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PRODUCTIVITY OF RADISH AS A SUCCEEDING CROP IN RESPONSE TO THE RESIDUAL EFFECT OF ORGANIC AND INORGANIC FERTILIZERS PREVIOUSLY APPLIED TO CARROT

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ABSTRACT

The study evaluated the impact of residual fertilizers on the yield response of radish. It aimed to determine the productivity of radish as a succeeding crop on plots from which carrot genotypes (Safety Touchon France, Carotte Touchon AM, Carotte Touchon ETS) were previously harvested; and treated with different types of fertilizers (0t/ha, 20 t/ha poultry manure, 10 t/ha pig manure, 10 t/ha poultry manure + 200 kg/ha NPK 15: 15:15, 10 t/ha pig manure + 200 kg/ha NPK 15: 15:15). The study was conducted using Split-plot in Randomized Complete Block Design with four replications at the Teaching and Research Farm of the University of Nigeria in the derived Savanna agro-ecology zone of Nigeria. The results of the study showed that the yield components of radish did not exhibit significant differences (p > 0.05) among the residual fertilizers. However, plots treated with 20 t/ha poultry manure resulted in higher bulb weight (274 g) and whole plant biomass yield (392 g). The Carotte Touchon AM genotype plot (P2) showed a higher yield advantage compared to other genotype plots. In terms of interaction, the combination of Carotte Touchon ETS plot and 20 t/ha poultry manure produced the highest whole plant biomass yield (496 g) and bulb weight (410 g). The control plot, 0 t/ha, had the highest radish seedling emergence percentage (86.1%). Although the residual effect of the fertilizers was not statistically significant, the study suggests that the applied fertilizers had enough remaining nutrients in the previously cultivated plots to support another cropping season on the same land. In conclusion, evaluating the yield response of radish to residual fertilizers is beneficial for farmers in terms of sustainable land use as it optimizes land productivity and reduces land pollution

Key words: *Raphnus sativus* L., Fertilizers, Yield, Residual effect

INTRODUCTION

Radish (*Raphanus sativus*), a member of the Brassicaceae family, is a versatile root vegetable that holds significant value in various culinary and agricultural contexts (Tsouvaltzis et al., 2014; Nishio, 2017; Manivannan et al., 2019; Gamba et al., 2021). Its distinctive pungent and spicy flavor, along with its diverse shapes and colors, make it a popular choice among consumers (Radovich, 2018; Gamba et al., 2021). Radish not only serves as a root vegetable but also finds utility as a leafy vegetable, a fruit vegetable, an oil crop, and even as a cover plant (Radovich, 2018; Gamba et al., 2021). Its ability to thrive in fertile soils makes it relatively easy to cultivate (Radovich, 2018; Gamba et al., 2021). In Nigeria, radish production faces challenges due to the inherent low concentration of essential nutrients in the soil, which can limit crop growth and development (Aderinoye-Abdulwahab and Salami, 2017; Sharma and Chetani, 2017; Bhatt et al., 2019). To overcome these limitations, farmers commonly rely on the application of fertilizers, both organic and inorganic, to supplement the nutrient requirements of radish crops (Aderinoye-Abdulwahab and Salami, 2017; Sharma and Chetani, 2017; Bhatt et al., 2019). Organic manure, with its slow nutrient release and long-lasting effects on the soil, offers a sustainable and environmentally-friendly option (Malik et al., 2014;Brar et al., 2015; Bhatt et al., 2019). In contrast, the use of inorganic fertilizers can lead to challenges such as increased soil acidity, nutrient leaching, and imbalances (Malik et al., 2014;Brar et al., 2015; Bhatt et al., 2019). However, the combination of organic and inorganic

fertilizers in crop production has shown promise in enhancing soil organic matter content, pH, cation exchange capacity, and nutrient release rates (Brar et al., 2015; Bhatt et al., 2019). This study aims to address the challenges faced in radish production in Nigeria by evaluating the effectiveness of different residual fertilizers in enhancing crop growth and development through residual cropping.

