IMPACT OF CERTAIN PLANT LEAF EXTRACTS ON THE GROWTH AND YIELD OF *Amaranthus hybridus* (L.)

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Abstract
The effects of leaf extracts from Moringa oleifera, Chromolaena odorata, Gliricidia sepium, Panicum maximum, and Tithonia diversifolia on the growth and yield of Amaranthus hybridus were assessed in a pot study at the screen house at the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria, using a completely randomized design. ANOVA was used to statistically examine data on plant height, stem girth, leaf area, number of leaves, and yield components. Results from the experiment indicate that: Amaranthus hybridus and Chromolaena odorata performed noticeably better than all other plant leaf extracts, resulting in increased plant height (30.26 cm), stem girth (0.68 cm), and leaf count (31.20). Moringa oleifera treated plants, exhibited larger leaf area (7.52 cm²), while the effects of Tithonia diversifolia and Gliricidia sepium were generally moderate, and Panicum maximum exhibited the lowest growth response, compared to the control which recorded the least performance. Chromolaena odorata applied singly also produced the highest whole yield (106.00 g) and edible yield (83.40 g), followed by Moringa oleifera. The study concludes that Chromolaena odorata and Moringa oleifera are effective bio-stimulants that enhance Amaranthus hybridus productivity, and can so be recommended for use.

Keywords: *Moringa oleifera*, *Chromolaena odorata*, *Amaranthus hybridus*, plant leaf extract, growth, and yield

Introduction

Amaranthus hybridus L., commonly called African spinach in English (Eseyin *et al*., 2015) and Tete opopo in Yoruba (Omoregie and Osagie, 2012), is an annual herbaceous plant species in the Amaranthaceae family, widely distributed across tropical and subtropical regions, and known for its fast growth. It is both a vegetable and a forage crop. The plant is particularly valued for its rich nutritional content, including vitamins, minerals, and antioxidants, contributing to its significance in human health and agriculture (Mendes *et al*., 2023).

In most African countries, the leaves of this plant are widely consumed as a green vegetable (Diéméléous *et al*., 2013). It is traditionally cooked as soup and

medicinally used as a blood booster (Ekpo, 2007). Antioxidant activity has been reported for this plant. The antioxidant activity of the methanol leaves extract of *A. hybridus* reported by Eseyin *et al.* (2015) was attributed to the presence of some phyto-nutrients like tannin, flavonoids, vitamin C. tocopherol and anthocyanin (Ouedraogo *et al.*, 2014). Ouedraogo *et al.* (2014) also reported a good DPPH radical scavenging activity, nitric oxide radical scavenging activity and Fe chelating ability, for *A. hybridus* among some plant species tested. Poor ferric-reducing antioxidant power was however reported for the methanol leaf extract of *A. hybridus* among the tested plant species.

Today's world is in high demand for agro-products derived from plant systems, whereas the demand for application of agrochemicals has become low or zero (Chiquito-Contreras *et al.* 2017). This had led to the alternative practice of using organic materials in place of inorganic fertilizers and pesticides.

This study therefore, investigated the effects of *Moringa oleifera, Chromolaena odorata, Gliricidia sepium, Panicum maximum, and Tithonia diversifolia* leaf extracts on the growth and yield of *Amaranthus hybridus*

Materials and Methods

Experimental Site: The experiment was conducted in the screen-house of the Department of Crop, Horticulture and Landscape Design Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Ekiti State, which lies between latitude 5° 45" and longitude 8° 15" in the tropical rain forest zone of Nigeria.

Experimental Design: Top soils (0-15cm) were collected, sieved and packed into 10 kg bags/pots, in a Completely Randomized Design (CRD) in five replicates, totaling 30.

Application of poultry manure: Poultry manure at a rate of 10 tons per hectare was thoroughly mixed with the soil in each bag. Seeds of *Amaranthus hybridus* were sown two weeks after poultry manure application, and the seedlings were thinned to five seeds per bag after germination.

