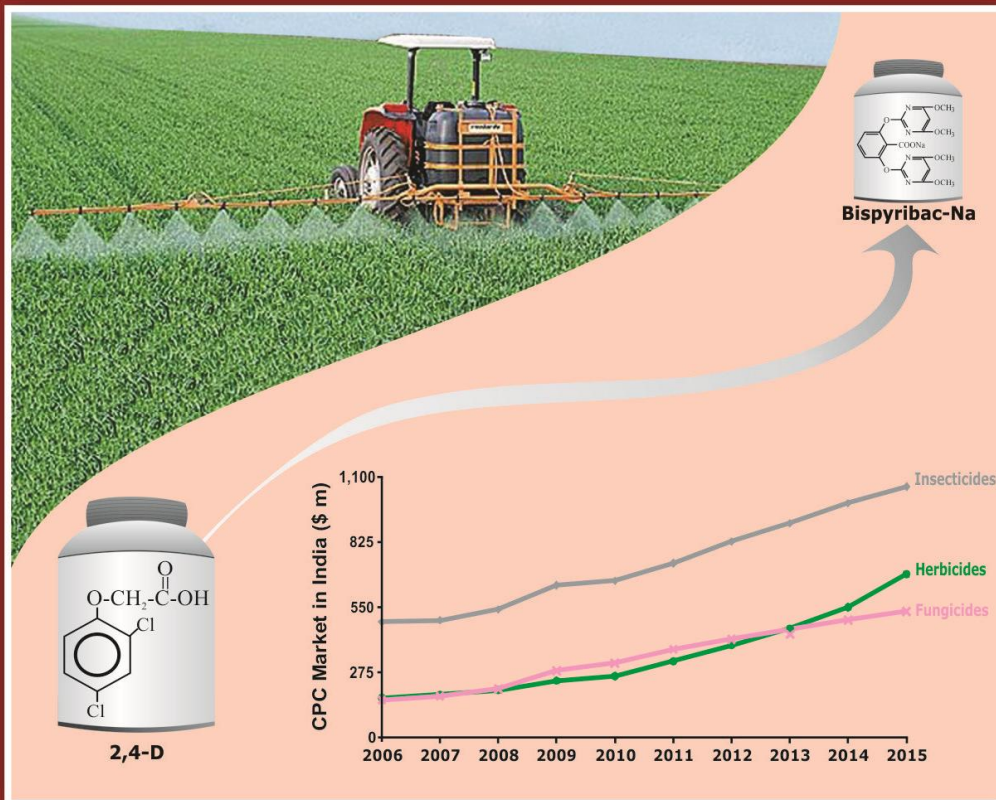


Herbicide Use in Indian Agriculture



ICAR - Directorate of Weed Research
Jabalpur, Madhya Pradesh
ISO 9001 : 2008 Certified



Cover theme :

Since the discovery of 2,4-D in the 1940s, which led to a revolution in chemical weed control, several low-dose high-potency molecules like bispyribac-sodium have been developed in the recent years. Herbicide market is growing at a much faster rate than other pesticides in India. Further, the application techniques through tractor-mounted power sprayer are also becoming increasingly popular among the farmers.

Information Bulletin No. 22

Herbicide Use in Indian Agriculture

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Jabalpur, Madhya Pradesh
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Preface

Considering the growing infestation of weeds in cropped and non-cropped lands, the Indian Council of Agricultural Research decided to establish the National Research Centre for Weed Science (NRCWS), which came into existence on 22nd April, 1989 with the joining of its first Director, Late Dr. V.M. Bhan. This centre was upgraded as Directorate of Weed Science Research (DWSR) on 23rd January, 2009; and further renamed as Directorate of Weed Research (DWR) on 27th November, 2014. This is a unique institute in the National Agricultural Research System, which is probably the only one of its own kind in the whole world dealing exclusively with weed science research. Besides, training, coordination, consultancy and collaborative programmes on weed management are also undertaken with various stakeholders.

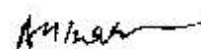
The Directorate has played a significant role in conducting the weed survey and surveillance, development of weed management technologies for diversified cropping systems, herbicide resistance in weeds, biology and management of problem weeds in cropped and non-cropped areas, and environmental impact of herbicides. Adoption of these technologies has been promoted in large areas through on-farm research and demonstrations, which has raised agricultural productivity and livelihood security of the farmers. Training and awareness, and consultancy programmes organized by the Directorate have been found highly beneficial and appreciated by various stakeholders. All these activities have been further geared up to address the emerging challenges in weed management including threats posed by climate change, invasive weeds, herbicide resistance, herbicide hazards, and safety concerns about herbicide tolerant crops.

Till recently, weed management in croplands was almost entirely a manual farm operation, involving women labour. The use of herbicides for weed control was limited to some major crops like rice and wheat in the high productivity areas of north-western India. However, with growing labour scarcity and increasing cost of manual weeding, herbicides are now becoming increasingly popular because of their cost-effectiveness and better weed control. This is evident from the increasing demand and consumption of herbicides every year, at a rate faster than other pesticides. Low-dose high-potency herbicides and their mixtures are now available for broad-spectrum weed control in all major crops including the foodgrain crops, horticultural plantations and also in the non-cropped areas.

There is no systematic information available on herbicide use in Indian agriculture with regard to their production, consumption and coverage under various situations. Moreover, such data records are not easily accessible because the herbicide industry is largely /fully controlled by the private sector, particularly multinationals. We made an effort to collect all possible information on herbicides from the available sources for compilation in this bulletin. There are 10 chapters providing details of herbicides introduced since 1930s; classification, regulation and registration; use in various crops and non-cropped situations, consumption in different states, application techniques and safety standards. List of manufacturing and marketing units is also given in the Annexure. Although all efforts were made to collect information from various sources, including some unpublished documents, it is possible that data in some cases may not provide the complete information on a given product. We shall appreciate receiving comments and suggestions from our stakeholders including the herbicide industry for further validation and updating of the information in a revised volume.

Grateful thanks are due to various individuals and organizations, including the scientists of the Directorate and AICRP on Weed Management for contributing inputs and data for this bulletin. We hope this information will be useful to scientists, teachers, students, farmers, policy makers and others associated with weed management in the country.

Date: 10 February, 2016



(A.R. Sharma)
Director

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1. Introduction

The problems of weeds and methods of controlling them have been with farmer since the early days of agriculture. The relatively labour-intensive and less effective methods of the pre-agricultural revolution era were replaced by the concept of crop-rotation and prophylactic measures. The improvement in the implements of mechanization and the introduction of tractor further increased farmer's ability to reduce crop-weed competition. The discovery of the synthetic and relative herbicides, however, empowered the farmer, horticulturist and forester to control broad leaf weeds in broad leaf crops, narrow leaf weeds in narrow leaf crops or broad leaf weeds in narrow leaf crops as well as narrow leaf weeds in broad leaf crops. Long before the beginning of synthetic herbicides, chemicals, mostly of inorganic in nature were reported to be used as weed management practice.

There are some reports on the use of lime, common salt, sulfuric acid and copper sulfate in Europe and America from the middle of the nineteenth century (Table 1.1). The first herbicide used for selective weed control was copper sulphate, which was tested to control charlock (*Brassica kaber*) in wheat in France. With the beginning of twentieth century, sodium arsenite became very popular in the United States and during the first four decades, it had been widely and extensively used for the control of annual weeds, perennial weeds and submerged aquatic weeds. There are some more reports available on the use of different chemicals like xylene, sodium chlorate, sodium borate, salt of dinitrophenol etc. In the 1930s, dinitro ortho cresol (DNOC) was introduced in agriculture as the first organic herbicide, albeit it did not fetch much success. The real breakthrough came after the invention of 2,4-dichlorophenoxyacetic acid (2,4-D), the first widely used synthetic herbicide. The property of 2,4-D to act as hormone was discovered independently by four groups in the United States and Great Britain: William G. Templeman and coworkers (1941); Philip Nutman, Gerard Thornton, and Juda Quastel (1942); Franklin Jones (1942); and Ezra Kraus, John W. Mitchell, and Charles L. Hamner (1943) (Troyer 2001). Sherwin-Williams Paint Company was the first to commercialise it in the late 1940s. In the United States, in 1950s and 1960s, 2,4-D replaced millions of agricultural workers formerly employed in weeding. In other words, 2,4-D revolutionized chemical weed control. This was the beginning of designing herbicide molecules specifically tailored to inhibit specific enzyme reaction. Atrazine followed 2,4-D in 1958, and Monsanto's glyphosate in 1974. Thereafter, around 2000 different herbicide molecules of 15 different modes of action have been introduced in the global market (Table 1.2).