Residual cropping, also known as residual effects or residual fertilization, is a management practice in sustainable agriculture that aims to utilize the remaining nutrients from previously applied fertilizers and this practice not only improves nutrient use efficiency but also reduces the environmental impact associated with excessive fertilizer applications (Li et al., 2018). Several studies have investigated the effects of residual cropping and residual fertilizers on crop productivity and soil fertility. For instance, Li et al. (2018) conducted a study on residual effects of organic amendments in a wheat-maize rotation system and found that the residual application of organic amendments, such as livestock manure and crop residues, significantly increased crop yields and improved soil physical and chemical properties. Findings have concluded that residual organic amendments can provide long-term benefits for crop production and soil health. In sustainable agricultural practices, residual cropping is employed to maximize the utilization of applied fertilizers, reduce environmental pollution, and optimize efficient nutrient management and economic yields. Previous research has shown the importance of nutrient management in radish production as nutrient deficiencies can lead to reduced crop growth, lower yields, and poor quality produce (Zhang et al., 2016; El-Naggar et al., 2020). By comparing the impact of residual fertilizers (organic and inorganic), the study sought to identify the most suitable approach for optimizing radish yield and quality. The understanding of the potential benefits and limitations of these residual fertilizers will contribute to sustainable agricultural practices and support farmers in their efforts to overcoming nutrient deficiency and maximize radish production in Nigeria. Therefore, by exploring the efficacy of applied residual organic and inorganic fertilizers from previous cropping season, the study provides valuable insights that can enhance crop growth, yield, and overall agricultural sustainability. The findings will contribute to the existing body of knowledge on sustainable farming practices and provide practical recommendations for farmers in Nigeria and other regions with similar agricultural challenges.

MATERIALS AND METHODS

Site Description: The experiment was conducted at the Teaching and Research Farm of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka (latitude $06^0$52'N and longitude $07^0$24'E with an altitude of 447.26m above sea level) in the derived savanna zone. It receives an annual rainfall of 1400mm per annum distributed from April to September and monthly temperature ranges from 23^0C - 35^0C (Uguru et al., 2011; UNN Meteorological station, 2019). The soil type of the area is sandy clay loam with pH of 4.8. Exchangeable calcium was 2.2 cmol/kg, exchangeable potassium was 1.40 mg/kg and exchangeable magnesium was 0.13 mg/kg. The soil organic carbon was 1.5% while available phosphorus and total nitrogen were 30.8 mg/kg and 0.14%, respectively (Soil Science laboratory, UNN).

Experimental Layout, Design and Treatments: The study was conducted on plots previously cultivated with three carrot genotypes (Safety Touchon France, CarotteTouchon AM and CarotteTouchon ETS) treated with organic and inorganic fertilizer combinations (0, 20 t/ha poultry manure, 20 t/ha pig manure, 10 t/ha poultry manure + 200kg/ha NPK 15:15:15, 10t/ha pig manure + 200kg/ha NPK 15:15:15). The experiment was a 3 x 5 Split plot laid out in a Randomized Complete Block Design and replicated four times. The field area on which Radish succeeded carrot was an area of 50m x 25m, which was ploughed, harrowed and ridged. The field was divided into 3.0m x 1.5m plots and ridges of 1.5m long with spacing of 1m x 50cm. The carrot was harvested and the experimental area was minimally slashed and ploughed in preparation for the succeeding crop. Radishseeds were planted as the succeeding crop after carrot.The appropriate rate of organic and inorganic fertilizers for the preceding crop, carrot, was thoroughly mixed with the soil in each ridge. Radish seeds were planted as a succeeding crop after carrot, the first crop was harvested and experimental area minimally slashed and incorporated into the soil.

Data collected on percent emergence, whole plant biomass yield, leaves weight and bulb weight were subjected to analysis of variance and means were compared using the Least Significance Difference (LSD) at 5% level of probability.

RESULTS

Main effects of Residual fertilizer levels and plots on percent emergence of radish seedlings.

