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Use of Cassia (Cassia obtusifolia) Green Manure and Nitrogen Rates for Striga (Striga hermonthica Del Benth) Management in Sorghum (Sorghum bicolor (L) Moench) in Sudan Savanna, Nigeria

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Abstract: A field experiment was conducted during the wet seasons of 2013 and 2014 at the College experimental Farm of Hassan Usman Katsina Polytechnic, Katsina (12 56 "N, 7 36" E; 465m above sea level) in the Sudan savanna of Nigeria to evaluate the effects of integrating nitrogen fertilizer and organic manures on sorghum varieties grown on Striga- infested field. The treatments consisted of two varieties of sorghum (SAMSORG-40 AND SAMSORG-41), three levels of nitrogen (0, 40 and 80 kg N ha^{-1}) and four levels of organic manure (Cassia obtusifolia green manure at 0, 7.5 and 15t ha^{-1}). The experiment was laid in a split-plot design and replicated three times; with nitrogen assigned to the main plot while factorial combinations of crop variety and organic manure were assigned to the sub-plots. The experimental sites were inoculated to boost Striga level. The number of days to Striga shoot emergence was not significantly influenced by green manure at all the sampling periods. In 2014, Application of 40 and 80 kg N ha^{-1} resulted in similar but shorter periods of Striga shoot emergence than the untreated control. Green manure at 15 t ha^{-1} supported lower number of Striga shoots than green manure at 7.5 t ha^{-1}. The untreated control was at par with each of the other treatments. In 2013, the use of 80 Kg N ha^{-1} reduced the number of Striga shoots over the untreated control only. Green manure did not influence the number of Striga infested sorghum stands. However, application of 80 Kg N ha^{-1} in 2013 and 40 and 80 kg N ha^{-1} in 2014 and the mean data suppressed the number of infested Sorghum stand compared to the untreated control. The values by 40 and 80 Kg N ha^{-1} were similar in 2014 and the means. At 9 WAS crop striga reaction score was significantly recorded by the use of 7.5t ha^{-1}green manure which is statistically comparable with 15 t ha^{-1}and with the least from the untreated control. The highest value of grain yield of sorghum was recorded by 15t ha^{-1} green manure under Striga pressure and infestations compared to all other treatments. The use of 80 kg N ha^{-1} gave the highest values of sorghum yield with reduced Striga infestation to sorghum.

Keywords: Cow dung, green manure, nitrogen, sorghum, Striga.

I. INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is commonly referred to as guinea corn in West Africa, is the fifth most important cereal crop in the world being surpassed only by rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and maize (*Zea mays* L.) (Abunyewa, 2008) and the world production is between 55 and 70 million of grain per annum from between 40 and 45 million hectares.

The world average yield is 1412 kg ha^{-1}(Samuel *et al.,* 2013). In 2010, the USA was the world largest producer of the crop (8.8) metric tonnes annually, followed by India (7.0), Mexico (6.9), Nigeria (4.8) and Argentina (3.6) (CGIAR, 2013). It is unique to adapt to environmental extremes of abiotic and biotic stresses and essential crop to diets to poor people in the semi-arid tropics where drought causes frequent failure of other crops (Godharle *et al*., 2010). Nigeria is the second largest producer of sorghum in the world, with an annual production in excess of 8 million metric tonnes.

In the semi-arid tropics sorghum is used in various ways. It is a principal source of nutrition for millions of people and provides a major source of energy to human diets in Africa and much of Asia. Sorghum is primarily used for human consumption and as a staple food in the diet of many people in countries of the world especially sub – Saharan Africa. "tuwo" (Anon., 2015). The grain and vegetative parts of the crops are used as animal feed. Sorghum serves as a major raw material in the brewing industry. Some varieties of sorghum can be malted to produce nutritious food stuff for infants and use as bakery products.