Table 1.1 Chronology of developments in weed management

Between 15000 and 10000 BC : Primitive agriculture was begun by neolithic man
6500 BC : Development of irrigation along the Euphrates and Tigris rivers in Mesopotamia and the Nile river in Egypt
3000 BC : Bone- or wood-made hand sickle was invented
1000 BC : Introduction of T-shaped wooden implement pulled by cattle or slaves
164 BC : Romans brought down Carthage using sulfuric acid, salts of copper and arsenic, and carbon bisulfide at high rates to destroy their agriculture
100 : Importance of weeding was realized by the Romans
1617 : The English developed wood plough with an iron pointed shear
1722 : Horse drawn 'hoe' developed by Jethro Tull in Britain
1777 : Use of the plough as the chief means of weed control in Sweden
1797 : Thomas Jefferson patented a mouldboard plough with iron shear
1840 : Lime was recommended for control of horsetail (<i>Equisetum</i> sp.) in Germany

Introduction

- 1854 : Salt (sodium chloride) as a herbicide was recommended in Germany
- 1848 : Wheel cultivator with steel shovel
- 1850 : Self-propelled steam tractor invented
- 1850 : Hand sprayer developed and used for insect and disease control
- 1855 : Kirchof recommended sulfuric acid and iron sulfate against weeds in Germany
- 1887 : Tractor sprayer developed
- 1896 : Copper sulfate was first used for selective weed control of charlock (*Brassica kaber* in wheat by the French
- 1897-1900 : Copper sulfate, iron sulfate, sulfuric acid, and nitric acid were tested for control of annual forbs in cereals by other workers in France, Germany, Canada, and the United States
- 1905 : Copper sulfate was introduced as algicide in the United States
- 1900 : Gasoline-powered sprayer was developed
- 1900-37 : Gasoline-powered crusher boats were used extensively by the US Army Corps of Engineers for control of water hyacinth in Louisiana
- 1902-37 : Sodium arsenite was used extensively by the Army Corps of Engineers for control of water hyacinth in Louisiana
- 1906 : Carbon bisulfide was found very effective as a soil fumigant for weed control
- 1908 : Bolley used various salts for non-selective control in wheat fields
- 1912-14 : Rodweeder, first field implement designed exclusively for weed control was developed in the Pacific Northwest
- 1914 : Orchard heating oil was used for control of garlic (*Allium tricoccum*) and wild onions (*Allium canadense*)
- 1913-45 : Sodium arsenite was used in Hawaii for controlling annual weeds
- 1920 : The tractor-mounted cultivator, the duckfoot and blade cultivators were developed and utilized for weed management
- 1925 : The airblast mist blower was developed
- 1926 : Jet-type pumps were developed
- 1926 : Sodium arsenite was found highly effective on submersed aquatic weeds in Wisconsin lakes
- 1930 : Tractor-mounted sprayer was developed
- 1932 : The first organic herbicide, dinitro-ortho cresol (DNOC) was introduced
- 1933 : Salt of dinitrophenol was used in France to control annual forbs in cereals
- 1937 : Use of sodium arsenate in Punjab, India for the control of *Carthamus oxycantha*
- 1937-50 : Common salt was used extensively for field bindweed (*Convolvulus arvensis*) control on highways and railroad in Kansas
- 1940 : Introduction of granule spreader for applying sodium chlorate as herbicide
- 1941 : Synthesis of 2,4-D
- 1944 : Selective nature of 2,4-D was discovered on dandelion
- 1945 : U.S. Patent No 2,390,941 was issued for 2,4-D to plant physiologist Dr. Franklin D. Jones of the American Chemical Paint Company
- 1946 : 2,4-D was registered for use in Canada on crops and turf grass
- 1948 : The effectiveness of emulsified xylene-type aromatic solvents for control of submerged aquatic weeds in flowing water was discovered
- 1951 : Phenyl substituted ureas (monuron, diuron) were discovered
- 1955 : Triazines (atrazine, simazine) were developed
- 1960 : Dinitroanilines (trifluralin, oryzalin) were introduced
- 1965 : Agent Orange was first introduced in South Vietnam when it was used to defoliate portions of the banks of the Saigon River from the capital city to the South China Sea (Cecil 1986)
- 1970 : First documented case of herbicide resistant biotypes of weeds appeared
- 1970 : Glyphosate was developed
- 1980 : ALS inhibitors (imidazolinones, sulfonyl ureas) were developed

Sources: Stainmaus, 2008; Holm and Johnson, 2009; Das, 2014

Table 1.2 Chronology of herbicides since 1936

Herbicide	Chemical nomenclature	Year of introduction
Pentachlorophenol	2,3,4,5,6-pentachlorophenol	1936
2,4,5-T	(2,4,5-trichlorophenoxy)acetic acid	1944
MCPA	(4-chloro-2-methylphenoxy)acetic acid	1945
Propham	isopropyl carbanilate	1945
2,4-D	2,4-dichlorophenoxyacetic acid	1946
TCA	trichloroacetic acid	1947
Fenuron	1,1-dimethyl-3-phenylurea	1951
Neburon	1-butyl-3-(3,4-dichlorophenyl)-1-methylurea	1951
Monuron	3-(<i>p</i> -chlorophenyl)-1,1-dimethylurea	1952
2,3,6-TBA	2,3,6-trichlorobenzoic acid	1952
Endothall	7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid	1953
Metham	sodium methylthiocarbamate	1953
Mecoprop	(<i>RS</i>)-2-(4-chloro-2-methylphenoxy)propanoic acid	1953
Dalapon	2,2-dichloropropionic acid	1954
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea	1954
Silvex	2-(2,4,5-trichlorophenoxy) propionic acid	1954
MCPB	4-(4-chloro-2-methylphenoxy)butanoic acid	1955
Amitrole	3-amino- <i>s</i> -triazole	1955
Erbon	2-(2,4,5-trichlorophenoxy)ethyl 2,2-dichloropropionate	1955
Naptalam	<i>N</i> -1-naphthylphthalamic acid	1955
Simazine	2-chloro-4,6-bis(ethylamino)- <i>s</i> -triazine	1956
CDAA	<i>N,N</i> -diallyl-2-chloroacetamide	1956
Chlorpropham	isopropyl- <i>m</i> -chlorocarbanilate	1956
DSMA	disodium methanearsonate	1956
Monuron TCA	3-(<i>p</i> -chlorophenyl)-1,1-dimethylurea mono (trichloroacetate)	1956
Sesone	2-(2,4-dichlorophenoxy)ethyl sodium sulfate	1956
Propazine	6-chloro- <i>N</i> 2, <i>N</i> 4-diisopropyl-1,3,5-triazine-2,4-diamine	1957
CDEC	2-chloroallyl diethylthiocarbamate	1957
Dazomet	tetrahydro-3,5-dimethyl-5H-1,3,5-thiadiazine-2-thione	1957
EPTC	<i>S</i> -ethyl dipropylthiocarbamate	1957
HCA	1,1,1,3,3,3-hexachloro-2-propanone	1957
PBA	chlorinated benzoic acid	1957
Paraquat	1,1'-dimethyl-4,4'-bipyridinium dichloride	1958
2,4-DB	4-(2,4-dichlorophenoxy) butyric acid	1958
Trietazine	6-chloro- <i>N</i> 2, <i>N</i> 2, <i>N</i> 4-triethyl-1,3,5-triazine-2,4-diamine	1958
Pebulate	<i>S</i> -propyl butyl(ethyl)thiocarbamate	1959
Atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)- <i>s</i> -triazine	1959
Fenuron TCA	1,1-dimethyl-3-phenylurea monotrchloroacetate	1959
D CPA	dimethyl tetrachloroterephthalate	1959