Preparation and application of plant extracts: The leaves of *Moringa oleifera*, *Chromolaena odorata, Gliricidia sepium, Panicum maximum,* and *Tithonia diversifolia* were collected, separated, cleaned, and air-dried. The air-dried leaves were soaked in distilled water at a ratio of 1:1 (1kg of leaves to 1 litre of water) for two days and then blended. The blended materials were sieved to get the concentrate. The plant extracts were diluted at a 1:10 ratio and sprayed once weekly, starting from the second week after germination.

Cultural practices: The soils were kept moist through regular watering and emerging weeds were removed immediately.

Data collection: Data was collected weekly on the number of leaves, plant height, and stem girth from the third week after sowing to measure the growth and yield parameters. The entire plants were harvested six weeks after sowing. The plants were cleaned of debris and soil, and weighed for the whole yield (root, shoot, and leaves). The edible yield (shoot and leaves, mainly used for soup and salad), were also weighed.

Statistical analysis: All data collected were subjected to analysis of variance using IBM SPSS version 23 and means were separated using Duncan's Multiple Range Test (DMRT[a]) at 0.05 level of probability.

Results

Impact of certain plant extracts on the growth of *Amaranthus hybridus*

Figure 1 shows the effect of different plant extracts on the growth of *Amaranthus hybridus*. The number of leaves of *Amaranthus hybridus* for all the treatments tested increases with age with *Chromolaena odorata* leaf extract producing significantly the highest number of leaves (31.2) at the sixth WAS. All the plant leaf extracts produced a higher number of leaves than the control.

The plant height of *Amaranthus hybridus* was also influenced by the plant extracts used as treatments in this study (Figure 1B). Although *Gliricidia sepium* leaf extract produced the plant with the highest plant height (7.90 cm) at the third WAS, *Chromolaena odorata* leaf extract produced the highest plant height (30.26 cm) at the sixth WAS. This was followed by *Moringa oleifera* (29.29 cm) and control with the lowest (21.12 cm). The treatments maintained the same pattern as the plant stem girth, with *Chromolaena odorata* leaf extract having the highest stem girth of 0.68 cm at the sixth WAS, which differed significantly from those of other treatments used in the study (Figure 1C).

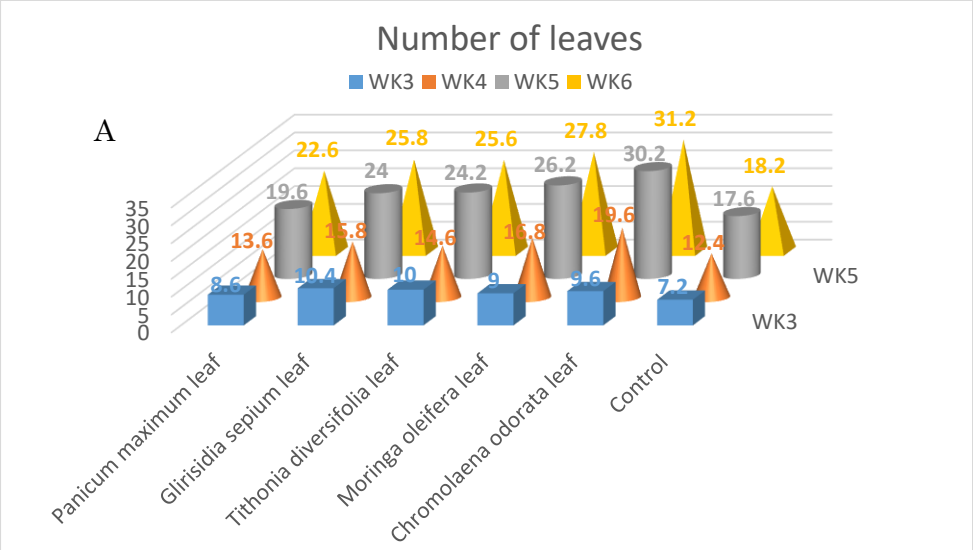
The results on leaf area (Figure 1D) indicate significant variations in leaf expansion among treatments, revealing the differential influence of the plant extracts on leaf development. Three weeks after sowing, *Moringa oleifera* leaf extract exhibited the largest leaf area (1.59 cm^2), which was significantly different from all other treatments, suggesting a strong initial growth-promoting effect. *Chromolaena odorata* leaf extract (1.54 cm^2) followed closely and was significantly higher than *Gliricidia sepium* (1.42 cm^2), indicating a similar trend in leaf expansion. This trend continues significantly until harvest at the sixth WAS with