The main effects of fertilizer levels and genotypes on percent emergence of radish seedlings showed non-significant ($p > 0.05$) difference (Table1). In the residual study, fertilizer had statistically similar effect on the emergence of radish. However the control plot produced the highest percentage emergence value, 86.1%, on the 8^{th} and 10^{th} day after planting. The least emergence occurred

(20.8%) in the application of 10 t/ha Pig M + 200 kg/ha NPK 15:15:15.The plots on which the different genotypes of carrots were grown were also statistically similar on percent emergence of radish seedlings. The plot on which CarotteTouchon AM was grown had the highest percentage emergence while the plot on which CarotteTouchon ETS was grown recorded the least percentage value on emergence.

Interaction of previously cultivated plots and fertilizer levels on percent emergence of radish seedlings.

Table 2 shows that fertilizer level interaction with plots from which carrot plants were harvested had statistically similar effect ($p<0.05$) on the emergence of radish seedlings. However, 20 t/ha poultry and 0t/ha applied to the plot on which CarotteTouchon AM was grown, gave the highest percentage emergence (91.7%) on day 10 after planting while least percent emergence value (58.3%) was obtained on day 10 by the plot where CarotteTouchon ETS received 10 t/ha PM + 200 kg/ha NPK 15:15:15.

Residual effect of fertilizer levels and genotype plots from which carrot roots were harvested on the growth and yield components of radish taken at harvest.

The growth and yield components of radish taken at harvested presented in Table 3 were not significantly ($p > 0.05$) influenced by fertilizer levels and plots previously cultivated.Fertilizers had statistically similar effect on number of bulbs per plot, whole plant biomass yield, bulb weight, weight of leaves and harvest index of radish plants harvested. Application of 20t/ha pig manure and 10 t/ha PM + 200 kg/ha NPK 15:15:15 gave the same mean values of number of bulbs per plot, this being the highest across fertilizer levels while 10 t/ha Pig M + 200 kg/ha NPK 15:15:15 gave the least mean values on number of harvested bulbs per plot. On whole plant biomass and bulb weight, 20t/ha poultry manure recorded the highest numerical mean values while on weight of leaves, 20t/ha Pig manure recorded the highest values across fertilizer levels. Hence, the increase in the growth and yield of radish could be attributed to enhanced nutrient use efficiency in the presence of organic fertilizer being an excellent source of macro- and micronutrients. Plots on which genotypes were previously grown had non-significant ($p > 0.05$) effect on the growth and yield components of radish. Although, Carotte Touchon AM Plot gave the highest values across parameters while Safety Touchon France plot recorded the least values on whole plant biomass yield, bulb weight and harvest index and Carotte Touchon ETS Plot recorded the lowest mean values on number of bulbs and weight of leaves.

Table 1: Residual effect of fertilizer levels and genotype plots on percentage emergence of radish seedlings.

Effects	Number of days after planting		
	D6	**D8**	**D10**
Fertilizers			
Control, 0t/ha	44.4	**86.1**	**86.1**
20t/ha PM	44.4	73.6	77.8
20t/haPigM	**48.6**	72.2	80.6
10t/haPM+200kg/ha NPK 15:15:15	37.5	63.9	65.3
10t/haPigM+200kg/ha NPK 15:15:15	20.8	56.9	59.7
$LSD_{(0.05)}$	NS	NS	NS
Genotype Plots			
Safety Touchon France Plot	**41.7**	70.0	70.0
CarotteTouchon AM Plot	39.2	**74.2**	**79.2**
CarotteTouchon ETS Plot	36.7	67.5	72.5
$LSD_{(0.05)}$	NS	NS	NS

PM: poultry manure, PigM: Pig manure, D6: Day 6, D8: Day 8, D10:Day 10

Table 2: Interaction effect of fertilizer levels and Genotype plots on percentage emergence of radish seedlings.