Introduction

Herbicide	Chemical nomenclature	Year of introduction
Vernolate	<i>S</i> -propyl dipropylthiocarbamate	1959
Chlorbufam	but-3-yn-2-yl <i>N</i> -(3-chlorophenyl)carbamate	1960
Chlorthal	(<i>RS</i>)-2-chloro-5-(1-hydroxy-3-oxo-2,3-dihydro-1 <i>H</i> -isoindol-1-yl)benzene-1-sulfonamide	1960
Propanil	<i>N</i> -(3,4-dichlorophenyl)propanamide	1960
Diphenamid	<i>N,N</i> -dimethyldiphenylacetamide	1960
Acrolein	acrolein or 2-propenal	1960
Amiben	3-amino-2,5-dichlorobenzoic acid	1960
Diallate	<i>S</i> -(2,3-dichloroallyl) diisopropylthiocarbamate	1960
Fenac	(2,3,6-trichlorophenyl) acetic acid	1960
2,4-DEP	tris[2-(2,4-dichlorophenoxy)ethyl] phosphate	1960
Triallate	<i>S</i> -2,3,3-trichloroallyl di-isopropylthiocarbamate	1960
Prometon	<i>N</i> ² , <i>N</i> ⁴ -diisopropyl-6-methoxy-1,3,5-triazine-2,4-diamine	1960
Pentachlor	3'-chloro-2-methylvaler- <i>p</i> -toluidide	1960
Dichlorprop (2,4-DP)	(<i>R</i>)-2-(2,4-dichlorophenoxy)propionic acid	1961
Amitrole-T	3-amino- <i>s</i> -triazole+ammonium thiocyanate	1961
Barban	4-chloro-2-butynyl- <i>m</i> -chlorocarbanilate	1961
Cacodylic acid	hydroxydimethylarsine oxide	1961
Propazine	2-chloro-4,6-bis(isopropylamino)- <i>s</i> -triazine	1961
Trifluralin	2,6-dinitro- <i>N,N</i> -dipropyl-4-(trifluoromethyl)aniline	1961
Bensulide	<i>S</i> -2-benzenesulfonamidoethyl <i>O,O</i> -diisopropyl phosphorodithioate	1962
Prometryn	6-methylsulfanyl-2- <i>N</i> ,4- <i>N</i> -di(propan-2-yl)-1,3,5-triazine-2,4-diamine	1962
Linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	1962
Chloridazone	5-amino-4-chloro-2-phenylpyridazin-3(2 <i>H</i>)-one	1962
Desmetryn	<i>N</i> ² -isopropyl- <i>N</i> ⁴ -methyl-6-methylthio-1,3,5-triazine-2,4-diamine	1962
Terbacil	3- <i>tert</i> -butyl-5-chloro-6-methyluracil	1962
Dicamba	3,6-dichloro- <i>o</i> -anisic acid	1962
Dichlobenil	2,6-dichlorobenzonitrile	1962
Diquat	6,7-dihydrodipyrido[1,2- <i>a</i> :2',1'- <i>c</i>]pyrazinediium salts	1962
Isocil	5-bromo-3-isopropyl-6-methyluracil	1962
Molinate	<i>S</i> -ethylhexahydro-1 <i>H</i> -azepine-1-carbothioate polychlorodicyclopentadiene	1962
Triallate	<i>S</i> -(2,3,3-trichloroallyl)diisopropylthiocarbamate	1962
Monolinuron	3-(4-chlorophenyl)-1-methoxy-1-methylurea	1962
Carbetamide	(<i>R</i>)-1-(ethylcarbamoyl)ethyl carbanilate	1963
Ioxynil	4-hydroxy-3, 5-diiodophenyl cyanide	1963
Picloram	4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid	1963
Benfluralin	<i>N</i> -butyl- <i>N</i> -ethyl-2,6-dinitro-4-(trifluoromethyl)aniline	1963
Bromacil	5-bromo-3- <i>sec</i> -butyl-6-methyluracil	1963
Butylate	<i>S</i> -ethyl diisobutylthiocarbamate	1963
Diphenamid	<i>N,N</i> -dimethyl-2,2-diphenylacetamide	1963

Herbicide	Chemical nomenclature	Year of introduction
MSMA	monosodium methanearsonate	1963
Picloram	4-amino-3,5,6-trichloropicolinic acid	1963
Trifluralin	, , -trifluoro-2,6-dinitro- <i>N,N</i> -dipropyl- <i>p</i> -toluidine	1963
Benazolin	4-chloro-2,3-dihydro-2-oxo-1,3-benzothiazol-3-ylacetic acid	1964
Siduron	1-(2-methylcyclohexyl)-3-phenylurea	1964
Lenacil	3-cyclohexyl-1,5,6,7-tetrahydrocyclopentapyrimidine-2,4(3 <i>H</i>)-dione	1964
Propachlor	2-chloro- <i>N</i> -isopropyl- <i>N</i> -phenylacetamide	1964
Fluometuron	1,1-dimethyl-3-[3-(trifluoromethyl)phenyl]urea	1964
Ametryne	2-(ethylamino)-4-(isopropylamino)-6(methylthio)- <i>s</i> -triazine	1964
Cycloate	<i>S</i> -ethyl <i>N</i> -ethylthiocyclohexanecarbamate	1964
Molinate	<i>S</i> -ethyl azepane-1-carbothioate	1964
Prometryne	2,4-bis(isopropylamino)-6-(methylthio)- <i>s</i> -triazine	1964
Vernolate	<i>S</i> -propyl dipropyl(thiocarbamate)	1964
Asulam	<i>N</i> -(4-aminophenyl)sulfonylcarbamic acid methyl ester	1965
Terbutryn	<i>N</i> 2- <i>tert</i> -butyl- <i>N</i> 4-ethyl-6-methylthio-1,3,5-triazine-2,4-diamine	1965
Dinoterb	2-(2-methyl-2-propanyl)-4,6-dinitrophenol	1965
Monalide	4'-chloro- <i>a,a</i> -dimethylvaleraniide	1965
Bromoxynil	3,5-dibromo-4-hydroxybenzonitriole	1965
Pyrazon	5-amino-4-chloro-2-phenyl-3(2 <i>H</i>)-pyridazinone	1965
Methoprotryne	<i>N</i> 2-isopropyl- <i>N</i> 4-(3-methoxypropyl)-6-methylthio-1,3,5-triazine-2,4-diamine	1965
Chlorbromuron	3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea	1966
Terbumeton	<i>N</i> 2- <i>tert</i> -butyl- <i>N</i> 4-ethyl-6-methoxy-1,3,5-triazine-2,4-diamine	1966
Benefin	<i>N</i> -butyl- <i>N</i> -ethyl- <i>a,a,a</i> -trifluoro-2,6-dinitro- <i>p</i> -toluidine	1966
Chloroxuron	3-[<i>p</i> -(<i>p</i> -chlorophenoxy)phenyl]-1,1-dimethylurea	1966
Nitrofen	2,4-dichlorophenyl- <i>p</i> -nitrophenyl ether	1966
Terbacil	3- <i>tert</i> -butyl-5-chloro-6-methyluracil	1966
Terbuthylazine	<i>N</i> 2- <i>tert</i> -butyl-6-chloro- <i>N</i> 4-ethyl-1,3,5-triazine-2,4-diamine	1966
Benzthiazuron	1-(1,3-benzothiazol-2-yl)-3-methylurea	1967
Phenmedipham	methyl 3-(3-methylcarbaniloyloxy)carbanilate	1967
Nitralin	4-(methylsulfonyl)-2,6-dinitro- <i>N,N</i> -dipropylaniline	1967
Bentazone	3-Isopropyl-1 <i>H</i> -2,1,3-benzothiadiazin-4(3 <i>H</i>)-one 2,2-dioxide	1968
Dipropetryn	6-ethylthio- <i>N</i> 2, <i>N</i> 4-diisopropyl-1,3,5-triazine-2,4-diamine	1968
Metoxuron	3-(3-chloro-4-methoxyphenyl)-1,1-dimethylurea	1968
Methabenzthiazuron	1-(1,3-benzothiazol-2-yl)-1,3-dimethylurea	1968
Metribuzin	4-amino-6- <i>tert</i> -butyl-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one	1968
Norflurazon	4-chloro-5-methylamino-2-(, , -trifluoro- <i>m</i> -tolyl)pyridazin-3(2 <i>H</i>)-one	1968

