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Performance of Green Bean (*Phaseolus vulgaris* L.) Varieties in Response to Poultry Manure in Sudan Savanna of Nigeria

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***Abstract:** Nutrients are limiting factors in green bean cultivation in the Sudan Savanna agro-ecological zone of Nigeria. Thus, field trials were conducted in the 2018 rainy season at the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano and Teaching and Demonstration Farm of Department of Agricultural Education, Federal College of Education, Katsina. To study the growth and yield performance of green bean varieties as affected by poultry manure. The treatments consisted of two green bean varieties (Bean Cora and Haricot Contender) and three different rates of chicken manure (0, 2.5 and 5 t ha^{-1}). The experimental design employed was Randomized Complete Block Design (RCBD) with three replicates. Data collected were analysed (ANOVA) using the Genstat statistical package. The results revealed that varieties differed significantly in most of the studied characters. Haricot Contender recorded significantly higher canopy height, number of leaves per plant, plant dry matter and leaf area per plant than Bean Cora. While, Bean Cora significantly produced more pods per plant, pod weight per plant and green pod yield than Haricot Contender. The results also indicated that 5 t ha^{-1} of poultry manure application significantly increased all the studied characters compared with 2.5 t ha^{-1} and control. Based on this Study, Bean Cora is a promising variety in these locations. Further research using poultry manure to ascertain the optimum rate for higher green bean production in the Sudan Savanna of Nigeria is required.*
***Keywords:** Green bean, Bean Cora, Haricot Contender, poultry manure, soil*

I. INTRODUCTION

Green bean (Phaseolus vulgaris L.) belongs to the family Fabaceae. It is one of the essential leguminous vegetable crops cultivated worldwide for green pods and dry seeds (Zeyada and Abdalla, 2014). It is the second most essential grain legume, and its total global production exceeds 23 million metric tons, of which 7 million metric tons are produced in Africa and Latin America (Broughton et al., 2003). In Africa, over 4 million hectares of land are under bean cultivation annually, giving an estimated output of over 2.5 million metric tons, providing dietary protein for over 100 million people living in rural and urban communities (Broughton et al., 2003). The immature green pods of these beans are also an important food source in many locations around the world, where they are known as Green bean, Snap bean, Common bean, French bean or String bean (Kenneth, 2012). Green beans are rich sources of vitamin A and C, calcium, phosphorus and in addition to proteins and iron in the human diet (Kwambe et al., 2015). The optimum temperature requirement for optimum green bean growth and yield ranges between 16o - 30oC. Green bean prefers areas with moderate rainfall, rather than dry areas with excessive rainfall (Wang et al., 2008).

Green bean production in tropical soil is low due to nutrient deficiencies, especially nitrogen and phosphorus, essential for crop growth and yield (Singh et al., 2003). Nitrogen and phosphorus are vital elements for crop growth and productivity (Cheminingwa et al., 2011; Hussein et al., 2016). Soil acidity and aluminium toxicity also limit roots development and inhibit access to moisture in lower soil strata (Beebe and Rao, 2014). The decline in soil fertility can also result from continuous cultivation of soils for decades without appropriate soil fertility management (Cheminingwa et al., 2011).

The green bean crop meets more than 50 % of the dietary protein requirements of households in sub - Saharan Africa (Feleafel and Mirdad, 2014). The annual per capita consumption of green bean is higher among poor people who cannot afford to buy nutritious foodstuffs, such as meat and fish as a source of proteins (Namugwanya et al., 2014). The fresh and succulent pods of green bean serve as an essential source of plant protein in any part of the world. Furthermore, the vegetative part of the plant is used as fodder to feed both small and large ruminants in the tropics.

Different forms of organic fertilizers such as poultry manure, compost, cow dung, household waste and compost tea improved soil fertility for better crop growth and yield. Poultry manure plays an essential role in improving soil physical properties (Adzemi and Haruna 2017).

It contributes to increasing soil organic carbon contents and improving soil productivity by increasing activities of the useful microorganisms in the soil (Feleafel and Mirdad, 2014). Green bean yield and yield attributes were increased with the application of poultry manure (Mohammad et al., 2016). It aimed at investigating the growth and yield performance of green bean varieties as affected by poultry manure rates.

