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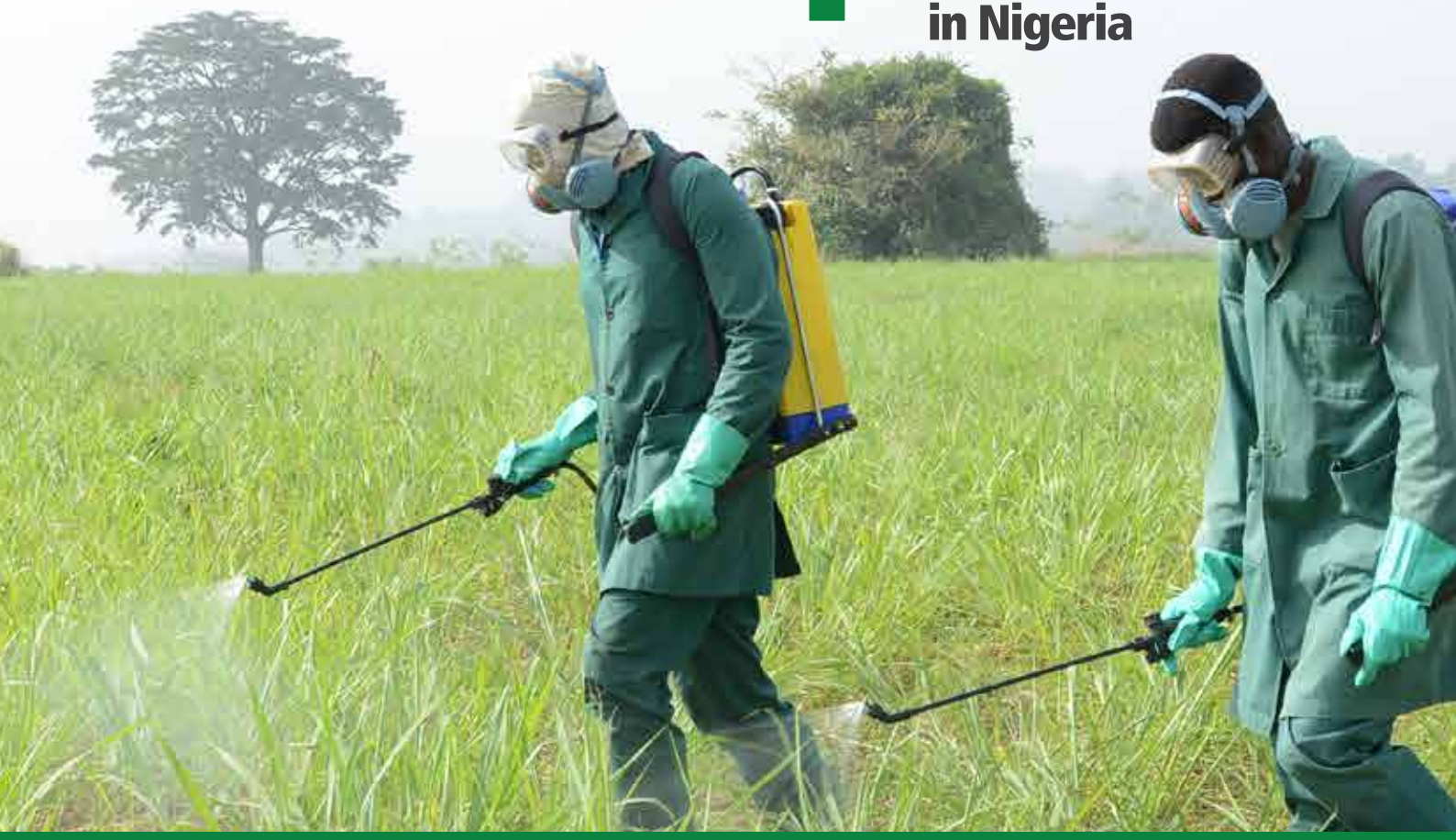
A case to De-register and Prohibit the use of Paraquat in Nigeria



by
COALITION AGAINST PARAQUAT (CAP)

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The Coalition Against Paraquat (CAP) is a group of eminent professionals from diverse disciplines that are promoting the use of safe and environment-friendly herbicides in Nigeria.

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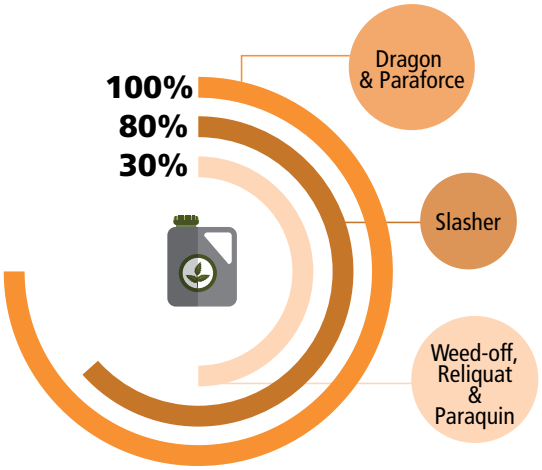
Executive summary

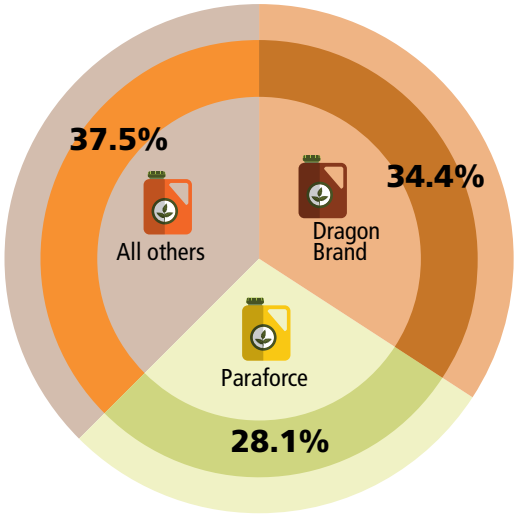
Paraquat is regarded as one of the most highly toxic herbicides in the world to have been marketed in the last 60 years. Its use is reported in more than 100 countries and on more than 100 crops in different cropping systems. A desk study and rural appraisal undertaken in six States of Nigeria to assess the current status of use, perceptions of farmers and other stakeholders, and levels of toxicity confirmed high levels of risk to farmers' health and the environment.