Introduction

Herbicide	Chemical nomenclature	Year of introduction
Karbutilate	(3,3-dimethylureido)phenyl- <i>tert</i> -butylcarbamate	1968
Chlortoluron	3-(3-chloro-4-methylphenyl)-1,1-dimethylurea	1969
Napropamide	(<i>RS</i>)- <i>N,N</i> -diethyl-2-(1-naphthyloxy)propionamide	1969
Flupropanate	2,2,3,3-tetrafluoropropionic acid	1969
Bromofenoxim	3,5-dibromo-4-hydroxybenzaldehyde-2,4-dinitrophenyloxime	1969
Desmedipham	ethyl-3-phenylcarbamoyloxy-carbanilate	1969
Ethofumesate	(2-ethoxy-3,3-dimethyl-2H-1-benzofuran-5-yl) methane-sulfonate	1969
Thiobencarb	<i>S</i> -4-chlorobenzyl diethyl(thiocarbamate)	1969
Oxadiazon	5- <i>tert</i> -butyl-3-(2,4-dichloro-5-isopropoxyphenyl)-1,3,4-oxadiazol-2(3 <i>H</i>)-one	1969
Propyzamide	3,5-dichloro- <i>N</i> -(1,1-dimethylprop-2-ynyl)benzamide	1969
Butachlor	<i>N</i> -(butoxymethyl)-2-chloro- <i>N</i> -(2,6-diethylphenyl)acetamide	1970
Butralin	(<i>RS</i>)- <i>N</i> - <i>sec</i> -butyl-4- <i>tert</i> -butyl-2,6-dinitroaniline	1971
Glyphosate	<i>N</i> -(phosphonomethyl)glycine	1971
Perfluidone	1,1,1-trifluoro- <i>N</i> -(4-phenylsulfonyl- <i>o</i> -tolyl)methane sulfonamide	1971
Fluchloralin	<i>N</i> -(2-chloroethyl)-2,6-dinitro- <i>N</i> -propyl-4-(trifluoromethyl)aniline	1972
Piperophos	<i>S</i> -2-methylpiperidinocarbonylmethyl - <i>O,O</i> -dipropyl phosphorodithioate	1972
Quinoclamine	2-amino-3-chloro-1,4-naphthoquinone	1972
Bifenox	methyl-5-(2,4-dichlorophenoxy)-2-nitrobenzoate	1973
Chloramben	3-amino-2,5-dichlorobenzoic acid	1973
Ethidimuron	1-(5-ethylsulfonyl-1,3,4-thiadiazol-2-yl)-1,3-dimethylurea	1973
Oryzalin	3,5-dinitro- <i>N,N</i> -dipropylsulfanilamide	1973
Profluralin	<i>N</i> -(cyclopropylmethyl)-2,6-dinitro- <i>N</i> -propyl-4-(trifluoromethyl)aniline	1973
Thiazafurion	1,3-dimethyl-1-(5-trifluoromethyl-1,3,4-thiadiazol-2-yl)urea	1973
Dimefuron	3-[4-(5- <i>tert</i> -butyl-2,3-dihydro-2-oxo-1,3,4-oxadiazol-3-yl)-3-chlorophenyl]-1,1-dimethylurea	1974
Ethalfuralin	<i>N</i> -ethyl- , , -trifluoro- <i>N</i> -(2-methylallyl)-2,6-dinitro- <i>p</i> -toluidine	1974
Tebuthiuron	1-(5- <i>tert</i> -butyl-1,3,4-thiadiazol-2-yl)-1,3-dimethylurea	1974
Hexazinone	3-cyclohexyl-6-dimethylamino-1-methyl-1,3,5-triazine-2,4-dione	1974
Flamprop	methyl <i>N</i> -benzoyl- <i>N</i> -(3-chloro-4-fluorophenyl)- <i>D</i> -alaninate	1974
Thiocarbazil	<i>S</i> -benzyl di- <i>sec</i> -butyl(thiocarbamate)	1974
Metolachlor	(<i>RS</i>)-2-Chloro- <i>N</i> -(2-ethyl-6-methyl-phenyl)- <i>N</i> -(1-methoxypropan-2-yl) acetamide	1974
Pyridate	<i>O</i> -6-chloro-3-phenylpyridazin-4-yl- <i>S</i> -octyl thiocarbonate	1974
Pendimethalin	<i>N</i> -(1-ethylpropyl)-2,6-dinitro-3,4-xylidine	1974
Fosamine	ethyl hydrogen carbamoylphosphonate	1974
Butamifhos	<i>O</i> -ethyl- <i>O</i> -6-nitro- <i>m</i> -tolyl <i>sec</i> -butylphosphoramidothioate	1975
Diclofop	4-(2,4-dichlorophenoxy)phenol	1975
Orbencarb	<i>S</i> -2-chlorobenzyl diethyl(thiocarbamate)	1975
Metamitron	4-amino-4,5-dihydro-3-methyl-6-phenyl-1,2,4-triazin-5-one	1975

Herbicide	Chemical nomenclature	Year of introduction
Oxyfluorfen	2-chloro- , , -trifluoro tolyl-3-ethoxy-4-nitrophenyl ether	1975
Daimuron	1-(1-methyl-1-phenylethyl)-3- <i>p</i> -tolylurea	1975
Triclopyr	[(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid	1975
Flamprop-M	<i>N</i> -benzoyl- <i>N</i> -(3-chloro-4-fluorophenyl)- <i>D</i> -alanine	1976
Dimethachlor	2-chloro- <i>N</i> -(2-methoxyethyl)acet-2',6'-xylidide	1977
Fluridone	1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]pyridin-4-one	1977
Tebutam	<i>N</i> -benzyl- <i>N</i> -isopropyl-2,2-dimethylpropionamide	1977
Acifluorfen	5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid	1980
Benfuresate	2,3-dihydro-3,3-dimethylbenzofuran-5-yl ethanesulfonate	1980
Chlorsulfuron	1-(2-chlorophenylsulfonyl)-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)urea	1980
Isouron	3-(5- <i>tert</i> -butyl-1,2-oxazol-3-yl)-1,1-dimethylurea	1980
Pyrazolynate	4-(2,4-dichlorobenzoyl)-1,3-dimethylpyrazol-5-yl toluene-4-sulfonate	1980
Anilofos	<i>S</i> -4-chloro- <i>N</i> -isopropylcarbaniloylmethyl <i>O,O</i> -dimethyl phosphorodithioate	1981
Fluazifop-P-butyl	butyl (<i>R</i>)-2-{4-[5-(trifluoromethyl)-2-pyridyloxy]phenoxy} propionate	1981
Glufosinate	(2 <i>RS</i>)-2-amino-4-[hydroxy(methyl)phosphinoyl]butyric acid	1981
Dinitramine	<i>N</i> 1, <i>N</i> 1-diethyl-2,6-dinitro-4-trifluoromethyl- <i>m</i> -phenylene-diamine	1982
Flurochloridone	mixture of the enantiomeric pairs (3 <i>RS</i> ,4 <i>RS</i> ;3 <i>RS</i> ,4 <i>SR</i>)-3-chloro-4-chloromethyl-1-(, , -trifluoro- <i>m</i> -tolyl)-2-pyrrolidone (isomers in the ratio 3:1)	1982
Imazamethabenz	reaction mixture of 6-[(<i>RS</i>)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]- <i>m</i> -toluic acid and 2-[(<i>RS</i>)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]- <i>p</i> -toluic acid in the ratio 3:2	1982
Metazachlor	2-chloro- <i>N</i> -(pyrazol-1-ylmethyl)acet-2',6'-xylidide	1982
Sulfometuron-methyl	Methyl 2-(4,6-dimethylpyrimidin-2-ylcarbamoylsulfamoyl) benzoate	1982
Imazapyr	2-[(<i>RS</i>)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl] nicotinic acid	1983
Imazaquin	2-[(<i>RS</i>)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl] quinoline-3-carboxylic acid	1983
Quizalofop	(<i>RS</i>)-2-[4-(6-chloroquinoxalin-2-yloxy)phenoxy]propionic acid	1983
Aclonifen	2-chloro-6-nitro-3-(phenoxy)aniline	1983
Bensulfuron-methyl	methyl -(4,6-dimethoxypyrimidin-2-ylcarbamoylsulfamoyl) - <i>o</i> -toluate	1983
Metsulfuron-methyl	2-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]-oxomethylsulfamoyl}benzoic acid methyl ester	1983
Fomesafen	5-(2-chloro- , , -trifluoro- <i>p</i> -tolylxy)- <i>N</i> -mesyl-2-nitrobenzamide	1983
Sethoxydim	(5 <i>RS</i>)-2-[(<i>EZ</i>)-1-(ethoxyimino)butyl]-5-[(2 <i>RS</i>)-2-(ethylthio)propyl]-3-hydroxycyclohex-2-en-1-one	1983