II. MATERIALS AND METHOD/METHODOLOGY

A. Study Area

The experiment was set out and conducted during the rainy season of 2018 at the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano (Latitude 11o 58'N and Longitude 8o 34'E; 475 m above sea level) and Teaching and Demonstration Farm of the Department of Agricultural Education, Federal College of Education, Katsina (Latitude 12o 56'N and Longitude 7o 36'E; 464 m above sea level) both located in the Sudan Savanna of Nigeria.

B. Treatments and Experimental Design

The treatments consisted of two improved varieties of green bean (Bean Cora and Haricot Contender) and three rates of poultry manure (0, 2.5 and 5 t ha^{-1}). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) with three replications. The gross plot sizes were 4.5 x 2 m (9 m^2) consisting of six rows and the net plot sizes were 3 x 1.5 m (4.5 m^2) composed of four inner rows. The plots were separated by 0.5 m. the amendment with Poultry manure was done two weeks before sowing as per treatment to allow for decomposition.

C. Data Collection

Data on the growth characters of green bean were recorded from each plot by taking five random plant samples at 6 WAS. Yield and yield characters were measured at harvest. The following characters were measured in the course of the study.

1) *Canopy Height (cm):* This was measured from five tagged plants in each net plot. The length of the five tagged plants was measured using graduated meter rule from the base to the top of the canopy. The mean height of the sample plants was recorded.
2) *Number of Branches per Plant:* This was counted from five tagged plants from each net plot, and the mean value was recorded.
3) *Leaves Number per Plant:* This was counted from five tagged plants and the mean value was recorded.
4) *Shoot Dry Matter (g):* Three random sample plants were up-rooted and packed in an envelope, oven-dried to a constant weight. The dried plants were weighed individually, and the mean value was recorded.
5) *Leaf Area per Plant (cm^2):* This was estimated by measuring the length and width of the sample leaf using meter rule multiplied by a crop factor (0.67) as reported by Yadav (2015). These were estimated from the five tagged plants in each plot. Three leaves were considered per plant, and the mean area of the leaf was recorded. The area of leaf per plant was obtained by multiplying the mean size of the leaf by leaves count on the plant.
6) *Number of Pods per Plants:* At each harvesting, the number of pods produced by five tagged plants per plot was recorded individually and the mean value was calculated.
7) *Pod Weight per Plant (g):* Pod weight per plant was recorded by weighing the pods harvested from five tagged plants individually per plot. From the weight taken, the mean was calculated.
8) *Green Pod Yield (kg ha^{-1}):* Green pod yield from two inner rows of each net plot were harvested, weighed, and expressed in kilograms per hectare (kg ha^{-1}).

Green pod yield (kg ha^{-1}) = (Yield per net plot (kg) ×10000 m^2) / (Net plot area (m^2)

D. Data Analysis

The data collected from the field were subjected to analysis of variance (ANOVA) using Genstat Statistical Package (17th edition). Means showing significant differences were separated using SNK at a 5 % level of probability.

III. RESULTS

A. Physical and Chemical Properties of soil of the Experimental sites and the Chemical Composition of Poultry Manure Used

Table 1 indicates the physical and chemical properties of the soil in the experimental sites before cropping and the chemical composition of poultry manure used in the study. The two experimental sites have sandy loam soils in texture, with a pH of 6.77 and 6.93 at BUK and FCE Katsina, respectively. The soil organic carbon contents were 1.35 g kg^{-1} and 1.10 g kg^{-1}, total nitrogen was 0.42 g kg^{-1} and 0.34 g kg^{-1} and available phosphorus were 9.89 mg kg-1 10.17 mg kg^{-1} at BUK and FCE Katsina, respectively. The exchangeable bases, i.e., Ca, Mg, K, Na and CEC were 2.12, 1.18, 0.32, 0.11 and 4.68 cmol kg^{-1} at BUK. While at FCE Katsina, the exchangeable bases i.e.Ca, Mg, K, Na and CEC were 2.28, 1.36, 0.19, 0.12 and 4.95 cmol kg^{-1}, respectively.

The chemical composition of the poultry manure used in the study, i.e., total nitrogen, total phosphorus, potassium and organic carbon were 4.27 %, 949.21 mg kg^{-1}, 6916.37 mg kg^{-1} and 6.37 %.