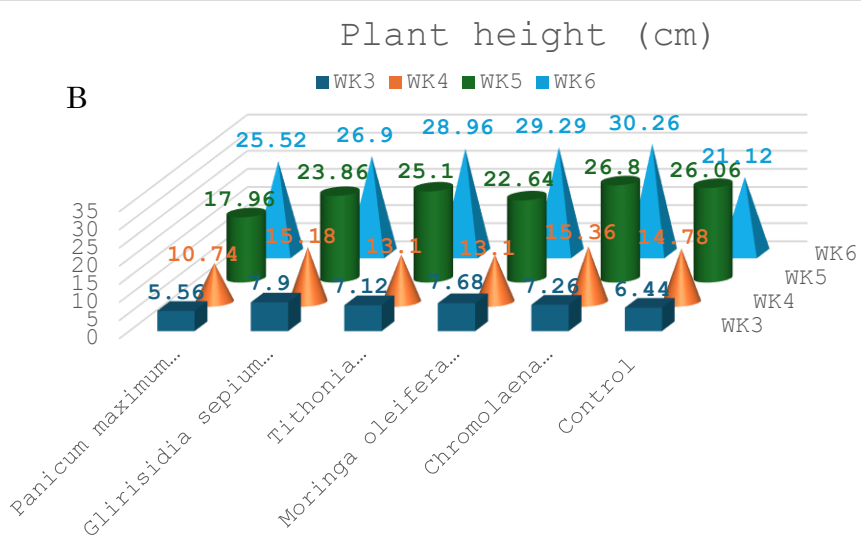
7.52 cm² leaf area by *Chromolaena odorata* leaf extract.

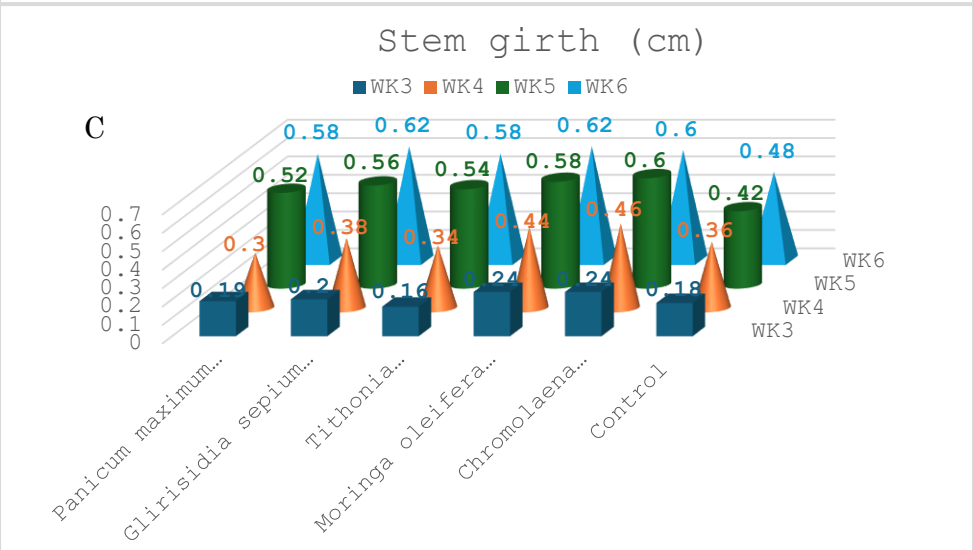
Influence of some plant extracts on the yield of *Amaranthus hybridus*

The yield of *Amaranthus hydridus* as influenced by different plant extracts, measured in terms of whole and edible yield, is shown in Table 1. For the entire yield, *Chromolaena odorata* (106.0 g) gave the highest yield value, which was significantly different from all other treatments. This report shows that *Chromolaena odorata* extract had the most pronounced effect on biomass accumulation. *Moringa oleifera* (90.6 g) was significantly higher than *Gliricidia sepium* (86.2 g) and *Tithonia diversifolia* (84.8 g), which were not significantly different from each other. *Panicum maximum* (82.8 g) was significantly higher than the control (62.6 g), which had the lowest whole yield. This result indicates that all plant extracts have improved yield relative to the control, with *Chromolaena odorata* having the most substantial impact on biomass accumulation.