Introduction

Herbicide	Chemical nomenclature	Year of introduction
Clopyralid	3,6-dichloro-2-pyridinecarboxylic acid	1984
Pyrazoxyfen	2-[4-(2,4-dichlorobenzoyl)-1,3-dimethylpyrazol-5-yloxy]acetophenone	1984
Dimepiperate	S-1-methyl-1-phenylethyl piperidine-1-carbothioate	1984
Isoxaben	N-[3-(1-ethyl-1-methylpropyl)-1,2-oxazol-5-yl]-2,6-dimethoxybenzamide	1984
Imazethapyr	5-ethyl-2-[(RS)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]nicotinic acid	1984
Acetochlor	2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl)acetamide	1985
Cycloxydim	(RS)-2-[(EZ)-1-(ethoxyimino)butyl]-3-hydroxy-5-[(3RS)-thian-3-yl]cyclohex-2-en-1-one	1985
Thifensulfuron	1,3-dimethyl-1-(5-trifluoromethyl-1,3,4-thiadiazol-2-yl)urea	1985
Fluroxypyr	[(4-amino-3,5-dichloro-6-fluoro-2-pyridinyl)oxy]acetic acid	1985
Quinclorac	3,7-dichloro-8-quinolinecarboxylic acid	1985
Triasulfuron	1-[2-(2-chloroethoxy)phenylsulfonyl]-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)urea	1985
Quinmerac	7-chloro-3-methylquinoline-8-carboxylic acid	1985
Tribenuron-methyl	methyl-2-[4-methoxy-6-methyl-1,3,5-triazin-2-yl(methyl) carbamoyl sulfamoyl] benzoate	1985
Chlorimuron-ethyl	ethyl 2-[[[(4-chloro-6-methoxypyrimidin-2-yl) amino] carbonyl]amino] sulfonyl] benzoate	1986
Clomazone	2-[(2-chlorophenyl)methyl]-4,4-dimethyl-3-isoxazolidinone	1986
Fluxofenim	4'-chloro-2,2,2-trifluoroacetophenone (EZ)-O-1,3-dioxolan-2-ylmethyloxime	1986
Clethodim	(5RS)-2-[(E)-1-[(2E)-3-chloroallyloxyimino]propyl]-5-[(2RS)-2-(ethylthio) propyl]-3- hydroxycyclohex-2-en-1-one	1987
Cinosulfuron	1-(4,6-dimethoxy-1,3,5-triazin-2-yl)-3-[2-(2-ethoxyethoxy) phenyl sulfonyl]urea	1987
Flurtamone	(RS)-5-methylamino-2-phenyl-4-(, , -trifluoro- <i>m</i> -tolyl) furan-3(2H)-one	1987
Lactofen	ethyl-O-[5-(2-chloro- , , -trifluoro- <i>p</i> -tolylloxy)-2-nitrobenzoyl]-DL-lactate	1987
Mefenacet	2-(1,3-benzothiazol-2-yloxy)-N-methylacetanilide	1987
Primisulfuron-methyl	methyl-2-[4,6-bis(difluoromethoxy)pyrimidin-2-ylcarbamoylsulfamoyl] benzoate	1987
Prodiamine	5-dipropylamino- , , -trifluoro-4,6-dinitro- <i>o</i> -toluidine	1987
Propaquizafop	2-isopropylideneaminoxyethyl-(R)-2-[4-(6-chloroquinoxalin-2-yloxy) phenoxy]propionate	1987
Tralkoxydim	(RS)-2-[(EZ)-1-(ethoxyimino)propyl]-3-hydroxy-5-mesitylcyclohex-2-en-1-one	1987
Benzofenap	2-[4-(2,4-dichloro- <i>m</i> -toluoyl)-1,3-dimethylpyrazol-5-yloxy]-4'-methylacetophenone	1987
Fluoroglycofen	O-[5-(2-chloro- , , -trifluoro- <i>p</i> -tolylloxy)-2-nitrobenzoyl] glycolic acid	1987
Isoproturon	3-(4-isopropylphenyl)-1,1-dimethyl urea	1987

Herbicide	Chemical nomenclature	Year of introduction
Esprocarb	<i>S</i> -benzyl (<i>RS</i>)-1,2-dimethylpropyl(ethyl)thiocarbamate	1988
Prosulfocarb	<i>S</i> -benzyl dipropyl thiocarbamate	1988
Clomeprop	(<i>RS</i>)-2-(2,4-dichloro- <i>m</i> -tolyl)oxypropionanilide	1989
Cinmethylen	(1 <i>RS</i> ,2 <i>SR</i> ,4 <i>SR</i>)-1,4-epoxy- <i>p</i> -menth-2-yl 2-methylbenzyl ether	1989
Flazasulfuron	1-(4,6-dimethoxypyrimidin-2-yl)-3-(3-trifluoromethyl-2-pyridylsulfonyl)urea	1989
Isoxapyrifop	(<i>RS</i>)-2-[2-[4-(3,5-dichloro-2-pyridyloxy)phenoxy]propionyl]-1,2-oxazolidine	1989
Pyrazosulfuron-ethyl	ethyl-5-[(4,6-dimethoxypyrimidin-2-ylcarbamoyl)sulfamoyl]-1-methylpyrazole-4-carboxylate	1989
Dithiopyr	Dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)pyridine-3,5-dicarbothioate	1991
Halosulfuron-methyl	Methyl 3-chloro-5-(4,6-diamethoxypyrimidin-2-yl)carbamoyl-1-methylpyrazole-4-carboxylate	1991
Sulcotrione	2-(2-chloro-4-mesylylbenzoyl)cyclohexane-1,3-dione	1991
Nicosulfuron	2-[(4,6-dimethoxypyrimidin-2-ylcarbamoyl)sulfamoyl]- <i>N,N</i> -dimethyl nicotinamide	1992
Haloxypop	(<i>RS</i>)-2-[4-[3-chloro-5-(trifluoromethyl)-2-pyridyloxy]phenoxy]propionic acid	1993
Flumioxazin	<i>N</i> -(7-fluoro-3,4-dihydro-3-oxo-4-prop-2-ynyl-2 <i>H</i> -1,4-benzoxazin-6-yl)cyclohex-1-ene-1,2-dicarboxamide	1994
Imzasulfuron	1-(2-chloroimidazo[1,2- <i>a</i>]pyridin-3-ylsulfonyl)-3-(4,6-dimethoxy pyrimidin-2-yl)urea	1994
Methylarsonic acid	methylarsonic acid	1994
Azimsulfuron	1-(4,6-dimethoxypyrimidin-2-yl)-3-[1-methyl-4-(2-methyl-2 <i>H</i> -tetrazol-5-yl)pyrazol-5-ylsulfonyl]urea	1995
Imazapic	2-[(<i>RS</i>)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]-5-methylnicotinic acid	1996
Bispyribac-sodium	sodium 2,6-bis(4,6-dimethoxypyrimidin-2-yloxy)benzoate	1998
Iodosulfuron-methyl sodium	sodium {[5-iodo-2-(methoxycarbonyl)phenyl]sulfonyl}carbamoyl(4-methoxy-6-methyl-1,3,5-triazin-2-yl)azanide	2000
Imazamox	2-[(<i>RS</i>)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]-5-methoxymethyl nicotinic acid	2001
Mesotrione	2-(4-mesylyl-2-nitrobenzoyl)cyclohexane-1,3-dione	2001
Mesosulfuron-methyl	methyl 2-[(4,6-dimethoxypyrimidin-2-ylcarbamoyl)sulfamoyl]- <i>a</i> -(methane sulfonamido)- <i>p</i> -toluate	2001
Topramezone	[3-(4,5-dihydro-1,2-oxazol-3-yl)-4-mesylyl- <i>o</i> -tolyl](5-hydroxy-1-methylpyrazol-4-yl)methanone	2006
Orthosulfamuron	1-(4,6-dimethoxypyrimidin-2-yl)-3-[2-(dimethylcarbamoyl)phenylsulfamoyl]urea	2007
Tembotrione	2-[2-chloro-4-(methylsulfonyl)-3-[(2,2,2-(trifluoroethoxy)methyl]benzoyl]-1,3-cyclohexanedione	2007
Metazosulfuron	1-{3-chloro-1-methyl-4-[(5 <i>RS</i>)-5,6-dihydro-5-methyl-1,4,2-dioxazin-3-yl]pyrazol-5-ylsulfonyl}-3-(4,6-dimethoxy pyrimidin-2-yl)urea	2011
Monosulfuron	2-[(4-methylpyrimidin-2-yl)carbamoylsulfamoyl]benzoic acid	2012