B. Characters Measured in the Study

1) *Canopy Height (cm):* There were significant differences ($p < 0.05$) between the varieties of green bean concerning canopy height at BUK with Haricot Contender significantly taller than Bean Cora (Table 2). No significant variation was observed between the green bean varieties at FCE Katsina at the same sampling period. Poultry manure application at different rates significantly influenced the canopy height of green bean at both locations. Application of 5 t $ha^{-1}$of poultry manure was significantly higher than the application of 2.5 t ha^{-1} which was significantly higher than control at both locations (Table 2). There was a highly significant interaction between the variety and poultry manure on the canopy height of green bean at BUK (Table 2). In both varieties, canopy height increased as poultry manure rates increased from 0 to 5 t ha^{-1} (Table 4). Haricot Contender treated with 5 t ha-1 of poultry manure significantly produced taller plants than Bean Cora under the same treatment. Statistically, similar canopy heights were recorded from both varieties treated with 2.5 t ha^{-1} of poultry manure which were significantly higher than the control treatment of both varieties.
2) *Number of branches per plant:* There were no significant differences ($p < 0.05$) between the green bean varieties in terms of the number of branches per plant at both BUK and FCE Katsina (Table 2).

Table 1: Physical and chemical properties of soils of the study sites and chemical composition of poultry manure used in the experiment.

Properties			Poultry manure	
Physical (%)	BUK	FCE Katsina	Chemical composition	Analytical value
Sand	74.50	78.80	Total nitrogen	4.27 %
Silt	14.60	11.70	Total phosphorus	949.21 mg kg^{-1}
Clay	10.90	9.50	Potassium	6919.37 mg kg^{-1}
Textural class	Sandy loam	Sandy loam	Organic carbon	6.37 %
Chemical composition				
pH in water	6.77	6.93		
pH ($CaCl_2$)	6.20	6.54		
Organic carbon (g kg^{-1})	1.35	1.10		
Total nitrogen (g kg^{-1})	0.42	0.34		
Available phosphorus (mg kg^{-1})	9.89	10.17		
Exchangeable bases (cmol kg^{-1})				
Ca++	2.17	2.28		
Mg++	1.18	1.36		
K+	0.32	0.19		
Na+	0.11	0.12		
CEC ($cmol^{+}$ kg^{-1})	4.68	4.95		

Poultry manure application at different rates significantly influenced the number of branches per plant of green bean at both locations (Table 2). Amendment using 5 t ha^{-1} of poultry manure resulted significantly in more number of branches per plant when compared with the use of 2.5 t $ha^{-1}$of poultry manure which was significantly higher than control treatment at BUK. This trend was similar to FCE Katsina.

3) *Number of Leaves Per Plant:* There were significant differences ($p < 0.05$) between the varieties of green bean for the number of leaves per plant at BUK with Haricot Contender significantly produced more number of leaves per plant than Bean Cora (Table 2). No significant variation was observed between the green bean varieties at FCE Katsina at the same sampling period. Poultry manure application at different rates significantly influenced the number of leaves per plant of green bean at both locations (Table 2). Application of 5 t ha^{-1}of poultry manure resulted significantly in more number of leaves per plant when compared with the use of 2.5 t ha^{-1}of poultry manure which was significantly higher than control treatment at BUK. This trend was similar to FCE Katsina.
4) *Shoot Dry Matter:* There were significant differences ($p < 0.05$) between the varieties of green bean concerning the shoot dry weight of green bean at both locations with Haricot Contender significantly higher than Bean Cora (Table 2). Poultry manure application at different rates significantly influenced the dry shoot weight of green bean at both locations. At BUK, poultry manure applications 5 and 2.5 t ha-1 were statistically similar but significantly higher than control. While at FCE Katsina, application of 5 t ha^{-1}of poultry manure resulted significantly in a higher shoot dry weight of green bean than the use of 2.5 t ha^{-1}of poultry manure which was better significantly than the control treatment.
5) *Leaf Area Per Plant (cm^2):* There were significant differences ($p < 0.05$) between the varieties of green bean in terms of leaf area per plant of green bean at both locations, with Haricot Contender significantly higher than Bean Cora (Table 2). Poultry manure application at different rates significantly influenced leaf area per plant of green bean at both locations (Table 2). Application of 5 t ha^{-1}of poultry manure resulted significantly in higher leaf area per plant than the use of 2.5 t ha^{-1}of poultry manure which was significantly higher than control treatment at BUK. This trend was similar to FCE Katsina.