		Number of days after planting		
Genotype Plots	**Fertilizers**	**D6**	**D8**	**D10**
Safety Touchon France Plot	Control, 0t/ha	45.8	**91.7**	87.5
	20t/ha PM	**50.0**	75.0	75.0
	20t/ha Pig M	**50.0**	70.8	75.0
	10t/ha PM + 200kg/ha NPK 15:15:15	33.3	58.3	58.3
	10t/ha Pig M + 200kg/ha NPK 15:15:15	29.2	54.2	54.2
CarotteTouchon AM Plot	Control, 0t/ha	45.8	83.3	**91.7**
	20t/ha PM	45.8	87.5	**91.7**
	20t/ha Pig M	45.8	70.8	83.3
	10t/ha PM + 200kg/ha NPK 15:15:15	37.5	70.8	62.5
	10t/ha Pig M + 200kg/ha NPK 15:15:15	20.8	58.3	66.7
CarotteTouchon ETS Plot	Control, 0t/ha	41.7	83.3	79.2
	20t/ha PM	37.5	58.3	66.7
	20t/ha Pig M	**50.0**	75.0	83.3
	10t/ha PM + 200kg/ha NPK 15:15:15	41.7	62.5	75.0
	10t/ha Pig M + 200kg/ha NPK 15:15:15	12.5	58.3	58.3
$LSD_{(0.05)}$		NS	NS	NS

PM: poultry manure, Pig M: Pig manure, D6: Day 6, D8: Day 8, D10: Day 10 .

Effect of the interaction of plots previously grown with different genotypes of carrot and fertilizer levels on the growth and yield components of radish taken at harvest

The combined effect of the plot on which Carotte Touchon ETS was grown with the application of 20 t/ha pig manure gave the highest whole plant biomass yield (496.0 g) and bulb weight (410.0 g) (Table 4) but was statistically similar across treatment combinations. The least values on whole plant biomass yield and bulb weight were recorded by the interaction of the plot on which Carotte Touchon AM was grown with 10 t/ha Pig M + 200 kg/ha NPK 15:15:15. CarotteTouchon ETS plot x 10 t/ha PM + 200 kg/ha NPK 15:15:15 gave the highest harvest index value while the least harvest index value was produced by Safety Touchon France plot x 10 t/ha Pig M + 200 kg/ha NPK 15:15:15.

Number of bulbs per plot was significantly ($p \leq 0.05$) influenced by the interaction of Safety Touchon France plot with 10 t/ha PM + 200 kg/ha NPK 15:15:15 obtaining the highest number of bulbs (13.8) and Carotte Touchon AM plot combined with 10 t/ha Pig M + 200 kg/ha NPK 15:15:15 had the least value (4.0).

PM: poultry manure, PigM: Pig manure, NBP: Number of bulb per plot, WPBY (g):Whole plant biomass yield in gram, BW(g): bulb weight per plot in gram,LW(g): weight of Leaves in gram, HI: Harvest Index.

DISCUSSION

The control treatment (0t/ha) plot resulted in relatively high percentage emergence of radish seedlings, which aligns with studies that have shown that the absence of fertilizer or nutrient inputs can have a positive effect on seedling emergence (Kaur and Singh, 2019). The finding that the residual plots with higher levels of poultry manure (20t/ha PM) and pig manure (20t/ha Pig M) generally showed lower percentage emergence compared to the control treatment indicates probable excessive organic matter, particularly in the form of manure, can inhibit seedling emergence due to factors such as high nitrogen content and the release of phytotoxic substances (Zhang et al., 2017). The treatments combining lower levels of manure with inorganic NPK fertilizer (10t/ha PM+200kg/ha NPK 15:15:15 and 10t/ha PigM+200kg/ha NPK 15:15:15) showed variable percentage emergence, with some improvement compared to the higher manure treatments, is consistent with studies that have shown the potential for synergistic residual effects between organic and inorganic fertilizers, leading to improved seedling emergence and growth (Xu et al., 2012). This suggests the presence of residual effects from previous organic fertilization or nutrient availability in the soil. Organic fertilizers, such as poultry manure and pig manure, can contribute to the buildup of organic matter and nutrients in the soil, providing a long-lasting source