A. Justification of the Study

The adverse effects of *Striga* damage on sorghum have been attributed to many factors, reduction in yield. The extent of yield losses is related to the incidence and severity of attack, the host's the susceptivility to *Striga,* environmental factors (edaphic & climatic) and the management level at which the crop is produced (Esilaba, 2006). Its effect on crop ranges from extraction of nutrients, moisture, diversion of hosts photosynthate, mineral salt and water from the host plant to the parasite, resulting in stunted growth, through wilting, yellowing and scorching of leaves to the lowered yields and death of many affected plants. It was reported that, annual sorghum losses attributed to *Striga* in SSA are estimated at 22-27% and specifically at 25% in Ethiopia, 35% in Nigeria (Anon, 2011). In terms of monetary value, the annual cereal losses due to *Striga* are estimated at US$ 7 billion in SSA. In Ethiopia, Mali and Nigeria, the annual losses are estimated at US$ 75 million, US$ 87 million and US$ 12 billion respectively (Anon., 2011). Parasitic weed species of the genus *Striga* establish preferentially on poor soils and fields which have been exhausted by continuous cropping (Vogt *et al.*,1991). Most *Striga* infested areas are characterized by agricultural production systems that witness low crop productivity. The use of inorganic nitrogen and organic fertilizer has been reported to reduce *Striga* infestation and are as effective as fallowing in maintaining soil productivity (Mumera and Bello, 1993; Pieterse, 1996) (Ogborn, 1984). This approach combines the short term benefits of inorganic fertilizer with the long term value of organic fertilizer (Mumera *et al.*,1993). Smaling *et al.* (1992) demonstrated the need for integrated nutrient management, especially in areas of low soil fertility where farmers cannot afford to rely on mineral fertilizer alone. Such integrated soil fertility management systems can reduce the inorganic fertilizer requirement, and at the same time increase the efficiency of the added input (Lee *et al.,* 2007).

B. Objectives of The Study

To determine the effect of varying rate of Green manure for the control of *Striga hermonthica* on Sorghum.
To determine the effect of varying levels of Nitrogen for the control of *Striga hermonthica* on Sorghum.

II. MATERIAL AND METHODS

A. Experimental Sites

Two field trials were conducted during each of the wet seasons of 2013 and 2014 to investigate the effects of nitrogen and organic manure, consisting of *Cassia obtusifolia* L. green manure and cow dung on two varieties of sorghum grown on a *Striga*-infested field at the Experimental farm of Hassan Usman Katsina Polytechnic, Katsina (Lat. 12 56 "N, 7 36" E; 465m above sea level) in the Sahel Savanna zone of Nigeria.
Details of meteorological data in the two locations and seasons were recorded and are presented in Appendices 1-4. Prior to land preparation in each season, soil samples were collected randomly from each experimental site at 0-30cm depth using a soil auger. The soil samples were bulked, air dried, ground and sieved using a 2mm wire mesh before being subjected to laboratory analysis for physical and chemical properties using standard procedures as described by Black (1965). The results of analysis are presented in Table 1. The chemical properties of *Cassia obtusifolia* green manure from Katsina in 2013 and 2014 were analysed and determined by the standard procedure and are presented in Table 2. Similarly, the chemical properties of cow dung used was also determined by standard procedure and are presented in Table 3.
The Experiment consisted of two sorghum varieties (SAMSORG-40 and SAMSORG-41), four levels of organic manure (*Cassia* green manure at 0, 7.5 and 15t ha^{-1} and cow dung at 10t ha^{-1}) and three nitrogen levels (0, 40 and 80kgNha^{-1}). The experiment was laid out in a split plot design, with nitrogen levels assigned to main plots and factorial combinations of organic manure levels and variety assigned to the sub-plots. The treatments were replicated thrice. The gross plot size consisted of six ridges,75cm apart, each 3m long giving an area of 13.5 m^2, while the net plot consisted of the two inner ridges, giving an area of 4.5 m^2.

B. Description of Cassia obtusifolia L. (or Cassia tora)

Cassia obtusifolia (L.) Irwin and Barkeby belongs to the family Leguminoseae, *Ceasalpinioidae*. It is an erect, branched and bushy annual or perennial dicotyledonous plant, up to 90cm high, that reproduces by seed. The stem is branched, cylindrical, hairless or sparingly hairy. The leaves are alternate, pinnate, 2.5- 7.5cm long. The flower is yellow, 2-3 cm across and borne on pedicel in the leaf axils. The fruit is cylindrical, 10 - 20cm long and 5-6mm wide, curved and beaked. The seed is about 5mm long and 2mm wide, somewhat rhomboid, brown and Smooth. It is a pan-tropic weed of road sides, grass lands and cultivated fields, common near settlements and widespread in West Africa.