Table 2: Effect of Green Bean Varieties and Poultry Manure on Canopy height, branches number per plant, leaves number per plant, plant dry matter and leaf area per plant of Green bean at 6 WAS at BUK and FCE Katsina in 2018 rainy season.

	BUK					FCE Katsina				
Treatments	Canopy height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Shoot dry matter (g)	Leaf area plant^{-1} (cm^2)	Canopy height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Shoot dry matter (g)	Leaf area plant^{-1} (cm^2)
Varieties (V)										
Bean Cora	16.93b	7.42	24.23b	7.32b	1300.70b	17.18	7.31	23.91	7.07b	1277.65b
Haricot Contender	17.38a	7.52	24.81a	7.66a	1372.76a	17.10	7.36	24.02	7.52a	1326.59a
SE±	0.146	0.102	0.285	0.154	22.700	0.211	0.074	0.205	0.163	20.700
Poultry manure (PM)										
0 t ha^{-1}	15.27c	6.64c	21.91c	6.59b	1113.47c	15.42c	6.56c	21.58c	6.39c	1091.21c
2.5 t ha^{-1}	17.19b	7.46b	24.51b	7.22a	1342.79b	17.04b	7.45b	24.16b	7.50b	1336.31b
5 t ha^{-1}	19.01a	8.33a	27.13a	8.06a	1553.75a	18.95a	8.00a	26.17a	7.99a	1478.84a
SE±	0.178	0.125	0.350	0.188	27.880	0.259	0.090	0.251	0.199	25.300
Interaction										
V x PM	0.0004	0.105	0.222	0.071	0.686	0.669	0.292	0.100	0.570	0.977

Means of the same letter(s) in a column are not significantly different at $p < 0.05$ using Student Newman Keuls (SNK). BUK = Bayero University Kano. FCE = Federal College of Education Katsina.

6) *Pods Number Per Plant:* There were significant differences ($p < 0.05$) between the varieties of green bean with respect to the number of pods per plant at both locations, with Bean Cora significantly higher than Haricot Contender (Table 4). Poultry manure application at different rates showed significant differences in the number of pods per plant of green bean at both locations (Table 4). Application of 5 t ha^{-1} and 2.5 t ha^{-1} of poultry manure were statistically similar but significantly higher than control at BUK. Application of 5 t ha^{-1}of poultry manure resulted significantly in more pods per plant of green bean than the use of 2.5 t ha^{-1} of poultry manure, which was significantly higher than control treatment at FCE Katsina. There was a between variety and poultry manure application on the number of pods per plant at BUK (Table 4). In Table 5, pods number per plant in both varieties differed significantly at each rate of poultry under 0 to 2.5 t ha^{-1}. Bean Cora treated with 2.5 t ha^{-1} of poultry manure significantly recorded more pods per plant, which was statistically similar with the same variety under 5 t ha^{-1} of poultry manure but significantly higher than Haricot Contender under 5 t ha^{-1} of poultry manure and control in both varieties.

7) *Pod Weight Per Plant (g):* There were significant differences ($p < 0.05$) between the varieties of green bean concerning pod weight per plant of green bean at both locations, with Bean Cora, recorded significantly higher pod weight per plant than Haricot Contender (Table 4). Poultry manure application at different rates showed significant differences in pod weight per plant of green bean at both locations (Table 4). Application of 5 t ha-1of poultry manure resulted significantly in higher pod weight per plant of green bean than the use of 2.5 t ha-1of poultry manure which was significantly higher than control treatment at BUK. This trend was similar at FCE Katsina.
8) *Green Pod Yield (Kg ha^{-1}):* There were significant differences ($p < 0.05$) between the varieties of green bean in terms of green pod yield, with Bean Cora, recorded significantly higher green pod yield than Haricot Contender at both locations (Table 4). Poultry manure application at different rates significantly influenced the green bean yield at both locations (Table 4). Amendment with 5 t ha^{-1} of poultry manure resulted significantly in higher green pod yield of green bean compared with the use of 2.5 t ha^{-1} of poultry manure which was significantly higher than control treatment at BUK and FCE Katsina, respectively.