of plant nutrients. These residual effects can positively influence seedling emergence and early growth stages. The variable percentage emergence observed in the treatments combining lower levels of manure with inorganic NPK fertilizer suggests the potential for synergistic residual effects between organic and inorganic fertilizers. When used in combination, organic and inorganic fertilizers can complement each other, promoting improved seedling emergence and growth (Kumar et al., 2019; Rana et al., 2020). The interaction between organic and inorganic nutrients can enhance nutrient availability, balance nutrient ratios, and provide a more favorable environment for seedling establishment (Kumar et al., 2019; Rana et al., 2020). In the interaction of the treatments, the emergence of radish seedlings varied among the different residual plots. However, there is no clear trend indicating one genotype residual plot consistently outperforming the others in terms of percentage emergence.

The residual plot with 20t/ha PM (poultry manure) resulted in higher values for growth and yield components such as WPBY (Whole plant biomass yield), BW (bulb weight), LW (leaf weight), and HI (Harvest Index) compared to the control treatment (0t/ha). This aligns with studies that have reported the positive impact of organic fertilizers, including poultry manure, on plant growth, yield, and nutrient uptake in various crops. (Yadav et al., 2016;(Kumar et al., 2019; Rana et al., 2020)). The treatment with 10t/ha Pig M (pig manure) combined with 200kg/ha NPK 15:15:15 resulted in lower values for most growth and yield components compared to other treatments. This may be attributed to the interaction between organic and inorganic fertilizers, as excessive nitrogen from pig manure combined with the additional nitrogen from the NPK fertilizer may have resulted in imbalanced nutrient availability and reduced plant performance (Xu et al., 2012;Kiziloglu et al., 2017; Singh et al., 2018). The inclusion of inorganic fertilizers in combination with organic fertilizers may provide additional nutrient supplementation, but the optimum combination and dosage can vary depending on soil conditions, crop requirements, and specific fertilizer types (Kiziloglu et al., 2017; Singh et al., 2018). The treatment with 20t/ha PM (poultry manure) resulted in higher values for growth and yield components of radish compared to the control treatment (0t/ha) across different genotype plots. The residual organic matter and nutrients from the previous application of poultry manure likely contributed to improved soil fertility and nutrient availability, leading to enhanced radish productivity (Yadav *et al*., 2016).

Table 3: Residual effect of fertilizer levels and genotype plots from which carrot roots were harvested on the growth and yield components of radish taken at harvest.

	Growth and Yield components				
Effects	**NBP**	**WPBY(g)**	**BW(g)**	**LW(g)**	**HI (%)**
Fertilizers					
Control, 0t/ha	9.2	169.0	188.0	49.2	65.0
20t/ha PM	9.7	**392.0**	**274.0**	81.4	71.8
20t/ha Pig M	9.8	324.0	236.0	**87.9**	71.9
10t/haPM+200kg/ha NPK 15:15:15	9.8	238.0	180.0	57.3	**75.0**
10t/haPigM+200kg/ha NPK 15:15:15	5.2	100.0	69.0	31.6	60.2
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
Genotype Plots					
Safety Touchon France Plot	9.1	234.0	170.0	63.6	64.9
CarotteTouchonAM Plot	**9.8**	**264.0**	**198.0**	**65.8**	**70.9**
CarotteTouchon ETS Plot	7.3	236.0	200.0	55.1	70.5
$LSD_{(0.05)}$	NS	NS	NS	NS	NS

Table 4: Effect of the interaction of plots previously grown with different genotypes of carrot and fertilizer levels on the growth and yield components of radish taken at harvest for the year, 2018.