C. Variety Description

SAMSORG- 40 (ICSVIII). It is non lodging, drought tolerant, and non senescent variety with good response to fertilization. Grains have a good food and malting qualities. Morphologically, it is semi-dwarf and semi-compact and seed colour is cream. It is adapted to Sudan and Sahel Savanna Zones. It is a early maturing variety (75 - 80 days). The potential yield of the variety is 1500 – 2000 kg ha^{-1} and it can grow up to 300 – 350cm. The leaves are brown at maturity. It is tolerant to most leaf diseases and *Striga* (Anon, 2015).

SAMSORG-41 (ICSV400). It is an improved variety, adaptable to both Guinea and Sudan Savanna ecological zones. It is characterized by brown colour hard grains, which make good local food quality. It is high yielding, draught and *Striga* tolerant. It matures within 90-110 days. It was developed by International Crops Research Institute for Semi Arid Tropics (ICRISAT). Its yield potential is 1000-2800 kg ha^{1} (Anon, 2015)

D. Land Preparation And Manure Incorporation

In each trial and season, the land was harrowed to a fine tilth and ridged, 75 cm apart. The site was marked into plots and replications. Alley path ways of one meter across and one ridge along the ridges were allowed as borders between the plots, while replications were separated by two ridges along and 1m across the ridges. *Cassia obtusifolia* plants were harvested at five weeks after emergence from nearby fields in both locations. The green manure and crushed cow dung were uniformly applied and incorporated into the soil, two weeks before sorghum seed sowing according to treatments. The incorporation was done by opening the center of each ridge to about 15cm depth, and applying cow dung or burying *cassia* plants according to treatments, after which, each was covered with soil.

E. Striga Seeds Inoculation

Each experimental site was inoculated with *Striga* seeds, a day to sowing. This was done by using 25g of *Striga* seeds per 1kg of fine sand to inoculate each field. The inoculants were uniformly applied by broadcasting immediately after ridging and prior to manure application. The inoculation was done to boost the *Striga* level of the infested fields.

F. Planting

Apron plus was used to dress the seed of each crop variety at the rate of 10g per sachet 3.0kg of seeds. Dressed seeds of Sorghum was planted on June 20th and 15th in 2013 and 2014, respectively at Katsina using 4 - 5 seeds per hill at a spacing of 30cm on 75cm ridges. Sorghum seedlings were thinned to two plants per stand at 3 weeks after sowing (WAS).

G. Nitrogen Fertilizer Application

Nitrogen in the form of Urea (46%N) was applied in two split doses as per treatment (0, 40 and 80kgNha^{-1}) at 3 and 6 W A S by side dressing.

H. Weed Control

Paraquat as a Gramazon 27 was applied on the experimental field prior to land preparation to control emerged weeds. This was followed by hoe weeding at 3 and 6 WAS. Subsequent weed control was done by hand pulling as the need arose, and *Striga* plants destruction was avoided.

I. Harvesting

Sorghum was harvested when the panicles had attained physiological maturity. This was when there was development of black layer at the placental region of the grain, which marked physiological maturity in sorghum (Eastin *et al*., 1973).

J. Observations and Data Collection

Data was collected on the following growth and yield components of sorghum at various sampling periods. Plant height, number of leaves, leaf area index, shoot dry weight, *Striga* infestation, 100 seed- weight and grain yield.

K. Data Analysis

The data collected were subjected to analysis of variance to test the significance of differences between treatment means using the F-test as described by Snedecor and Cochran (1967). The treatment means were compared using the Duncan Multiple Range Test (Duncan, 1955).

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III. RESULTS AND DISCUSSIONS

Table 1. The physical and chemical properties of soil of the experimental site before planting shows that the textural class of the soil was sandy loam, with pH level slightly acidic. The organic carbon, N, available P was very low in contrast with CEC which was relatively higher.

Table 2 : The chemical composition of *Cassia obtusifolia* green manure used for this research revealed that available K had the lowest value in percentage in both years than the total N and available in both years. Total nitrogen in 2014 appreciated significantly (1.78) when compared to the percent value recorded in 2013.