The study indicated more than 20 brand or trade names for Paraquat with several variations in terms of the percentage of active ingredient. The brands most commonly used by farmers across the States are Dragon, Paraforce, Weed-off, Slasher, Paraquin, and Reliquat.

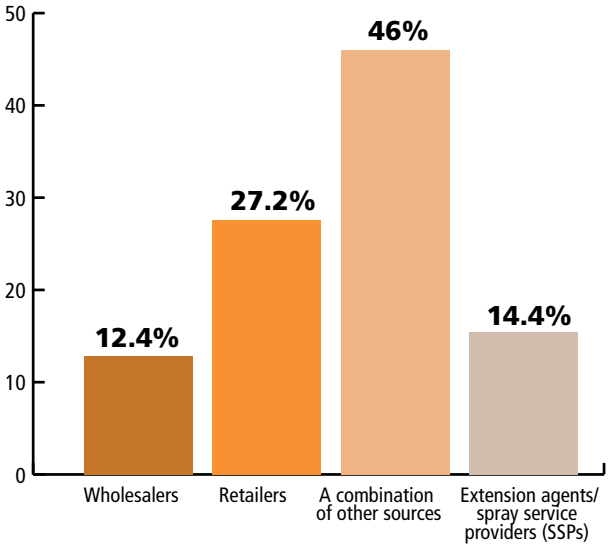
In order of accessibility:



In order of preference by farmers across the States:



Paraquat is not manufactured or formulated in Nigeria and about 60% of the quantity used is imported from China. The supply chain to the six States surveyed was as follows:

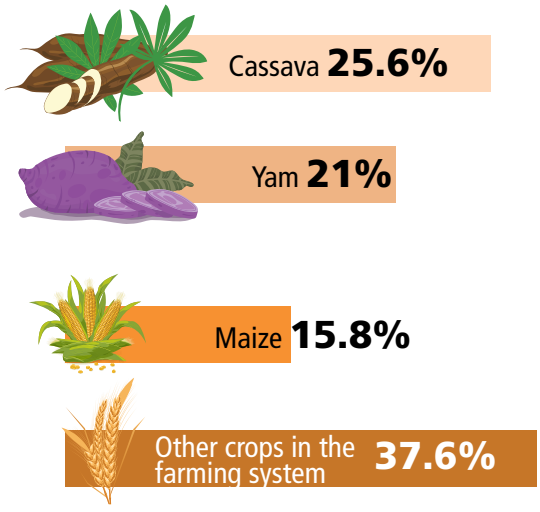


The majority of end users are as follows:

- Small-scale farmers (45%); most (90%) have over ten years' experience in the use of PQ and apply the herbicide themselves (72%) using knapsack sprayers.
- Commercial farms (32%).
- Estate owners (22%).

The involvement of certified SSPs in the six States surveyed was very limited (35%). They were the only end users with personal protective equipment (PPEs) and clothing (PPCs). They had had substantial training in the handling of chemicals in general and of Paraquat in particular. The Nigerian small-scale farmers, the predominant users, usually have no such knowledge or training. Even when they have it, they may not deploy it appropriately.

Paraquat was used mainly in the production of:



There is compelling proof from survey results and science-based evidence at international level that PQ and its various derivatives are sufficiently hazardous to human health and the environment for the recommendation that it should be deregistered and its importation, distribution, sale, and use declared a legal offence. It is considered to be, potentially, one of the most highly dangerous herbicides ever sold. The World Health Organization, European Union, and Center for Disease Control (USA) as well as the United States Environmental Protection Agency have confirmed the following:

- Paraquat is a toxic chemical, harmful to the environment.

It is highly poisonous and harmful to human health. Protracted exposure and ingestion have been shown to lead to muscle weakness, pulmonary oedema, respiratory infection, and heart, liver, and kidney damage. There are, however, safe and environmentally friendly alternative herbicides. The Glyphosate group, Glufosinate ammonium, Fusilade, and Gallant Super, provide such preferred alternatives. They have been demonstrated to be equally effective and are currently available in Nigeria.

Counter measures from Industry and manufacturers cannot be guaranteed as sufficiently effective in the Nigerian situation and consist mainly of compulsory regulation on use, education, and training which prescribe a desirable level of knowledge and skill for end users through the use of PPE/PPC. The proposal for status of restricted use by formulation industries and agrochemical dealers' associations could also not be an option because the effective structures for this method of control are not at all available in Nigeria. Paraquat has been placed under restricted use or banned in most of the agrarian countries of the world. Therefore, Nigeria has no option other than to deregister the product.

For these compelling reasons it has become necessary to call on the Federal Republic of Nigeria, through the appropriate agency, National Agency for Food and Drug Administration (NAFDAC) to deregister PQ and its derivatives and declare importation, distribution, and use illegal in Nigeria.

1. Introduction

Paraquat (1, 1′-dimethyl-4, 4′-bipyridinium dichloride – PQ) is a broad-spectrum, non-selective contact herbicide that has been widely used in weed management for many years. It was first synthesized in 1882 although its herbicidal properties were not recognized until 1955 (Madeley 2002). Paraquat was first sold in commercial quantities by the Imperial Chemical Industries (ICI) in early 1962 and it is among the herbicides most commonly used in agriculture. Today, PQ is marketed in well over 100 countries for use on small and large farms of different crop enterprises and cropping systems for the purpose of weed control, and in non-agricultural lands and estates for amenity weed control. Globally, PQ has been classified as one of the most highly toxic herbicides to be marketed in the last 60 years.