		Growth and Yield Components				
Genotype Plots	**Fertilizers**	**NBP**	**WPBY(g)**	**BW(g)**	**LW(g)**	**HI (%)**
Safety Touchon France plot	Control, 0t/ha	7.5	115.0	78.0	36.8	57.2
	20t/ha PM	9.0	345.0	258.0	87.0	75.5
	20t/ha Pig M	8.5	266.0	188.0	78.0	70.0
	10t/ha PM + 200kg/ha NPK 15:15:15	**13.8**	318.0	240.0	76.5	75.0
	10t/ha Pig M + 200kg/ha NPK 15:15:15	6.5	125.0	85.0	39.8	46.8
CarotteTouchon AM Plot	Control, 0t/ha	11.8	240.0	175.0	65.0	69.0
	20t/ha PM	9.0	334.0	263.0	71.3	74.6
	20t/ha Pig M	13.0	434.0	326.0	**107.8**	75.1
	10t/ha PM + 200kg/ha NPK 15:15:15	11.0	233.0	175.0	57.5	73.2
	10t/ha Pig M + 200kg/ha NPK 15:15:15	4.0	79.0	53.0	27.3	62.5
CarotteTouchon ETS Plot	Control, 0t/ha	8.3	153.0	107.2	45.8	68.8
	20t/ha PM	11.0	**496.0**	**410.0**	86.0	65.2
	20t/haPigM	7.8	271.0	193.0	78.0	70.7
	10t/haPM + 200kg/ha NPK 15:15:15	4.7	162.0	125.0	38.0	**76.7**
	10t/haPigM + 200kg/ha NPK 15:15:15	5.0	97.0	69.0	27.8	71.2
$LSD_{(0.05)}$		10.7	NS	NS	NS	NS

CONCLUSION

In conclusion, the findings of this study shed light on the response of radish to residual fertilizers previously applied to carrot genotypes. The residual organic matter and nutrients from poultry manure application contributed to improved soil fertility, nutrient availability, and overall plant health. This resulted in higher values for growth and yield components of radish compared to the control treatment. The radish crop growth was principally due to efficient utilization of the applied organic manure and inorganic fertilizers and it is therefore concluded that residual cropping should be carried out after harvest of main crops to obtain efficient use of the applied fertilizers and sustain soil fertility. However, further study could be done on radish as a test crop for residual effect to obtain response pattern across other locations.

REFERENCES

Aderinoye-Abdulwahab, S. A. and Salami, S. T. (2017). Assessment of organic fertilizer usage by vegetable farmers in Asa LGA of Kwara State. Agrosearch (2017) 17(1), 101– 114. doi:10.4314/agrosh.v17i1.8

Ben-Hur, M. and Skirycz, A. (2019). Carrot (Daucus carota L.) seed germination and emergence: A review. Scientia Horticulturae, 254, 23-31.

Bhatt M., Sharma A., Singh B., et al. (2019). Impact of organic and inorganic fertilizers on nutrient availability, soil health and productivity of okra (Abelmoschusesculentus L.) under subtropical conditions. Journal of Plant Nutrition, 42(7), 777-787.

Brar K. K., Chahal G. B. S., Gill R. I. S., et al. (2015). Soil fertility, nutrient uptake and yield of maize (Zea mays L.) as influenced by integrated nutrient management. Indian Journal of Agricultural Sciences, 85(6), 865-869.

El-Naggar A. H., Abd El-Hamid E. M. and Kabeil S. S. (2020). Effect of bio-fertilizers and nitrogen levels on growth, yield and quality of radish (Raphanussativus L.). Journal of Plant Production, 11(12), 1143-1150.

Gamba, M., Asllanaj, E., Raguindin, P., Glisic, M., Franco, O., Minder, B. and Muka, T. (2021).

Nutritional and phytochemical characterization of radish (Raphanus sativa). Trends in Food Science Technology, 113(11), 205-218. doi:10.1016/j.tifs.2021.04.045.

Kaur, G. and Singh, G. (2019).Effect of organic and inorganic fertilizers on seed germination and seedling growth of vegetable crops. International Journal of Chemical Studies, 7(1), 851-854.