For edible yield, *Chromolaena odorata* (83.4 g) has the highest mean value, maintaining its lead as observed in the whole yield, which was significantly different from all other treatments. This implies that its application led to superior leaf quality and biomass accumulation, making it suitable for consumption. *Moringa oleifera* (69.2 g) also gave a high biomass accumulation value following *Chromolaena odorata*, significantly higher than *Tithonia diversifolia* (68.0 g) and *Gliricidia sepium* (64.8 g), which were also significantly different from each other. *Panicum maximum* (58.6 g) had a significantly higher edible yield than the control (47.6 g), which had the lowest edible yield. *Chromolaena odorata* consistently produced the highest whole and edible yields, followed by *Moringa oleifera*, while the control recorded the lowest values. The significant differences observed suggested that *Chromolaena odorata* leaf extract is particularly effective in enhancing the productivity of *Amaranthus hybridus*, making it a viable natural growth enhancer for improved yield.


Number of leaves
WK3 WK4 WK5 WK6
A
35
30
25
20
15
10
5
0
8.6
13.6
19.6
22.6
10.4
15.8
24
25.8
10
14.6
24.2
25.6
9
15.8
26.2
27.8
9.6
19.6
30.2
31.2
7.2
17.4
17.6
18.2
WK5
WK3
Panicum maximum leaf
Glirisidia sepium leaf
Tithonia diversifolia leaf
Moringa oleifera leaf
Chromolaena odorata leaf
Control


Plant height (cm)
WK3 WK4 WK5 WK6
B
35
30
25
20
15
10
5
0
5.56
10.74
17.96
25.52
7.9
15.18
23.86
26.9
7.12
13.1
25.1
28.96
7.68
13.1
22.64
29.29
7.26
15.36
26.8
30.26
6.44
14.78
26.06
21.12
WK6
WK5
WK4
WK3
Panicum maximum...
Glirisidia sepium...
Tithonia...
Moringa oleifera...
Chromolaena...
Control


Stem girth (cm)
WK3 WK4 WK5 WK6
C
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.18
0.3
0.52
0.58
0.2
0.38
0.56
0.62
0.16
0.34
0.54
0.58
0.24
0.44
0.58
0.62
0.24
0.46
0.6
0.6
0.18
0.36
0.42
0.48
WK6
WK5
WK4
WK3
Panicum maximum...
Glirisidia sepium...
Tithonia...
Moringa oleifera...
Chromolaena...
Control