A desk study and rural appraisal were undertaken to provide information on the status of use of PQ in Nigeria, and its relevance to the on-going global discourse on the risk that its continued use poses to human health and a sustainable environment. The availability of PQ on the market triggered the growth of minimum tillage and soil conservation which are the most important environmental innovations in agriculture in recent years. Despite the perceived benefits, PQ is very toxic to the farmers and workers who apply it. A report by PAN (2017) indicates that it remains a pesticide with an active ingredient responsible for more fatal poisonings than any other substance. Workers who are exposed to PQ over a long period of time have been found to have an increased risk of developing Parkinson's disease later in life. Paraquat also has endocrine and immunotoxin effects. Based on the numerous health hazards toxicologists (Nagami *et al.* 2005) have questioned the rationale of World Health Organization (WHO) in categorizing PQ as a Class II ('Moderately hazardous') chemical instead of assigning it to Class I. Iserring (2006) also argued that PQ should be in the Class I category because of its acute toxicity, delayed effects, and the absence of an antidote. Cal EPA (2010) stated that it could cause loss of appetite, thirst, vomiting, headache, fever, muscle pain, abdominal pain, diarrhea, rapid heartbeat, cerebral oedema, and brain damage. There have been global calls for PQ to be banned by the European Union (EU) and many international organizations, such as Rainforest Alliance, Forest Stewardship Council, and Fair-Trade.

1.1 Global concern about Paraquat

Paraquat herbicide has become a global worry to toxicologists, farmers, and the general public because of its acute toxicity and the absence of any antidote (cure), the danger to human and animal health and to the environment (Joshi, 2002). The body parts identified with high level of exposure in users were hand, wrist, back, and scrotum (Joshi, 2002). The source of exposure to the body included splashing during preparation of the spray solution and open transportation, discharge in spraying, contact with spray solution when the knapsack was being filled, leakage from the knapsack on back and groin, in adjustment of spray equipment, and by contact while walking through sprayed vegetation. Accidental and occupational exposure has been reported in various places, especially in the developing countries. For instance, such exposure resulting in death for about 27% of 700 cases of poisoning in Malaysia was reported in 10 years (Majid 1997). Accidental poisoning can occur when it is stored in re-used refreshment, liquor, or medicine bottles. Severe poisoning has occurred with children playing with empty bottles and rinsed spray jets and bottle tops (Wesseling *et al.* 2001). Paraquat is

one of the most common herbicides used to cause death by suicide. Reports show that PQ poisoning has 60-70% mortality rate (Seok *et al.* 2009), much higher than with other agents. Cases of self-poisoning have been reported in Malaysia, South Korea, Taiwan, Thailand, and Sri Lanka (Agarwal *et al*. 2006). According to the National Poison Center, the number of poisonings has been rising in recent years (Whittle 2010).

1.2 Paraquat affects humans in the following ways:

Eyes: causing keratitis, conjunctivitis, destruction of the ocular surface

- Skin: ranging from reddening and blistering to severe burns, dermatitis. In the worst cases, absorption into the body through damaged skin can lead to death
- Lungs: chronic lung damage
- Brain: increase in the risk of Parkinson's disease is suspected by long-term exposure
- Fingernails and toenails: from discoloration to detachment
- Respiratory arrest: Ingestion leads to lung fibrosis and death from respiratory failure
- Damage to the liver, kidneys, the gastro-intestinal tract, and the cardiovascular system are also possible (https://www.publiceye.ch/en/topics/pesticides/paraquat)

Extensive Oral Ulceration

Paraquat Poisoned lungs

Source: **Tan *et al*. (2014) (Left); Qian *et al.* (2013).** https://doi.org/10.3892/etm.2013.1320 **(Center);** *Kondal et al. (2013). https://doi: 10.4103/2230-8229.1220230) (Right)*

1.3 Concern in Nigeria about the use of paraquat

Nigeria, a predominantly agrarian nation, cannot be exempt from the on-going global concern. Agriculture here is tropical, characterized by high rainfall, relatively high humidity, and rapid weed growth (Parker 1972). This has favored the continual use of paraquat as an herbicide despite being restricted or banned in other countries (US EPA 2001). A study conducted in the southern part of Nigeria showed that residues of PQ were found in common crops and vegetables (Akinloye *et al.* 2011). This can be considered very risky as PQ is an extremely toxic chemical that can damage many body organs including lungs, heart, kidneys, spleen, and the central nervous system. This can further dovetail into multiple organ failure. According to Dinham (2004), Watts (2011), and Isenring (2017), the long-term effects include acute health problems such as severe dermatitis, secondary burns, and respiratory failure; there is mounting evidence that chronic exposure is linked to development of Parkinson's disease. Paraquat is the most common herbicide used in Plateau State and the northern parts of Nigeria due to the fragile ecology and sparse vegetation dotted with annual grasses. In a recent study, Gushit *et al*. (2013) examined PQ poisoning among farmers and pesticide retailers in Nigeria. The study surveyed the practices and risks associated with its use by farmers, agrochemical retailers, and agricultural extension workers in Plateau State of Nigeria in 2010. The authors concluded that a low literacy level and the lack of knowledge resulted in an indiscriminate use of herbicides and, if not properly taken into consideration and addressed, this might present a threat to public health. Although PQ appears to have been banned for use on cocoa in Nigeria (Mokwunye *et al.* 2010) it is still a very "popular" herbicide for various cropping systems and presents a major risk and health hazard to farmers, the general public and the environment. In terms of acute poisoning, the lungs are the primary target organ of PQ poisoning. However, it is also distributed to the heart, liver, and kidneys (Watts 2011). According to a report by Cal EPA (2010), the brain is now recognized as another target organ for PQ poisoning. Acute kidney injury and death were associated with two 16 and 23 year old adolescent females who were exposed to PQ (Adejumo *et al*. 2016; Slater *et al*. 2017) (Appendix 1).