Sources: The Pesticide Manual (BCPC), 1991 and 2012, and Pesticide Properties Database, University of Hertfordshire, 2015

The earliest attempt to control weeds in India with herbicides was made in 1937 in Punjab for controlling *Carthamus oxyacantha* by using sodium arsenite. 2,4-D was first tested in India in 1946. Since then a number of herbicides have been imported and tried for their effectiveness in controlling many weed species. In 1952, ICAR initiated schemes for testing the field performance of herbicides in rice, wheat and sugarcane in different states of India. The era of herbicide-use started effectively with the import of 2,4-D during the 1960s. But initially for a long period it was not very much acceptable to common Indian farmers. They used cheap labour to manage weed problems. In fact the organised tea planters started herbicide application with 2,4-D in the beginning; and paraquat thereafter. In field crop situations it gained importance with the increasing population pressure, more and more urbanisation, and higher input-dependent intensive agriculture. Farmers are now aware of crop loss due to weed infestation. Weed management is a compulsory event today for them to raise a crop. The labour crisis is compelling farmers to move forward with chemical weed management. Within a very short span of time, herbicide use shore up by manifolds. Now, 60 herbicides of different modes of action are registered in our country. More than 700 formulations of herbicides are available in the market. Nowadays combination formulations of two different herbicides are also becoming popular amongst farmers for broad-spectrum weed control. Even, proposal for combination formulation of more than two active principles has been suggested to the Registration Committee to combat resistant weeds.

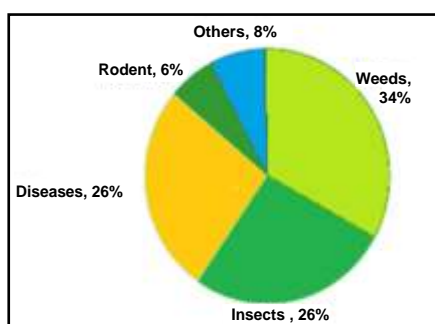


Fig. 1.1 Losses caused by different pests
Source: Tata Strategic Management Group (2014)

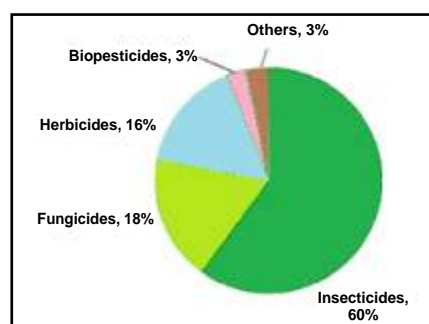


Fig. 1.2 Crop protection market segments in India
Source: Tata Strategic Management Group (2014)

The herbicide use, in comparison to industrialized countries, is significantly low in India till today. Albeit the crop loss is more due to the weed infestation than that caused by other pests (Fig 1.1), the use of insecticides takes the lion's share, around 65%, whereas, the use of herbicide is well around 16% (Fig. 1.2). Moreover, it was below 5% during 1970s and 1980s. If we consider the load of herbicides in Indian soil from the beginning, it is negligible in comparison to insecticides. But taking the lesson from industrialized countries, where the herbicide consumption is more than 65% of total pesticides, we should be alert and plan accordingly to minimize the toxicity due to herbicides in the future.

2. Herbicide Classification

In the 1940s, farmers did not have much choice for herbicides. To control broad leaf weeds, 2,4-D was used in crop fields. For non-selective weed control, herbicides like lead arsenate or salt were opted. But in the 1970s, a substantial number of herbicides of different chemical nature and with different modes of action were developed. It became urgent to develop a system to keep these products organized, so that it would be easy for the proper herbicide selection, easy diagnosis of herbicide injury symptoms, resistance management strategies, and mode and time of applications. Herbicides were classified depending upon needs, according to the time of application, viz. pre-plant, pre-emergence, and post-emergence. Also, they were classified by their method of application, viz. foliar or root absorbed; selective or non-selective; and contact or systemic. From the chemistry point of view, herbicides were classified into different chemical groups, viz. phenoxyalkanoic acid, triazines, ureas, sulfonylureas, imidazolinones, etc. (Table 2.1). But the most effective way of herbicide classification, made by the Herbicide Resistance Action Committee (HRAC) is based on their modes of action (Table 2.2). The system was not based on product names, rather focused on how a herbicide acted upon the plant. This system allows for the proper herbicide selection, resistance management strategies, and the more efficient diagnosis of herbicide injury symptoms.

Table 2.1 Chemical classification of herbicides

Group	Sub-group	Herbicides
Amide	Amide	Allidochlor, Beflubutamid, Benzadox, Benzipram, Bromobutide, Cafenstrole, CDEA, Cyprazole, Dimethenamid, Dimethenamid-P, Diphenamid, Epronaz, Etnipromid, Fentrazamide, Flupoxam, Fomesafen, Halosafen, Isocarbamid, Isoxaben, Napropamide, Naptalam, Pethoxamid, Propyzamide, Quinonamid, Tebutam
	Anilide	Chloranocryl, Cisanilide, Clomeprop, Cypromid, Diflufenican, Etobenzanid, Fenasulam, Flufenacet, Flufenican, Mefenacet, Mefluidide, Metamifop, Monalide, Naproanilide, Pentanochlor, Picolinafen, Propanil
	Arylalanine	Benzoylprop, Flamprop, Flamprop-M
	Chloroacetanilide	Acetochlor, Alachlor, Butachlor, Butenachlor, Delachlor, Diethatyl, Dimethachlor, Metazachlor, Metolachlor, S-Metolachlor, Pretilachlor, Propachlor, Propisochlor, Prynachlor, Terbuchlor, Thenylchlor, Xylachlor
	Sulfonanilide	Benzofluor, Cloransulam, Diclosulam, Florasulam, Flumetsulam, Metosulam, Perfluidone, Pyrimisulfan, Profluazol
	Sulfonamide	Asulam, Carbasulam, Fenasulam, Oryzalin, Penoxsulam, Pyroxsulam (see also Sulfonylurea herbicides)
	Thioamide	Bencarbazone, Chlorthiamid
Antibiotic		Bilanafos
Aromatic acid	Benzoic acid	Chloramben, Dicamba, 2,3,6-TBA, Tricamba
	Pyrimidinyloxybenzoic acid	Bispyribac, Pyriminobac
	Pyrimidinylthiobenzoic acid	Pyrithiobac
	Phthalic acid	Chlorthal
	Picolinic acid	Aminopyralid, Clopyralid, Picloram
Quinolinecarboxylic acid		Quinclorac, Quinmerac