In 2013, *Striga* shoots were rarely recorded when higher doses of organic manures were used. The high manure level enhanced vigorous crop growth and leaf spread (LAI) (Table 3), which smothered emerged *Striga* shoots, leading to dieback. The non significant effect of the varying rates of organic manure on *Striga* shoot count in 2014 might be attributed to early *Striga* emergence before the mineralization of organic materials and hence, this could lead to the insufficient amount of nitrogen to suppress the parasitic weed.

Sorghum crop and with organic manure application, *Striga* shoots were scarcely recorded when higher dose of the manure was used. This might probably be caused by crop growth and reduction of *Striga* shoots. Application of varying rates of green manure did not show significant influence on *Striga* incidence on sorghum stands at harvest in both locations. This might be due to the inadequate amount of available N to suppress the weed. At this stage, green manure had not completely decomposed, to release N that could reduce *Striga* infestation to crop plants even with higher green manure levels. The high *Striga* count recorded on the untreated control could be due to the low amount of nitrogen that increased crop susceptivility to *Striga* attack. At higher levels of green manure crop growth increased and this facilitated its tolerance to *Striga*, under which some *Striga* plants did not survive.

Sorghum grain yield increased with increase in green manure rates. This is because nutrients in the manure were possibly released toward the post-anthesis stage. Nutrients such as N and P are important for grain formation and yield development. The application of manure provides other essential nutrients that are limiting in mineral fertilizers, and this could increase grain yield of sorghum even under *Striga* pressure as observed by Parker and Riches (1993). The finding showed that *Cassia* green manure significantly increased growth and yield of sorghum, probably due to improved soil physical and chemical properties. Organic matter is known to improve porosity and moisture holding capacity, of soil and enhances root growth, water and nutrient uptake capability. Apart from the fact that nutrients released from the green manure has direct effect on growth and yield. The importance of N in organic matter in improving sorghum performance has been highlighted by Arunah *et al.* (2006), who found that poultry manure was superior to the applied N in promoting yield of sorghum. With varying rates of organic manures the panicle length recorded in 2013 and 2014, was proportional to the rate. Enhancement in crop growth obviously improved assimilate production and translocation to the sink, including the reproduction portion which is explained by heavier panicles.

With nitrogen at varying rates, *Striga* shoots were rarely recorded when higher doses of nitrogen were used and this probably caused stunted growth of *Striga* shoots, which eventually died. Esilaba *et al.* (2000) reported that the greatest reduction in the mean *Striga* density across all the treatments was obtained with 120 kg N ha^{-1} and 20 t ha^{-1} organic manure in maize. The least *Striga* shoot count was under higher rate of 80 kg N ha^{-1}. Indeed there was a general decline in infestation with increasing N rates. These results are in agreement with the reports by Mumera and Bello (1993) who found that *Striga* infestation declined with increasing N availability and the impact depended on the severity of infestation. However, high *Striga* infestation was recorded from the untreated control compared to plots that were treated with N. Nitrogen at the rate of 40-80 kg N ha^{-1} markedly reduced *Striga* infestation. Similar report was made by Lagoke *et al.* (1994) that application of certain levels of nitrogenous fertilizer reduced the severity of *Striga* attack and increased yield of the affected host crop. The positive influence on crop reaction score recorded from nitrogen treatment at 3 WAS in 2013 at Samaru showed that, the lowest crop reaction score was witnessed when 80 kg N ha^{-1} was used, indicating that sufficient amount of N can lower sorghum crop reaction to *Striga* with consequent increase in yield. This is because nutrients were available and released toward the post-anthesis stage, and made available for the development of the site of photosynthesis, there by aiding yield development of the crop. Another reason might be due to enhanced P uptake since the native P level was good as shown at pre and post harvest soil physical-chemical analysis respectively. These results affirm that, application of nitrogenous fertilizers, provided that other essential nutrients are not limiting, can increase grain yield of sorghum even under high *Striga* infestation as reported by Parker and Riches (1993).