The effect of PQ on aquatic life in the Nigerian food chain has been another source of concern (Shallangwa and Auta 2008). There is evidence that its use triggered the death of Nile Tilapia (Ajani *et al*. 2007; Fidelis *et al*. 2012) and cat fish (Kori-Siakpere *et al.* 2007). Several other studies have confirmed that PQ is hazardous to aquatic life, exacerbated environmental degradation, caused pollution, and endangered the sustainability of the eco-system (Babatunde *et al.* 2001; Omitoyin *et al*. 2006; Ayanda *et al*. 2015 (Appendix 1).

2. Current source of supply and list of PQ products available in Nigeria

2.1 Current suppliers and products

There are more than 30 trade brands (trade names) of PQ products and derivatives registered and marketed in Nigeria today by several companies including the global giant, Syngenta. Although sold under different names by different manufacturers, the PQ manufactured by Syngenta and sold under the "trade name Gromoxone" is the most common. In recent years, the market has been flooded with brands (trade names) of PQ with varying percentages and concentrations of the active ingredient by different registrants. The most common is the Paraquat ion (200g/L) formulated as Paraquat dichloride with 276 g/L. Table 1 shows formulations of PQ and derivative products and their registrants in the Nigerian market.

Table 1: Paraquat/derivative product formulations in the Nigerian market and Registrants in Nigeria.

S/N	Paraquat Product Trade Name	Active Ingredient	NAFDAC (Nig)/Status of Registration		Pesticide Registrant/License Number/Country	
			NAFDAC No.	Duration	Registrant/Nigeria	Licensed -Country
1.	Paraforce	Paraquat dichloride (PDC) -276g/L	A5-0109	2008-2013	Jubaili Agrotec. Ltd, Kano, Nigeria	United Phosphorus Ltd. Ankleshwar, Gujerat, India
2	Dragon	PDC 24% (W/W) of PDC	04-8610	2006-2011	West African Cotton Co. Ltd, Oshodi, Lagos	P.R., China
3	Weed Crusher	PDC 276g/L	04-7132	2005-2010	Harvest field Industries Ltd, Lagos, Nigeria	UK
4	Reliquat	PDC 276g/L	None	RUP	Reliable Agro-Allied Ltd, Ikeja Lagos)	China
5	Chemquat	PDC 276g/L	None	RUP		China
6	Weed-Off	PDC 276g/L(200 g/L)	A5-0260	2009-2014	Saro Agroscience Ltd, Apapa, Lagos	China
7.	Bret P-20 Liquid	PDC 276g/L(200 g/L)	A5-0247	2006-2011	Amanik Investment Ltd, Enugu	China
8	Bret P-(1 L Bottle)	Paraquat 279g/L	04-5927	2004-2009	Amanik Investment Ltd, Maryland, Lagos	China

S/N	Paraquat Product Trade Name	Active Ingredient	NAFDAC (Nig)/Status of Registration		Pesticide Registrant/License Number/Country	
			NAFDAC No.	Duration	Registrant/Nigeria	Licensed -Country
10.	Dizmazone @ 20%	200g/L	04-9406	2009-2014	Dizengoff W. A (Nig.) Ltd Apapa, Lagos	South Africa
11.	Glopara-Liquid	PDC 276g/L	A5-03235	2009-2014	Century Global Agricultural Ltd, Small-scale Industrial Estate, Kano	China
12.	Gramoxone Super	PDC 276g/L	04-5237	2004-2009	Syngenta Nig. Ltd, 387 Agege Motor Road, Mushin, Lagos	Switzerland
13.	Gramoxone Super	PDC 276g/L	04-0196	2009-2014	Syngenta Nig. Ltd, Mushin, Lagos	Switzerland
14.	Grass Cutter	PDC 20%	A5-0288	2010-2015	Crop Care Ltd 10 Km Gunduwawa District Hadeja Road, Kano	China
15.	Mxiquat	PDC 276G/L	A5-0125	2008-2013	Adebajo Close Avenue Nice Way Idumagbo Avenue Idumota Lagos.	China
17.	Paracom Eraser Liquid	PDC 276G/L	A5-0290	2010-2015	Comfort Agro Chemical Nigeria Ltd, 7a, Niger Street, Kano	China
18.	Paracot	PDC 276G/L	A5-0024	2007-2012	Afcott Nig. Ltd, Plot 122-132, Oshodi-Apapa Expressway, Isolo, Lagos	China
20.	Para-One	PDC 200G/L	A5-0123	2008-2013	Vancol, Cropcare Ltd, .G. Leventis Complex, Iddo, Lagos	India

S/N	Paraquat Product Trade Name	Active Ingredient	NAFDAC (Nig)/Status of Registration		Pesticide Registrant/License Number/Country	
			NAFDAC No.	Duration	Registrant/Nigeria	Licensed -Country
21.	Paratex	PDC 276G/L	A5-0092	2008-2013	Vertex Agro Ltd Km 10 Abuja-Kaduna Road Suleja.	China
22.	Philozone	PDC 276G/L	A5-0181	2009-2014	Floret Trust Ltd, 13 Adejie Osunbanwo Street, Ejigbo, Lagos	Germany
23.	Premium Paraquat	PDC 20% SC	04-9555	2006-2011	African Agro Products Ltd. 37, Niger Street, Kano	China
24.	Ravage	PDC 276G/L	04-7485	2005-2010	Crop Care, 3 Are Avenue, Bodija, Ibadan, Oyo State	China
25.	Scud	PDC 276G/L	A5-0026	2007-2012	Fitsco (Nig) 1st Floor Ance Building Jericho, Ibadan, Oyo	UK
26	Slasher	PDC 276 G/L	A5-0110	2008-2013	Unique Agrochemicals Ltd., 92 Younis Bashorun Street, Victoria Island, Lagos	China
27.	Uniquats Liquid	PDC 20%	A5-0294	2010-2015	H.D.F & Sons Nig. Ltd 24, Unity Road, Kano	India
28.	Uniquat	PDC 276G/L	04-6411	2004-2009	H.D.F & Sons Nig. Ltd 24, Unity Road, Kano	China
30	DYMOZONE	276g/L	A5-0047	2007-2009	Dymota Agro. Nig. Ltd 1 Court. Road, Sabo Gari, Kano	China

Source: *https://www.scribd.com/document/341073233/Nafdac-Approved-Pesticides-in-Nigeria*. ***Retrieved May, 2018***

The major agrochemical companies that import and distribute PQ, the brands (trade names) and area of coverage in the surveyed States are shown in Table 2.