Table 3: Effect of Green bean varieties and poultry manure on the number of pods per plant, pod weight per plant and green pod yield of green bean at harvest at BUK and FCE Katsina in the 2018 rainy season.

	BUK			FCE Katsina		
Treatments	No. of pods plant-1	Pod weight plant-1 (g)	Green pod yield (Kg ha-1)	No. of pods plant-1	Pod weight plant-1 (g)	Green pod yield (Kg ha-1)
Variety (V)						
Bean Cora	17.36a	70.91a	3781.49a	18.02a	69.50a	3706.86a
Haricot Contender	15.41b	61.29b	3285.80b	15.72b	61.54b	3267.36b
SE±	0.191	0.727	42.200	0.131	0.583	30.200
Poultry manure (PM)						
0 t ha-1	15.42b	59.24c	3187.07c	15.31c	58.23c	3105.78c
2.5 t ha-1	16.69a	66.32b	3534.80b	16.87b	66.30b	3513.78b
5 t ha-1	17.06a	72.74a	3879.07a	18.43a	72.03a	3841.78a
SE±	0.234	0.891	51.700	0.160	0.714	37.000
Interaction						
V x PM	0.0004	0.087	0.211	0.087	0.143	0.419

Means of the same letter(s) in a column are not significantly different at $p < 0.05$ using Student Newman Keuls (SNK). BUK = Bayero University Kano. FCE = Federal College of Education Katsina.

Table 4: Effect of interaction of variety with poultry manure rates on canopy height (cm) and number of pods per plant of green bean at BUK.

Treatments	Canopy height (cm)	Number of pods per plant
$V_1$0	15.15d	16.56c
$V_1$2.5	17.26c	18.04a
$V_1$5	18.39b	17.47ab
$V_2$0	15.39d	14.29e
$V_2$2.5	17.14c	15.33d
$V_2$5	19.62a	16.62bc
SE±	0.253	0.331

Means of the same letter(s) differ significantly at $p < 0.05$ using Student Newman Keuls (SNK).
V1 = Bean Cora, V2 = Haricot Contender. BUK = Bayero University, Kano.

IV. DISCUSSION

The significant differences obtained in this study in most of the growth characters of green bean varieties were probably attributed to the genetic makeup of the varieties and their response to the growing environment, as earlier reported by Abdel-Mawgoud et al. (2005). These are related to the assertion made by Das *et al*. (2018), who said that the genetic composition of a variety greatly determines its growth and yield characteristics. These findings confirm with the report of Sharma et al. (2013), who reported that difference in the ecological response of green bean varieties leads to differences in growth and yield. The yield and yield characters of green bean varieties exhibited significant variations in this study. This can be attributed to the genetic composition of varieties, as supported by Das *et al*. (2018). Moniruzzaman et al. (2009) reported similar results, who also found a significant influence of cultivar on growth and yield attributes in French bean.

There was a positive response of green bean to poultry manure application in this study. The significant effect on growth characters of green bean recorded by the application of poultry manure could be due to improvement in soil conditions and slow release of nutrients throughout the growing period and making it available at all the critical periods (Amanullah *et al.*, 2007). The study's findings are in harmony with the report made by Feleafel and Mirdad (2014). They reported that the application of 200 kg ha-1 of chicken manure as an alternative source of mineral fertilizer significantly increased the growth and yield of green bean. These findings are also in conformity with the assertion of Hussein *et al*. (2016), who reported that the application of 20 t ha-1 of chicken manure increased growth, yield and yield attributes of green bean. The significant increase in yield and yield characters of green bean recorded in the present study with poultry manure might be due to reduced soil pH, which made nutrients such as N and P more available to the plants, as asserted by Hussein et al. (2016). This finding conforms with the assertion of Datt et al. (2013), who reported a significant yield increase of French bean with the application of farmyard manure at 10 t ha^{-1}.