The least grain yield was obtained from the untreated plots. This describes the role of nitrogen as the single most important nutrient for cereal crop production. Padwick (1983) has observed that many tropical soils showed nutrient deficiency problems and decrease in crop yield after only a short period of cultivation. Another reason for the low yield recorded despite the heavy rainfall experienced during the vegetative growth, might be as a result of the erratic supply of rains towards the grain filling stage.

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IV. CONCLUSION

Striga count and infestation to sorghum was not significant with the used of green manure when compared to the untreated control. This shows the effect of organic N in reducing the impact of *Striga* density and infestation. Application of *Cassia* green manure at 15 t ha^{-1} resulted in higher growth components such as plant height, number of leaves and LAI when compared to both application of 0, 7.5-10 t ha^{-1} of green manure and cow dung. This contributed significantly to not only crop yield, but helped in replenishing the lost nutrients to the soil of the experimental lands. Influence of green manure at 15 t ha^{-1} on the final grain yield of sorghum was superior to all other treatments and sampling periods and locations. Application of 10t ha^{-1} cow dung was at par with 0- 7.5 t ha^{-1} green manure with respect to yield.

With nitrogen application at 80 kg N ha^{-1}, *Striga* count, number of *Striga* infested plants and *Striga* crop reaction score were found to be significantly lower when compared to the untreated control. Yield attributes and yield were significantly greater with the application of 80 kg N ha^{-1} than 40 kg N ha^{-1} in both years of study.

Table 1: Physical and chemical characteristic of soil (0-30cm) taken from the experimental site during 2013 and 2014 wet seasons at Katsina

Soil properties	2013	2014
Physical properties		
Sand (%)	80.0	76.0
Silt (%)	6.00	8.5
Clay (%)	14.0	16.4
Textural class	Sandy loam	Sandy loam
Chemical properties		
pH in water (1:2.5).	6.35	6.45
pH in 0.01m $CaCl_2$ (1:2.5.).	5.82	5.08
Organic carbon (g/kg).	0.70	0.41
Total Nitrogen (g/kg).	0.24	0.50
Available P mg/kg	3.08	4.30
Exchangeable cation (Cmol/kg)		
K	0.12	1.23
Mg	0.91	1.52
Ca	2.00	4.03
Na	0.41	0.21
CEC (meq/100g)	6.40	5.27

Table 2: N, P and K contents of Cassia green manure used in the experiments at Katsina in 2013 and 2014 wet seasons.

Nutrients (%)	Katsina	
	2013	2014
Total N	1.57	1.78
Available P	1.45	1.50
Available K	0.52	0.61

Table 3: Effect of green manure and nitrogen on *Striga* parameters and sorghum grain yield during 2013 wet season at Katsina

Treatment	Number of days to Striga emergence	*Striga* shoot count @ harvest	*Striga* infestation	Crop *striga* reaction score @ 9 WAS	Grain yield ($kgha^{-1}$).
Green manure ($t\ ha^{-1}$)					
0	102	0.94ab	0.83	3.6ab	1289d
7.5	102	1.22a	0.52	4.7a	1526c
15	101	0.44b	0.39	1.6b	1888b
SE±	0.2	0.221	0.223	0.55	17.2
Nitrogen (kg Nha^{-1}).					
0	105	1.25a	0.88a	3.9	1554c
40	101	0.67ab	0.42ab	5.5	1644b
80	103	0.29b	0.21c	5.1	1785a
SE±	0.2	0.220	0.154	0.88	5.6

Means followed by the same letter (s) within a column of each treatment group are not significantly different at 5% level of probability using the DMRT.

Table 4: Effect of green manure and nitrogen on *Striga* parameters and sorghum grain yield during 2014 wet season at Katsina

Treatment	Number of days to Striga emergence	*Striga* shoot count @ harvest	*Striga* infestation	Crop *striga* reaction score @ 9 WAS	Grain yield ($kgha^{-1}$).
Green manure ($t\ ha^{-1}$)					
0	93	1.50	0.94	4.1	1429d
7.5	92	1.17	0.72	4.3	1683c
15	93	1.11	0.67	4.0	2056a
SE±	0.2	0.402	0.223	0.55	3.5
Nitrogen (kg Nha^{-1}).					
0	94	1.71a	1.89a	4.0	1650c
40	92	0.71b	0.33b	4.1	1745b
80	92	0.80b	0.17c	4.0	1861a
SE±	0.2	0.131	0.151	0.23	6.0

Means followed by the same letter (s) within a column of each treatment group are not significantly different at 5% level of probability using the DMRT.