Table 2: Major agrochemical companies, their paraquat product trade name, and area of coverage in Nigeria.

S/N	Agrochemical Company	Paraquat Trade name	States/cities of Nigeria covered/ where product is distributed
1.	Syngenta	Gramoxone Super	Abia, Bornu, Enugu, Delta, Imo, Lagos, Kaduna, Oyo, and Zamfara
2.	Saro Agroscience	Weed-off	Bauchi, Enugu, Niger, Oyo, and Port Harcourt
3.	West Africa Cotton Company	Dragon	Abia, Abuja, Bauchi, Enugu, Niger, Oyo, and Port Harcourt. Kano, Kaduna, Zuba, Ilorin, Lagos, Ibadan. Onitsha, Asaba and Benin City
4.	Jubaili Agrotech	Paraforce	Abuja, Enugu, Ibadan, Rivers, Kano, Akwa Ibom, Lagos, Delta, and Ogun
5.	Dizengoff West Africa	Dizmazone-20%	Abia, Bauchi, Enugu, Lagos, and Port Harcourt
6.	HarvestField Industries	Weed Crusher	Enugu, Onitsha, Kaduna, Ondo, Osun, Ekiti, Abuja, Lagos
7.	The Candel Company	Paraquat Liquid	Gombe, Ibadan, Kano, Makurdi, Onitsha, and Suleja

Source: *Udensi, 2020.*

Paraquat imported into the country is registered by the Directorate of Registration and Regulatory Affairs of National Agency for Food and Drug Administration and Control (NAFDAC).

Besides these major importers, there are currently more than 100 registered crop protection and agrochemical companies or dealers that are officially recognized by NAFDAC and its Directorate of Registration which have one or two formulations of PQ in their list of products. In addition, there are reports of PQ derivatives being smuggled into the country by unauthorized dealers. According to Osibanjo (2002), between 1983 and 1990, Nigeria imported annually about 15,000 t of more than 130 chemical pesticides marketed locally with over 150 different product/brand names and formulations. Brands and formulations of PQ constituted the majority.

2.2 Types of paraquat brands and preferences across six States

The survey result indicated that numerous brands of PQ were available in the market. Tables 3 and 4 show the brands available, marketed, and farmers' preferences by State.

Table 3: Brands of paraquat marketed across six States in Nigeria

	Availability of the various brands of PQ by States						
Paraquat brands	**Abia**	**Benue**	**Enugu**	**Ogun**	**Oyo**	**Rivers**	**Across (%)**
Dragon	+	+	+	+	+	+	100
Gramoxone					+		16.7
Paraforce	+	+	+	+	+	+	100
Weedoff	+	+		+			50
Slasher	+	+	+	+	+		83.3
Maxiquat					+		16.7
Uniquat					+		16.7
Weedcrusher	+			+			33.3
Paracot						+	16.7
Reliquat		+	+		+		50
Paraquin	+		+			+	50

Source: *Udensi, 2020. The plus sign (+) indicates availability/popularity.*

Table 4: Brands of paraquat and farmers' preferences across six States

	Percentage of Persons preferring a particular brand of PQ by State.						
Paraquat brands	Abia	Benue	Enugu	Ogun	Oyo	Rivers	Preference Across States (%)
Dragon	3 (25)	5 (31.25)	2 (50)	2 (16.67)	6 (50)	2 (33.33)	34.38
Paraforce	2 (16.67)	3(18.75)	1(25)	6 (50)	3 (25)	2 (33.33)	28.12
Weedoff	1 (8.33)	5 (31.25)	0	2 (16.67)	0	0	9.38
Slasher	2 (16.67)	3(18.75)	1(25)	2 (16.67)	3 (25)	0	17.02
Weed crusher	3 (25)	0	0	0	0	0	4.17
Paracot	0	0	0	0	0	1 (16.67)	2.78
Paraquin	1 (8.33)	0	0	0	0	1 (16.67)	4.17

Source: *Udensi, 2020. Figures in parentheses are the percentage of respondents.*

3. Status of current use and users of Paraquat in Nigeria

The result of the field survey indicated that PQ is used predominantly by small-scale farmers on food and tree crops. Off-farm/ non-crop use of it is restricted to estate maintenance/management of lawns, rights of way in road construction and highways, public utilities, infrastructure, and village amenities (Table 5). Other identified users include owners of farm enterprises (commercial farms), SSPs, farm management service providers, and health workers.