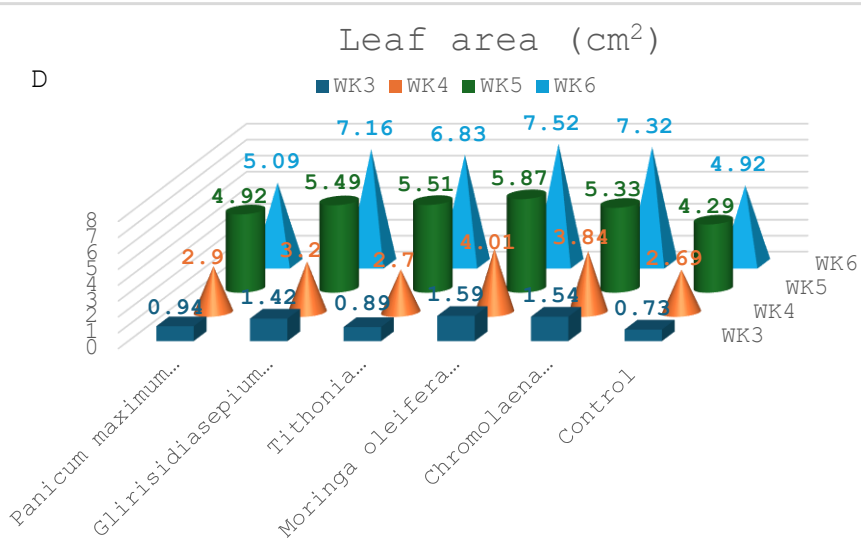

Leaf area (cm²)
WK3 WK4 WK5 WK6
D
8
7
6
5
4
3
2
1
0
0.94
2.9
4.92
5.09
1.42
3.2
5.49
7.16
0.89
2.7
5.51
6.83
1.59
4.01
5.87
7.52
1.54
3.84
5.33
7.32
0.73
2.69
4.29
4.92
WK6
WK5
WK4
WK3
Panicum maximum...
Glirisidiasepium...
Tithonia...
Moringa oleifera...
Chromolaena...
Control

Table 1: Influence of some plant extracts on the yield of *Amaranthus hybridus*

Treatments	Yield (g)	
	Whole	**Edible**
Panicum maximum leaf	82.80e	58.60e
Glirisidia sepium leaf	86.20c	64.80d
Tithonia diversifolia leaf	84.80d	68.00c
Moringa oleifera leaf	90.60b	69.20b
Chromolaena odorata leaf	106.00a	83.40a
Control	62.60f	47.60f

Mean values in the same column with the same letter (s) are not significantly different ($p<0.05$)

Discussion

The results of this study revealed that plant extracts have significant influence on the growth, development and yield of *Amaranthus hybridus*. Plant height is known as an essential growth parameter that reflects the vigour of plants. The results indicated that *Chromolaena odorata* consistently produced the tallest plants across all weeks, followed by *Moringa oleifera* and *Gliricidia sepium*. This significant increase in plant height could be attributed to the high nitrogen content and bioactive compounds present in *Chromolaena odorata* extracts, as reported by Suryanto *et al.* (2020) and Akinrinola and Tijani-Eniola H. (2022). Abolusoro *et al.* (2020) reported that nitrogen plays a key role in chlorophyll synthesis and photosynthesis, leading to enhanced cell division and elongation. The result of this experiment is also consistent with Olawale *et al.* (2021), who reported that *Chromolaena odorata* extract significantly increased the height of *Amaranthus cruentus* due to its ability to enhance nutrient uptake and stimulate metabolic activities. Results of the experiments results also confirmed similar reports by Aluko and Omotoso, 2022; Agbaniyon, and Aluko, 2023; and Aluko, 2016.

Moringa oleifera extract also significantly increased plant height compared to the control, which is in support of the findings of Adediran *et al.* (2020), who observed that *Moringa oleifera* leaf extract enhances growth in leafy vegetables due to its rich composition of auxins, cytokinins, and gibberellins. These phytohormones play an essential role in promoting stem elongation and vegetative growth (Ogundele and Adeyemi, 2023). The relatively lower plant height observed in the control suggests that the absence of bio-stimulants limited the plant's ability to achieve optimal growth.

Stem girth is a vital indicator of structural integrity and nutrient transport efficiency in plants. The results revealed that *Chromolaena odorata* and *Moringa oleifera* consistently produced the thickest stems, which were significantly different from those of other treatments. The increased stem girth observed in these treatments may be due to their high levels of metabolite factors and vital nutrients, particularly nitrogen and potassium, which are known to enhance vascular tissue development and cell wall thickening (Babalola *et al.,* 2021). This result corroborates the research of Okonkwo *et al.* (2022), who reported that plant-derived bio-stimulants, especially those rich in nitrogen, significantly improve stem thickness in vegetable crops. Similarly, the enhanced stem girth recorded in plants treated with *Moringa oleifera* aligns with previous studies, which indicate that *Moringa* extracts contain high levels of antioxidants, vitamins, and amino acids that support plant structural growth (Ibrahim and Oladipo, 2023). In contrast, the control and *Panicum maximum* treatments recorded the lowest stem girth, suggesting that the absence of additional nutrients limited secondary growth processes.

