saeed, I.M., Abbasi, R. and Kazim, M. (2001). Response of maize (*Zea mays*) to nitrogen and phosphorus fertilization under agro-climatic condition of Rawalokol, Azad Jammu and Kaslim and Kashmir, *Pak. J. Bio. Sci.* 4: 949-952.

[7]. Adekalu, K.O., Ogunjimi, L.A.O., Olaosebikan, F.O. and Afolayan S.O. (2008). Response of Okra to irrigation and mulching. *Int. Journal of Vegetable Science* 14(4): 339-350.

[8]. Osunbitan, J.A. (2013). Response of amaranth to irrigation and organic matter. *Journal of Agricultural Science and Technology.* 3(2A): 131-139.

[9]. Dauda, S. N., Ajayi, F. A. and Ndor, E. (2008). Growth and yield of watermelon (C*itrillus lanatus)* as affected by poultry manure application. *J. Agric. Social Sciences.* 121-124.

[10]. May, D.M. and Gonzales, J. (1994). Irrigation and nitrogen management as they affect fruit quality and yield of processing tomatoes. *Acta Hort.*, 277: 129-134.

[11]. Peet, M.M. and Willits, D.H. (1995). Role of excess water in tomato fruit cracking. *Hort. Sci.*, 30: 65-68.

[12]. Singandhupe, R.B., Rao, G.G., Patil, N.G. and Brahman, P.S. (2002). Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (*Lycopersicon esculentum* Mill). *Eur. J. Agron.*, 1: 1-14.

[13]. Byari, S.H., and Rabighis S.M. (1996). Yield and growth responses of eggplant cultivars to water deficit. *Egypt J. Horticult.* 23(1): 89-100.

[14]. John, L. N., James, D. B., Samuel, L. T. and Warner, L. W. (2004). Soil fertility and fertilizer. An introduction to nutrient management, Pearson Education, India pp. 106 – 53.

[15]. Kadyampakeni, D.M. (2013). Comparative Response of Cabbage to Irrigation in Southern Malawi. *Journal of Agricultural Science*; 5(8): 1-7.

[16]. Reddi, G.H.S. and Reddi, T.Y. (1995). Irrigation of principal crops, In: Efficient use of irrigation water, 2nd Ed, Kalyani Publishers, New Delhi, India, pp. 229-259.

[17]. Sarker, B.C., Hara, M. and Uemura, M. (2005). Proline synthesis, physiological responses and biomass, yield of eggplants during and after repetitive soil moisture stress. *Scientia Horticulturae*, 103: 387-402.

[18]. Aliyu, L. (2010). The effect of organic and mineral fertilizer on growth, yield and composition of pepper (*capsicum annum L.*). *Biol-Agric. Hore.*18: 29 – 35.

[19]. Ayoola, O.T. and Adeniyan, O.N. (2006). Influence of poultry manure and NPK fertilizer on yield and systems in south west Nigeria. *Afr. J. Biotechnol.* 5(15): 1386 – 1392.

[20]. Udom, G.N. and Bello, N.M. (2009). Effect of Poultry litter on the yield of two maize varieties in the Northern Guinea Savana. *J. Trop. Agric., Food, Environ. and Exten.* 8(1): 51 – 54.

[21]. Nyakatawa, E. Z., Reddy, K. C. and Brown, G. F. (2010). Residual effect of poultry litter applied to cotton in conservation tillage systems on succeeding rye and corn. *J. Sust. Agric.* 71: 159 – 170.