Table: 5 Evidence of Paraquat use on-farm and off-farm in studied States in Nigeria

	Place where PQ is used (%)					Persons applying PQ (%)	
States	**On-farm use (Crop use)**	**Off-farm use (Non-crop use**	**Smallholders**	**Large farm holders**	**Estates**	**Farmers**	**SSPs**
Abia	70	30	50	37.5	12.5	63.6	36.4
Benue	69.2	30.8	37.4	31.3	31.3	69.2	30.8
Enugu	75	25	50	25	25	75	25
Ogun	83.3	16.7	25	58.3	16.7	83.3	16.7
Oyo	75	25	75	8.3	16.7	75	25
Rivers	66.7	33.3	33.4	33.3	33.3	66.7	33.3
Across States	73.2	26.8	45.1	32.3	22.6	72.1	27.9

Source: *Udensi, 2020.*

3.1 Types of crops where Paraquat is commonly used

In the studied States, farmers produced arable, horticultural, and plantation crops, and used PQ as the preferred herbicide for weed control. Common arable crops produced were cassava, yam, maize, okra, tomato, soybean, and rice. Common plantation crops were plantain, banana, oil palm, and cashew. Farmers' use of PQ in weed management was dependent on the weed control need, weed-crop situation, weed flora type, crop, and cropping systems. In a study by Udensi (2020), PQ was prominently used in cassava (25.6%); yam (21.1%), maize-cassava intercrop (20.3%) and maize (15.8%) across the studied States. The reason adduced by farmers for the high rate of consumption in these crops was the importance and high commercial value of the crops in the States as well as the effectiveness of PQ in post-emergence weed suppression in cassava and yam production.

3.2 Source of supply (importation), distribution, and sale of Paraquat products in Nigeria

Paraquat is not manufactured or formulated in Nigeria but imported mostly from developed countries. About 90% of the PQ used in Nigeria are imported as finished, prepacked, or completely packaged products, mainly from China, also Germany, the United Kingdom,

Switzerland, and India. China is currently the world's largest manufacturer of PQ with 19 brands (trade marks) distributed and sold in Nigeria. The products from China constitute about 63% of the quantity sold in Nigeria with India coming second and contributing about 17% (Table 6).

Table 6: Country of origin of Paraquat products sold in Nigeria

S/N	Country of Product	No. of brands of Country's PQ product	Country's product in Nigeria (%)
1.	China	19	63.3
2.	India	5	16.7
3.	United Kingdom	2	6.7
4.	Switzerland	2	6.7
5.	Germany	1	3.3
6.	South Africa	1	3.3

Source: *Udensi, 2020 (**Adapted from NAFDAC, 2018**)*

3.3 Distribution and sale in Nigeria

Paraquat is supplied, distributed, and sold through the following outlets:

- Country of manufacture or origin
- Multinational agrochemical companies or their representatives
- Indigenous company distributors or off-takers, importing through the agrochemical companies
- Intermediary wholesalers or certified input or licensed agrochemical dealers
- Open market
- Retailers

The suppliers, distributors, and marketers may be classified into three main groups:

- wholesalers,
- retailers, and
- a combination of both, depending on the location. The majority of the local companies double as both wholesalers and retailers.

Other distributors and suppliers used by farmers include Agricultural Development Programs (ADPs) and farmers' cooperatives. Paraquat is readily available to farmers through these channels, and sometimes through SSPs who sell and also provide the services of spraying. There are also small retail agrochemical and input retailers at the levels of villages and small towns. The major players in the supply/distribution and service provider chain are shown in Table 7.

Table 7: Percentage of Paraquat importers and marketers in some parts of Nigeria

	Involvement in import and marketing (%)				Actor in supply chain (%)			
	Involvement in import (%)		Involvement in Marketing (%)		Wholesalers	Retailers	Others (EAs/ SSPs)	Combination
State	Importing	Not importing	Marketing	Not marketing				
Abia	11.1	88.9	47.0	53.0	0	12.5	12.5	75
Benue	0	100	28.2	72.2	7.7	30.8	53.8	7.7
Enugu	0	100	66.7	33.3	0	0	0	100
Ogun	0	100	88.9	11.1	66.7	0	0	33.3
Oyo	0	100	33.3	66.7	0	100	0	0
Rivers	0	100	50.0	50	0	20	20	60
Across States	1.8	98.2	52.5	47.5	12.4	27.2	14.4	46

Source: *Udensi, 2020*

4. Alternatives to Paraquat in Nigeria

There are safe, available, effective, substantially equivalent, affordable, and environmentally friendly alternative herbicides to PQ in Nigeria. These products are as follows.

- Glufosinate-ammonium (Basta), Broad spectrum herbicide.
- Fusilade (Fluazifop-p-butyl, specific for annual and perennial grasses.
- Haloxyfop-p-methylester (GallantSuper, for grasses.
- 2, 4-D for broadleaves in cereals.
- Glyphosate Broad spectrum.

The alternative herbicides of interest – glyphosate and glufosinate – have been reported as those most commonly used by farmers. Glyphosate has broad-spectrum activity, is systemic, kills both annual and perennial weeds and is widely used in no-till agriculture.

Other herbicides identified were mainly pre-emergence herbicides (Primextra; Atrazine, Butachlor, Metolachlor, Pendimethalin, Orizo-plus, and their derivatives. The grass-specific herbicides including the arlyoxyphenoxy-propionates and cyclohexanediones are effective against a variety of annual and perennial grasses and have excellent safety properties in all broadleaf crops, such as cassava.

5. Evidence of exposure to Paraquat use from rural appraisal

The result of the survey undertaken in Nigeria revealed that a majority of the farmers (56.5%) and other end users in the six States were unduly exposed to PQ during application. A significant proportion of those exposed suggested that it was owing to the absence of due diligence in the use of PPE/PPC and other precautionary measures. Farmers and end users who were exposed to PQ suffered injuries but cases of poisoning were not taken seriously, because some of the manifested symptoms were not perceived to be different from the everyday results of normal life and stress/injuries associated with work on the farm. Therefore, most of those were exposed did not consult doctors at all. This shows the typical behavior of average Nigerians in the rural setting; consultations are usually not made until health issues get out of hand. Many will not even show up for treatment until the long-term damage is done, so prevention in the form of deregistering is far better.