Moringa oleifera and *Chromolaena odorata* significantly enhanced leaf expansion across all weeks, supporting previous research conducted by Adegbite *et al.* (2022) that links bio-extracts to increased chlorophyll content and improved leaf morphology. The superior leaf area observed in *Moringa oleifera* treatments may be associated with its rich composition of vitamins, minerals, and phytohormones, particularly cytokinins, which promote cell division and leaf expansion (Adediran *et al.,* 2020). This result aligns with the result of Ogundele and Adeyemi (2023), who reported that *Moringa oleifera* extract enhanced leaf area development in *Telfairia occidentalis* due to its high nutritional content. Similarly, *Chromolaena odorata* promoted larger leaf areas, which may be due to its allelopathic properties that stimulate vegetative growth (Ekanem *et al.,* 2022). The relatively smaller leaf area observed in the control treatment further highlights the importance of plant-derived bio-stimulants in leaf development as stated by Yusuf *et al.* (2021), who demonstrated that plants supplied with organic bio-stimulants exhibit higher leaf area index due to improved nutrient uptake and cell expansion.

Leaf production is a crucial factor in determining plant productivity, as it contributes to increased photosynthetic efficiency and biomass accumulation. The

study showed that *Chromolaena odorata* consistently resulted in the highest number of leaves, followed by *Moringa oleifera* and *Gliricidia sepium*. The increased leaf production in *Chromolaena odorata*-treated plants may be attributed to its high nitrogen content and bioactive compounds, which enhance chlorophyll synthesis and stimulate leaf initiation (Nwachukwu and Ugwuoke, 2023). This result is in agreement with the experiment results of Ekanem *et al.* (2022), who observed that *Chromolaena odorata* extract increased the number of leaves in leafy vegetables due to its stimulatory effect on cell division. Additionally, the higher leaf production observed in *Moringa oleifera* treatments supports the research of Ibrahim and Oladipo (2023), who demonstrated that *Moringa oleifera* extract enhances leaf proliferation in vegetables by promoting rapid cell differentiation and growth. The lower number of leaves recorded in the control treatment suggests that the absence of growth enhancers limited the plant's ability to develop a dense canopy, which could reduce overall photosynthetic efficiency and yield.

Yield is often regarded as the ultimate measure of plant productivity. The result of this study shows that *Chromolaena odorata* consistently produced the highest whole and edible yields. The superior performance of *Chromolaena odorata* can be attributed to its ability to enhance vegetative growth, increase chlorophyll content, and improve nutrient uptake efficiency. Aboyeji *et al.,* (2020) reported that *Chromolaena odorata* extract significantly improved yield parameters in *Amaranthus* due to its high nitrogen content and growth-promoting properties.

Moringa oleifera also contributed significantly to higher yields, supporting previous research that highlights its role as a natural bio-stimulant, improving crop productivity (Adeoye *et al.,* 2023). The enhanced yield observed in *Moringa oleifera* treatments may be linked to its rich composition of amino acids, vitamins, and essential minerals, which enhance plant metabolism and biomass accumulation (Ogundele and Adeyemi, 2023). The control recorded the lowest yield, confirming that the absence of external growth stimulants limits plant productivity. This result aligns with Akande *et al.* (2024), who emphasized that the application of plant-based fertilizers and bio-stimulants often leads to improved crop yields and sustainability.

Conclusion and Recommendation

1. Results from this study indicated that plant extracts have significant influence on the growth, development and yield of *Amaranthus hybridus*.
2. That extracts from Siam weed (*Chromolaena odorata*) and *Moringa oleifera* exhibited superior performance in plant height, stem girth, leaf area, number of leaves, and overall yield the plant (*Amaranthus hybridus*), than other plant materials tested.
3. *Treatments with Gliricidia sepium and Tithonia diversifolia* had moderate effects on *Amaranthus hybridus*, while *Panicum maximum* showed lower performance.
4. The observed effects of the tested plant extracts on the growth and yield performance of *Amaranthus hybridus* is an indication that plant-derived bio-stimulants has the potential of being sustainable alternatives to synthetic fertilizers, and can be used to improve crop productivity.
5. Based on the results and findings of this experiment therefore, the use of *Chromolaena odorata* and *Moringa oleifera* extracts for enhancing the growth and productivity of *Amaranthus hybridus* is hereby recommended. The tested extracts can be integrated into sustainable agricultural practices to reduce dependency on chemical fertilizers while maintaining high crop yields.