Herbicide Classification

Group	Sub-group	Herbicides
Arsenical		Cacodylic Acid, CMA, DSMA, Hexaflurate, MAA, MAMA, MSMA, Potassium arsenite, Sodium arsenite
Benzoylcyclohexanedione		Mesotrione, Sulcotrione, Tefuryltrione, Tembotrione
Benzofuranyl alkylsulfonate		Benfuresate, Ethofumesate
Carbamate		Asulam, Carboxazole, Chlorprocarb, Dichlormate, Fenasulam, Karbutilate, Terbutcarb
Carbanilate		Barban, BCPC, Carbasulam, Carbetamide, CEPC, Chlorbufam, Chlorpropham, CPPC, Desmedipham, Phenisopham, Phenmedipham, Phenmedipham-ethyl, Propham, Swep
Cyclohexene oxime		Alloxydim, Butoxydim, Clethodim, Cloproxydim, Cycloxydim, Profoxydim, Sethoxydim, Tepraloxym, Tralkoxydim
Cyclopropylisoxazole		Isoxachlortole, Isoxaflutole
Dicarboximide		Benzfendizone, Cinidon-ethyl, Flumezin, Flumiclorac, Flumioxazin, Flumipropyn
Dinitroaniline		Benfluralin, Butralin, Dinitramine, Ethalfluralin, Fluchloralin, Isopropalin, Methalpropalin, Nitralin, Oryzalin, Pendimethalin, Prodiamine, Profluralin, Trifluralin
Dinitrophenol		Dinofenate, Dinoprop, Dinosam, Dinoseb, Dinoterb, DNOC, Etinofen, Medinoterb
Diphenyl ether	Diphenyl ether	Ethoxyfen
	Nitrophenyl ether	Acifluorfen, Aclonifen, Bifenox, Chlormethoxyfen, Chlornitrofen, Etnipromid, Fluorodifen, Fluoroglycofen, Fluoronitrofen, Fomesafen, Furoxyfen, Halosafen, Lactofen, Nitrofen, Nitrofluorfen, Oxyfluorfen
Dithiocarbamate		Dazomet, Metam
Halogenated aliphatic		Alorac, Chloropon, Dalapon, Flupropanate, Hexachloroacetone, Iodomethane, Methyl Bromide, Monochloroacetic Acid, SMA, TCA
Imidazolinone		Imazamethabenz, Imazamox, Imazapic, Imazapyr, Imazaquin, Imazethapyr
Nitrile		Bromobonil, Bromoxynil, Chloroxynil, Dichlobenil, Iodobonil, Ioxynil, Pyraclonil
Organophosphorus		Amiprofos-Methyl, Anilofos, Bensulide, Bilanafos, Butamifos, 2,4-DEP, DMPA, EBEP, Fosamine, Glufosinate, Glyphosate, Piperophos
Oxadiazolone		Dimefuron, Methazole, Oxadiargyl, Oxadiazon
Phenoxy	Phenoxy	Bromofenoxim, Clomeprop, 2,4-DEB, 2,4-DEP, Difenopenten, Disul, Erbon, Etnipromid, Fenteracol, Trifopsime
	Phenoxyacetic	4-CPA, 2,4-D, 3,4-DA, MCPA, MCPA-thioethyl, 2,4,5-T
	Phenoxybutyric	4-CPB, 2,4-DB, 3,4-DB, MCPB, 2,4,5-TB
	Phenoxypropionic	Cloprop, 4-CPP, Dichlorprop, Dichlorprop-P, 3,4-DP, Fenoprop, Mecoprop, Mecoprop-P,
	Aryloxyphenoxy propionic	Chlorazifop, Clodinafop, Clofop, Cyhalofop, Diclofop, Fenoxaprop, Fenoxaprop-P, Fenthiaprop, Fluazifop, Fluazifop-P, Haloxyfop, Haloxyfop-P, Isoxapyrifop, Metamifop, Propaquizafop, Quizalofop, Quizalofop-P, Trifop
Phenylenediamine		Dinitramine, Prodiamine
Pyrazole	Pyrazole	Azimsulfuron, Difenzoquat, Halosulfuron, Metazachlor, Pyrazosulfuron, Pyroxasulfone
	Benzoylpyrazole	Benzofenap, Pyrasulfotole, Pyrazolynate, Pyrazoxyfen, Topramezone
	Phenylpyrazole	Fluazolate Nipyraclofen Pyraflufen

Group	Sub-group	Herbicides
Pyridazine		Credazine, Pyridafol, Pyridate
Pyridazinone		Brompyrazon, Chloridazon, Dimidazon, Flufenpyr, Metflurazon, Norflurazon, Oxapyrazon, Pydanon,
Pyridine		Aminopyralid, Clodinate, Clopyralid, Dithiopyr, Fluroxypyr, Haloxydine, Picloram, Picolinafen, Pyriclor, Pyroxsulam, Thiazopyr, Triclopyr
Pyrimidinediamine		Iprymidam, Tioclorim
Quaternary ammonium		Cyperquat, Diethamquat, Difenzoquat, Diquat, Morfamquat, Paraquat
Thiocarbamate		Butylate, Cycloate, Di-allate, EPTC, Esprocarb, Ethiolate, Isopolinate, Methiobencarb, Molinate, Orbencarb, Pebulate, Prosulfocarb, Pyributicarb, Sulfallate, Thiobencarb, Tiocarbazil, Tri-allate, Vernolate
Thiocarbonate		Dimexano, EXD, Proxan
Thiourea		Methiuron
Triazine	Triazine	Dipropetryn, Triaziflam, Trihydroxytriazine
	Chlorotriazine	Atrazine, Chlorazine, Cyanazine, Cyprazine, Eglinazine, Ipazine, Mesoprazine, Procyazine, Proglinazine, Propazine, Sebuthylazine, Simazine, Terbutylazine, Trietazine
	Methoxytriazine	Atraton, Methometon, Prometon, Sebumeton, Simeton, Terbumeton
	Methylthiotriazine	Ametryn, Aziprotryne, Cyanatryn, Desmetryn, Dimethametryn, Methoprotryne, Prometryn, Simetryn, Terbutryn
Triazinone		Ametridione, Amibuzin, Hexazinone, Isomethiozin, Metamitron, Metribuzin,
Triazole		Amitrole, Cafenstrole, Epronaz, Flupoxam
Triazolone		Amicarbazone, Bencarbazone, Carfentrazone, Flucarbazone, Propoxycarbazone, Sulfentrazone, Thienicarbazone
Triazolopyrimidine		Cloransulam, Diclosulam, Florasulam, Flumetsulam, Metosulam, Penoxsulam, Pyroxsulam
Uracil		Butafenacil, Bromacil, Flupropacil, Isocil, Lenacil, Terbacil
Urea	Urea	Benzthiazuron, Cumyluron, Cycluron, Dichloralurea, Diflufenzopyr, Isonoruron, Isouron, Methabenzthiazuron, Monisouron, Noruron
	Phenylurea	Anisuron, Buturon, Chlorbromuron, Chloreturon, Chlorotoluron, Chloroxuron, Daimuron, Difenoxuron, Dimefuron, Diuron, Fenuron, Fluometuron, Fluothiuron, Isoproturon, Linuron, Methiuron, Methylmymron, Metobenzuron, Metobromuron, Metoxuron, Monolinuron, Monuron, Neburon, Parafluron, Phenobenzuron, Siduron, Tetrafluron, Thidiazuron
	Pyrimidinyl sulfonylurea	Amidosulfuron, Azimsulfuron, Bensulfuron, Chlorimuron, Cyclosulfamuron, Ethoxysulfuron, Flazasulfuron, Flucetosulfuron, Flupyralsulfuron, Foramsulfuron, Halosulfuron, Imazosulfuron, Mesosulfuron, Nicosulfuron, Orthosulfamuron, Oxasulfuron, Primisulfuron, Pyrazosulfuron, Rimsulfuron, Sulfometuron, Sulfosulfuron, Trifloxysulfuron
	Triazinyl sulfonylurea	Chlorsulfuron, Cinosulfuron, Ethametsulfuron, Iodosulfuron, Metsulfuron, Prosulfuron, Thifensulfuron, Triasulfuron, Tribenuron, Triflusulfuron, Tritosulfuron
	Thiadiazolylurea	Buthiuron, Ethidimuron, Tebuthiuron, Thiazafuron, Thidiazuron

Herbicide Classification

Group	Sub-group	Herbicides
Unclassified		Acrolein, Allyl alcohol, Azafenidin, Benazolin, Bentazone, Benzobicyclon, Buthidazole, Calcium cyanamide, Cambendichlor, Chlorfenac, Chlorfenprop, Chlorflurazole, Chlorflurenol, Cinmethylin, Clomazone, CPMF, Cresol, Ortho-dichlorobenzene, Dimepiperate, Endothal, Fluoromidine, Fluridone, Flurochloridone, Flurtamone, Fluthiacet, Indanofan, Methyl isothiocyanate, OCH, Oxaziclomefone, Pentachlorophenol, Pentoxazone, Phenylmercury acetate, Pinoxaden, Prosulfalin, Pyribenzoxim, Pyriftalid, Quinoclamine, Rhodethanil, Sulglycapin, Thidiazimin, Tridiphane, Trimeturon, Tripropindan, Tritac
Inorganic		Ammonium sulfamate, Borax, Calcium chlorate, Copper sulfate, Ferrous sulfate, Potassium azide, Potassium cyanate, Sodium azide, Sodium chlorate, Sulfuric acid

Table 2.2 Herbicide Resistance Action Committee (HRAC) - classification of herbicides