6. The case for de-registering the importation, distribution, sale, and use of Paraquat and Its derivatives in Nigeria

There is substantial and incontrovertible science-based evidence that PQ is dangerous to human health and hazardous to the environment. The sale and use of this chemical in Nigeria is a danger to the health of the applicators and others, as confirmed in scientific literature. Most researchers agree that PQ can be fatal if directly ingested. Most scientific studies show that chronic and acute exposure can lead to severe health problems in humans. The negative effects of exposure have been shown for lungs, liver, kidneys, adrenals, thymus, cardiac and hematolympathic systems, cancer, diabetes, genotoxicity and mutagenicity, endocrine disruption, reproductive and developmental birth defects/teratogenicity, immune system, nervous system, Parkinson's disease, and many deaths from accidental and intentional ingestion (Webb 1983; IPCS 1984: USEPA 1997; Dere and Polat 2000; Noriega *et al*. 2002; Dinham 2004; Kimura et al. 2007; Kimura 2010; Shibata et al. 2010; Watts 2011).

Some documented effects of the negative response of humans to exposure are enumerated below:

- **Eyes** – USEPA (1997) – clouding of lens and cataracts in rodents
- **Skin** – No absorption through intact skin (USEPA 1997); can enter through damaged skin and some fatalities have occurred. Eleven fatalities from dermal exposure occurred between 1974 and 1994 (Gear et al. 2001). A death was reported within 3.5 hours from a 0.5% solution from a leaking backpack which saturated the applicator coming (Wesseling 2001).
- In Thailand, a farmer spraying PQ all day using a leaking backpack and not wearing any PPE/PPC developed a cough, skin disease, lost hair and sight, and died within 3 months (Bartliet and Bjilmakers, 2003).
- Fifteen deaths were reported from exposure to applicators in Costa Rica banana plantations (Wesseling 2001). These researchers also reported a correlation between applicator exposure and subsequent wheezing accompanied by shortness of breath (Castro-Gutierrez *et al*. 1997).
- A few reports have shown dermal exposure to PQ and subsequent death (Smith 1988) and from exposure to dilute spray tank concentrations (Wesseling et al. 1997; Athanaselis *et al*. 1983).
- Van Wendel *et al*. (1996) showed that PQ spray applicators in Central American banana plantations had a high exposure level of 113mg/kg body weight during normal spray events. Once it is internalized, PQ can affect respiration and hepatic and renal system function (Castro-Gutierrez *et al*. 1997; Soloukides *et al.* 2007) and result in death.
- Many epidemiological studies have associated exposure to PQ with skin cancers in humans in coffee and banana growing regions of Costa Rica (Wesseling *et al*. 1999) including squamous cell carcinoma associated with combined sunlight exposure and bypridilium precursors among workers in PQ factories in Taiwan (Jee *et al*. 1995).
- The FAO (2008) concluded PQ was mutagenic in human lymphocytes and Chinese Hamster lung fibroblasts.

- PQ has been shown to cross the placenta in the mother's blood (Tsatskis *et al*. 1996) and Wesseling *et al*. (2001) reported fetal death in pregnant women after exposure to PQ.
- The CAL EPA (2010) concluded that PQ is a neurotoxin affecting brain function based on direct evidence that it can penetrate the central nervous system.
- Since introduction in 1963, PQ has been implicated as a causal agent in human deaths from ingestion, whether accidental or intentional for suicides (Castro-Gutierrez et al. 1997).
- In the developing world it has been estimated (Gunnell 2007) that up to one- third of all suicides result from pesticide ingestion and PQ has often been involved. Other reports showed such suicides accounted for 232 deaths worldwide between 1962 and 1974 (Taylor *et al*. 1985) and PQ is the preferred choice for suicides in Asia and the Pacific Islands (Taylor *et al*. 1985; Naito and Yamashita 1987; Perriens *et al*. 1989).
- Even when people survive poisoning, they suffer fibrosis and abnormalities of pulmonary function, especially decreased diffusing capacity (Fock 1987; Hettiarachchi and Fernando 1988; Anderson 1970; Fisher *et al*. 1971). Numerous scientific articles have conducted research on possible links of exposure to PQ and the onset of Parkinson's disease in humans. Epidemiological studies have been conducted with human populations with known exposure to PQ for association with higher occurrence of Parkinson's disease. The National Institute of Environmental Health Sciences in the US showed in a 2011 study that people exposed to PQ were twice as likely to develop Parkinson's disease. The USEPA (2016) stated: "There is a large amount of epidemiological data on the association of PQ with Parkinson's disease and connections to thyroid disease, wheezing, and chronic bronchitis in non-smoking women". However, the USEPA says additional research is necessary to show a more direct effect.

Those who justify the continued use of PQ substantiate their position on the premise of appropriate regulation enforceable though compliance with prescribed parameters for use. This argument is, however, questionable in Nigeria, a developing agricultural country where repeated applications are made within and over years and exposure can be extreme. The evidence from literature and desk analysis shows that PQ is a dangerous herbicide with potential to cause grave danger to spray applicators and hazards to the environment.

The result of the desk study, literature review, and survey on use in Nigeria showed as follows.

1. It is a highly hazardous herbicide implicated in the acts of self-poisoning and suicide in the rural areas of most developing countries including Nigeria, making it a major public health problem.
2. It has been declared an active ingredient in any pesticide substance responsible for more fatal poisonings, with alarming rates of occupational hazard when in use (PAN 2017)
3. It is internationally recognized as one of the Highly Hazardous Pesticides (HHPs) being phased out or replaced. It is highly toxic to humans, especially to children where one sip can be fatal, and there is

no antidote presently (http://pan-international.org/resources)