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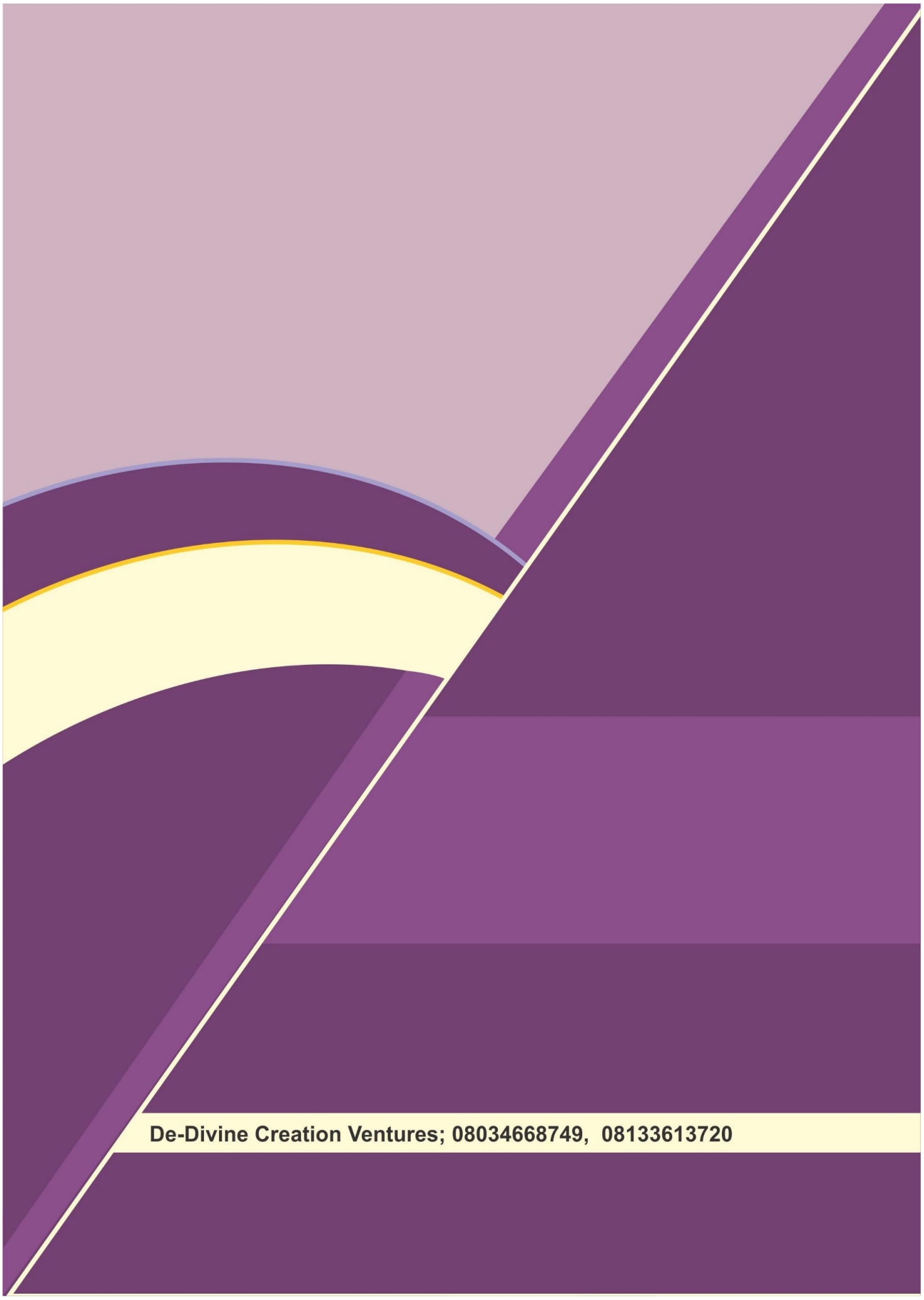
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