V. CONCLUSION

Based on the result obtained from this Study, Bean Cora resulted significantly in a higher yield than Haricot Contender; this is probably due to the adaptability of the variety to the growing environment and its genetic superiority. The study also indicates that the application of poultry manure improved the growth and green pod yield of green bean.

VI. RECOMMENDATION

Further research should be conducted using poultry manure to ascertain the optimum rate for higher green bean production in the Sudan Savanna of Nigeria.

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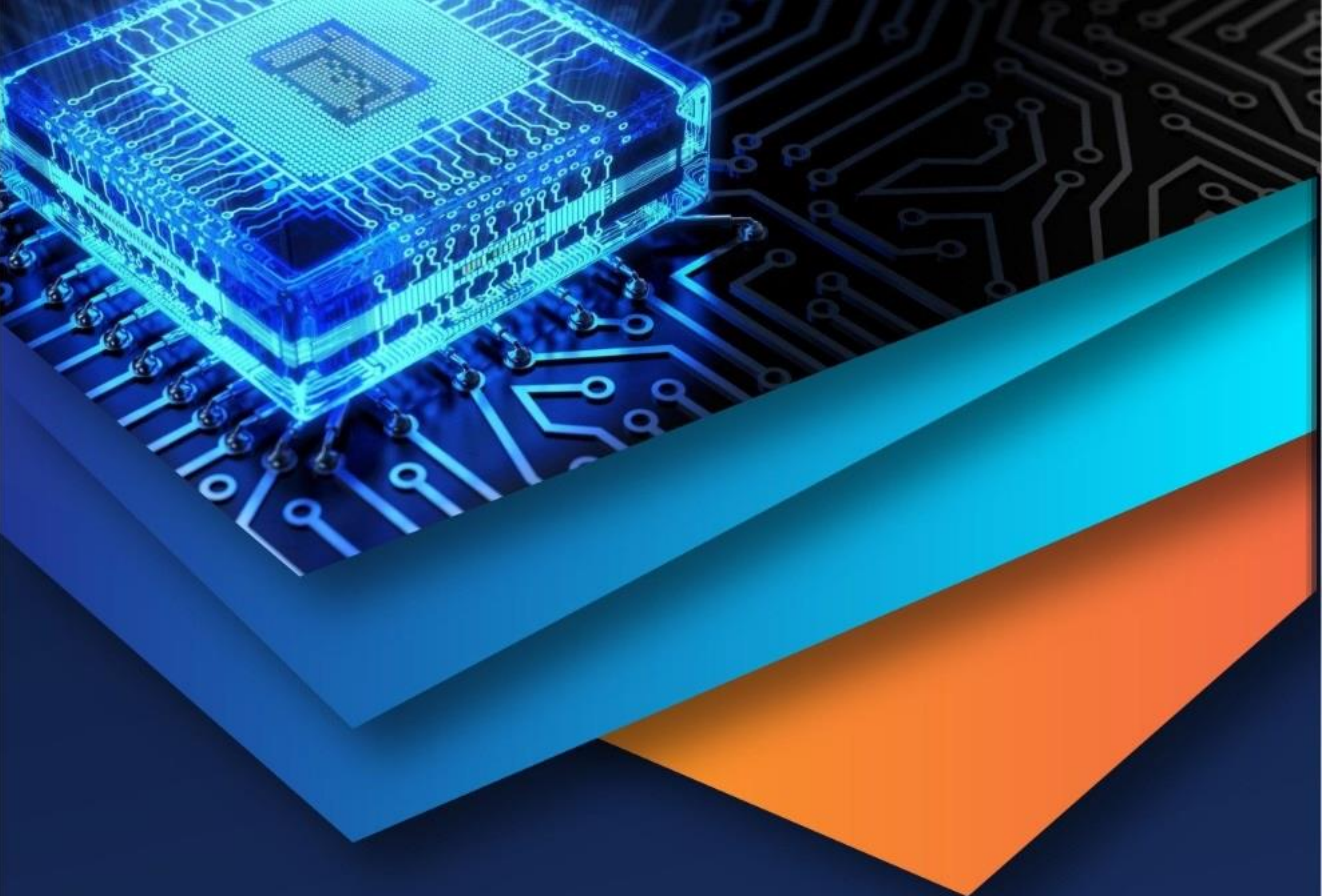

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IMPACT FACTOR: 7.429