4. It has long-term health effects that may lead to Parkinson's disease, acute renal injury,
5. and failure. Deaths have been reported elsewhere and in Nigeria of girls 16 and 23 years old. (*Weeseling et al. 2001; Andreas-Soloukides et al. 2007; Gushit et al. 2013; Adejumo et al. 2016; Slater et al. 2017).*
6. Most applicators in Nigeria use the knapsack/back pack sprayer. However the European Union (EC 2002) stated that applicators using knapsack sprayers might exceed the short-term acceptable exposure level by 60 times when PPEs are worn, and by 100 times when PPEs are not worn. This suggests the need for equipment that will touch the body less, e.g., the boom sprayer. Because farmers in developing nations lack such capacity, deregistration would appear to be a better option.
7. Most of the rural farmers that use PQ are not able to separate the symptoms of herbicide intoxication from those of daily work stress and therefore may not consult a doctor until it is too late for these to be managed. Hence, prevention in the form of deregistering is far better as many will not even show up for treatment till the damage is done.
8. This can be further strengthened by the fact that in the US where PQ is under restricted use, licensed applicators adhere to due diligence in using all PPE/PPC and this is well enforced by appropriate agencies contrary to the situation in Nigeria where farmers hardly use any form of PPE. This clearly shows that the structure for retaining PQ in the Nigerian market is not there.
9. Thirty-two countries including the EU, Africa and others (Watt 2011) have banned or de-registered PQ ,This is in addition to over 5,000 signed petitions to ban PQ in the Cayman Islands (www.cayman.com/2013/01/09/Renwed-push-to-ban-paraquat); as well as global online stop press on a PQ ban by concerned groups due to the alarming death rate.
10. Research and evidence-based reports have shown that food crops, aquatic food resources (fish, periwinkle mollusk), and drinking water with residues of PQ can result in high rates of exposure.
11. The extended soil half-life, bioaccumulation, pollution, and contamination of the environment may lead to habitat and biodiversity losses and ecosystems destabilization.
12. The rising number of Pesticide Cocktail effects in Nigeria implicating PQ is alarming.
13. China that accounts for about 80% of the total export to the world and about 60% or more of the product sold in Nigeria has concluded plans to ban the use and sales of any PQ formulation in China by September 2020 (http://www.cnchemicals.com/Press/89866-).

We strongly recommended that the Federal Republic of Nigeria through the appropriate agency (NAFDAC) de-register the importation and prohibit the distribution, sale, and use of Paraquat in Nigeria. This is based on research and science-based evidence that PQ is dangerous to human health and hazardous to the environment.

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Appendix 1: Cases of exposure to Paraquat across zones in Nigeria

S/N	Zones	PQ Exposures Reported			Effect of Exposure : Deaths (D) or Symptom	References
		Human Exposure Cases Study		Other research and case reports of PQ-related exposure		
		Unintentional (occupational)	Intentional (Suicides)			
1	North East					
	Bornu (Alan, Dam)			PQ among other pesticides (Butachlor and Glyphosate) residues found in fish samples (1)	Residues in fish, potential hazards to humans	Akan et al. 2019
2	**North Central**					
	Benue	*77% of study focus group		Exposure beyond MRLs of lethal concentration became hazardous; Implication in depletion of agricultural soils (1). *75% of expressed symptoms of exposure	Depletion of water soluble Cu^{2+} K^{+} and Mg^{2+} suppression of water-soluble nutrients by sorption *Manifestation of symptoms of exposure.	Oche 2017; Mbuk et al. 2009 *Udensi 2020
3	North West					
	Sokoto			Effect on Nile Tilapia -(*Orechromis niloticus*). Haematological changes (1)	Anaemia, Extended effect on the aquatic environment	Oluwatoyin et al. 2015
	Kaduna (Zaria)			Effect on Nile Tilapia -(*Orechromis niloticus*) (1).	Sublethal dose of PQ induced effect suggesting Anaemia,	Babatunde *et al. 2001; 2014*

S/N	Zones	PQ Exposures Reported			Effect of Exposure : Deaths (D) or Symptom	References
		Human Exposure Cases Study		Other research and case reports of PQ-related exposure		
		Unintentional (occupational)	Intentional (Suicides)			
	Enugu State	*67% of study focus group		16 year old girl with fatal case of PQ poisoning with dysphagia, cough and dyspnea resulting in AKI (1) *Effect of Expossure not reported	Death *No exposure symptom	Slater et al. 2017 *Udensi 2020
5	**South South**					
	Delta			Case of symptoms of exposure on fish (*Clarias gariepinus*) and Periwinkle Molluscs; Samples (water, sediments, and fish from Warri River Basin contaminated (3)	Residues in fish, water and sediments – River Basin Warri	Kori-Siakpere et al. 2007; Ogeleka et al. 2017; Ikpesu 2015
	Bayelsa			Stress induced decrease in metabolites in muscle and gill of Cat fish, and acute toxicity on (*Heterobronchus bidorsalis)* (2)		Ogamba et al. 2011; Ogaga et al. 2018
	Rivers State	*40% of study focus group		*20% of study focused group expressed symptoms of PQ exposure Chronic effect on testicular histology of *C, gariepinus* fingerlings (1)	Manifestation of symptoms of exposure *C. gariepinus* fingerlings seriously affected	*Udensi 2020 Woryi et al. 2020

S/N	Zones	PQ Exposures Reported			Effect of Exposure : Deaths (D) or Symptom	References
		Human Exposure Cases Study		Other research and case reports of PQ-related exposure		
		Unintentional (occupational)	Intentional (Suicides)			
	Oyo State	114[1] (95%) of 120 farmers *67% of study focus group	-	Undefined health challenges. Potential hazards identified with the indiscriminate use and disposal of containers (2) [1]Egbeda, in Oyo State, where 107 (89.3%) of 120 use Paraquat, 95% exhibited symptoms of exposure *8% of study focus group expressed symptoms of exposure (1)	Health risk due consumption of food crops with high PQ residues [1]77 (64.1%) of 120 farmers reported severe health issues that are related to Paraquat. * Manifestation of symptoms of exposure	Babarinsa *et al*. 2018 [1]Adekunle *et al*. 2017 * Udensi 2020
	Ogun State	*67% of study focus group		Residues (MRLs) in common port herbs/vegetables and arable crops. Residues and disruption of metabolites in *C. gariepinus* (2) * 50% of study of focus group expressed symptoms of exposure	None *Manifestation of symptoms of exposure	Akinloye et al. 2011; Ayanda et al. 2015 * Udensi 2020