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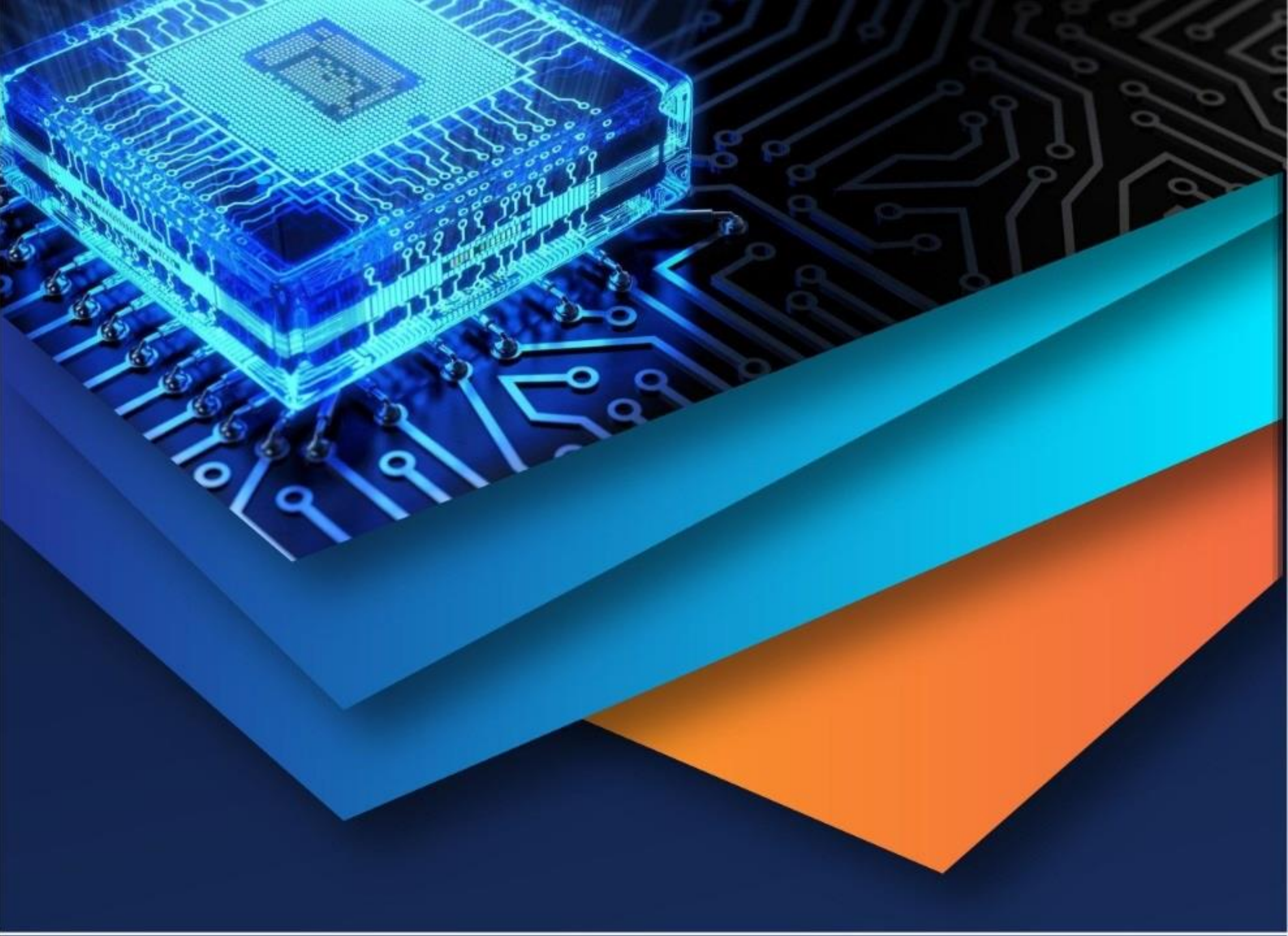

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