Kiziloglu F. M., Turan M. and Sahin U. (2017). Effect of different ratios of organic and inorganic fertilizers on yield and quality of tomato under greenhouse conditions. Fresenius Environmental Bulletin, 26(5), 3379-3386.

Kumar P., Singh V. P. and Singh R. (2019). Influence of organic and inorganic sources of nutrients on soil fertility, productivity and quality of carrots (Daucuscarota L.) in a sandy loam soil of Northern India. International Journal of Current Microbiology and Applied Sciences, 8(4), 69-81.

Li C., Liu E., Sun J., et al. (2018). Residual effects of organic amendments on crop productions in a wheat-maize rotation system. Frontiers in Plant Science, 9, 986.

Malik M. A., Cheema M. A., Khan M. A., and Saleem M. F. (2014).Comparative efficacy of organic and inorganic fertilizers on the yield and quality of carrot (Daucuscarota L.). Journal of Soil Science and Plant Nutrition, 14(3), 667-679.

Manivannan, A., Kim, J.-H., Kim, D.-S., Lee, E.-S. and Hye-Eun, L. (2019). Deciphering the Nutraceutical Potential of Raphanus sativus—A Comprehensive Overview. Nutrients, 11(2), 402. Retrieved from https://doi.org/10.3390/nu11020402

Nishio, T. (2017). Economic and Academic Importance of Radish. In T. Nishio, and H. Kitashiba, The Radish Genome (pp. 1-10). Springer International Publishing.

Radovich, T. J. (2018). Biology and Classification of Vegetables. In M. Siddiq, & M. A. Uebersax (Eds.), Handbook of Vegetables and Vegetable Processing (2nd ed., Vol. 1, pp. 1-23). John Wiley & Sons Ltd. Retrieved from https://doi.org/10.1002/9781119098935.ch1

Rana A., Kumar S., Kumar R., et al. (2020). Effect of organic and inorganic sources of nutrients on soil fertility, crop productivity and economics of wheat (Triticumaestivum L.)-maize (Zea mays L.) cropping system. Journal of Applied and Natural Science, 12(1), 58-64.

Sharma A. K. and Chetani R. (2017). Impact of organic and inorganic sources of nutrients on yield, quality and economics of baby corn (Zea mays L.). Journal of Pharmacognosy and Phytochemistry, 6(5), 1893-1898.

Singh P., Singh B. and Singh Y. (2018). Effect of organic and inorganic nutrient sources on growth, yield and nutrient uptake of radish (Raphanussativus L.) in an Inceptisol of Punjab. International Journal of Current Microbiology and Applied Sciences, 7(9), 1286-1295.

Uguru, M. I., Baiyeri, K. P. and Aba S. C. 2011. Indicators of climate change in the derived savannah niche of Nsukka, South-eastern Nigeria. Agro-Science, 10(1): 17 -26.

Tsouvaltzis, P. and Brecht, J. K. (2014). Changes in Quality and Antioxidant Enzyme Activities of Bunched and Topped Radish (Raphanus sativus L.) Plants during Storage at 5 or 10C. Journal of Food Quality, 37(3), 157–167. doi:10.1111/jfq.12082.

Xu, G., Fan, X. and Miller, A. J. (2012). Plant nitrogen assimilation and use efficiency. Annual Review of Plant Biology, 63, 153-182.

Yadav, R. L., Dwivedi, B. S. and Singh, R. (2016).Effect of organic manures and inorganic fertilizer on productivity, profitability and nutrient uptake of wheat (Triticumaestivum) in Indo-Gangetic plains. Indian Journal of Agronomy, 61(2), 126-131.

Zhang J., Xie Z. and Zhang X. (2016). Effects of different nutrient levels on growth, yield, and quality of radishes (Raphanussativus L.). Communications in Soil Science and Plant Analysis, 47(3), 309-318.

Zhang, M., Li, Y. and Yang, J. (2017). Seed germination and seedling growth of vegetable crops as affected by organic and inorganic fertilizers. Horticultural Plant Journal, 3(3), 97-104.