Mode of action	Chemical family	Active ingredient
Inhibition of acetyl CoA carboxylase (ACCase)	Aryloxyphenoxy propionate Cyclohexanedione	Fenoxaprop, Fluazifop, Quizalofop Clethodim, Sethoxydim
Inhibition of acetolactate synthase (ALS)	Sulfonylurea	Chlorimuron, Chlorsulfuron, Foramsulfuron, Halosulfuron, Iodosulfuron, Nicosulfuron, Primisulfuron, Prosulfuron, Rimsulfuron, Sulfometuron, Thifensulfuron, Tribenuron
	Imidazolinone Triazolopyrimidine	Imazamox, Imazapyr, Imazaquin, Imazethapyr, Flumetsulam, Cloransulam
Inhibition of microtubule assembly	Dinitroaniline	Benfen, Ethalfuralin, Pendimethalin, Trifluralin
Inhibition of indoleacetic acid transport	Phenoxy	2,4-D, MCPA, MCPP
	Benzoic acid	Dicamba
	Carboxylic acid	Clopyralid, Fluroxypyr, Picloram, Triclopyr
	Semicarbazone	Diffenozopyr
Inhibition of photosynthesis at photosystem II site A	Triazine	Atrazine, Ametryn, Prometon, Simazine
	Triazinone	Hexazinone, Metribuzin
	Uracil	Bromacil, Terbacil
Inhibition of photosynthesis at photosystem II site B	Nitrile	Bromoxynil
	Benzothiadiazole	Bentazon
Inhibition of photosynthesis at photosystem II site A- different binding behavior	Urea	Diuron, Linuron, Tebuthiuron
Photosystem I - electron diversion	Bipyridilium	Paraquat, Diquat

Mode of action	Chemical family	Active ingredient
Inhibition of EPSP synthase	None accepted	Glyphosate
Inhibition of glutamine synthetase	None accepted	Glufosinate
Inhibition of lipid biosynthesis - not ACCase inhibition	Thiocarbamate	Butylate, EPTC
Bleaching: Inhibition of DOXP synthase	Isoxazolidinone	Clomazone
Bleaching: Inhibition of 4-HPPD	Isoxazole	Isoxaflutole
	Triketone	Mesotrione, Sulcotrione
	Pyrazolone	Topramezone
Inhibition of protoporphyrinogen oxidase (Protox or PPO)	Diphenylether	Acifluorfen, Fomesafen, Lactofen
	N-Phenylphthalimide	Flumiclorac, Flumioxazin
	Aryl triazinone	Sulfentrazone, Carfentrazone
Inhibition of synthesis of very-long-chain fatty acids (VLCFA)	Chloroacetamide	Acetochlor, Alachlor, Metolachlor, s-Metolachlor, Dimethenamid
	Oxyacetamide	Flufenacet

3. Herbicide Regulation and Registration

The Ministry of Agriculture, Government of India regulates the manufacture, sale, import, export and use of herbicides through the 'Insecticides Act, 1968'. Central Insecticides Board (CIB) constituted under Section 4 of the Act advises Central and State Governments on technical matters. The Registration Committee (RC) constituted under section 5 of the Act approves the use of pesticides and new formulations to tackle the pest problem in various crops. The Registration Committee is responsible to register pesticides after scrutinizing the chemistry, bioefficacy and toxicology of the products. Presently 60 technical herbicides and 17 combination herbicides are registered (as on 20.10.2015) for use in our country (Table 3.1 and 3.2). Some herbicides, which were once registered are presently debarred from use in agriculture due to various problems, mainly related to toxicology (Table 3.3).

Table 3.1 Herbicides and their formulations registered in India under the Insecticides Act, 1968

S. No.	Name of herbicide	Formulation registered
1.	2,4-Dichlorophenoxy acetic acid (2,4-D sodium, amine and ester salt)	a) 2,4-D sodium salt used as tech a.i. 80% w/w min. b) 2,4-D amine salt 58% SL 22.5% SL c) 2,4-D ethyl ester 38% EC, 4.5% Gr, 20% WP
2.	Alachlor	50% EC, 10% Gr
3.	Anilofos	30% EC, 18% EC
4.	Atrazine	50% WP
5.	Azimsulfuron	50% DF
6.	Bensulfuron-methyl	60% DF
7.	Bispyribac-sodium	10% SC
8.	Butachlor	50% EC, 5% Gr, 50% EW
9.	Carfentrazone-ethyl	40% EC
10.	Chlorimuron-ethyl	25% WP
11.	Chlorpropham	50% HN
12.	Cinmethylin	10% EC
13.	Clodinafop-propargyl (Pyroxofop-propinyl)	15% WP
14.	Clomazone	50% EC
15.	Cyhalofop-butyl	10% EC
16.	Dazomet	Dazomet technical (soil sterilant Gr)
17.	Diclofop-methyl	28% EC
18.	Diclosulam	84% WDG
19.	Diuron	80% WP
20.	Ethoxysulfuron	10% EC
21.	Fenoxaprop-P-ethyl	10% EC, 9.3% EC one time import, 6.7% EC
22.	Fluazifop-P-butyl	13.4% EC
23.	Fluchloralin	45% EC
24.	Flufenacet	60% WP
25.	Glufosinate-ammonium	13.5% SL
26.	Glyphosate	41% SL, 20.2% SL, 5% SL
27.	Glyphosate-ammonium salt	71% SG
28.	Halosulfuron-methyl	75% WG
29.	Imazamox	In combination product
30.	Imazethapyr	10% EC
31.	Isoproturon	50% WP, 75% WP, 50% Flow

S. No.	Name of herbicide	Formulation registered
32.	Linuron	50% WP
33.	Methabenzthiazuron	70% WP
34.	Methyl chlorophenoxy acetic acid	40% SL or 40% WSC (amine salt)
35.	Metsulfuron-methyl	20% WDG, 20% WG
36.	Metolachlor	50% EC
37.	Metribuzin	70% WP
38.	Orthosulfamuron	50% WDG
39.	Oxadiazon	25% EC
40.	Oxadiargyl	80% WP, 6% EC
41.	Oxyfluorfen	23.5% EC, 0.35% Gr
42.	Paraquat dichloride	24% SL
43.	Pendimethalin	30% EC, 5% Gr, 38.7% CS
44.	Penoxsulum	21.7% SC
45.	Pinoxaden	5.1% EC
46.	Pretilachlor	50% EC, 30.7% w/w EC, 37.0% EW
47.	Propanil	35% EC
48.	Propaquizafop	10% EC
49.	Pyrazosulfuron-ethyl	10% WP
50.	Pyrithiobac-sodium	10% EC
51.	Quizalofop-ethyl	5% EC
52.	Quizalofop-P-tefuryl	4% EC
53.	Sirmate	38% WP, 4% Gr
54.	Sulfosulfuron	75% WG
55.	Tembotrione	34.4% SC
56.	Thiobencarb (Benthiocarb)	50% EC, 10% Gr
57.	Topramezone	33.6% SC
58.	Triallate	50% EC
59.	Triasulfuron	20% WG
60.	Trifluralin	48% EC

Source: Insecticides / Pesticides Registered under section 9(3) of the Insecticides Act, 1968 for use in the Country (as on 20/10/2015), Central Insecticides Board and Registration Committee, Ministry of Agriculture, Government of India

Herbicides applied in combination either pre-plant incorporated or pre-emergence or post-emergence generally increase the spectrum of weed control or the length of residual weed control. Tank-mixing of herbicides may improve the spectrum of weeds controlled in a single application which saves time and labour in a weed management programme. Mixing compatible herbicides from different chemical families may improve control of specific weed populations, such as 2,4-D applied with dicamba for broadleaf weeds. Herbicide combinations may also provide control of several weed types at the same time, such as grassy and broadleaf weeds. For example, the combinations of mesosulfuron and iodosulfuron, clodinafop and metsulfuron, and sulfosulfuron and metsulfuron control both grasses and broad leaf weeds in wheat. The combination product of chlorimuron and metsulfuron controls sedges and grassy weeds in rice. In soybean, pendimethalin + imazethapyr and imazamox + imazethapyr control grasses and broad leaf weeds. Presently, in our country, 14 combination products of two active ingredients are available. Recently, Registration Committee, Central Insecticide Board has given approval for the combination pesticides having three active ingredients. New combination products containing three active ingredients will be very useful in controlling grassy weeds, broadleaf weeds, and sedges at a time saving application cost and time. This trend in herbicide combination products is likely to continue in the crop production.

Table 3.2 List of herbicide combination products registered in India

Sl. No.	Combination product	Sl. No.	Combination product
1	Anilofos 24% + 2,4-D 32% EC	9	Pendimethalin 30%+Imazethapyr 2% EC
2	Bensulfuron methyl 0.6% + Pretilachlor 6% Gr	10	Clodinafop-propargyl 15% + Metsulfuron-methyl 1% WP
3	Clomazone 20% + 2,4-D ethyl ester 30% EC	11	Sulfosulfuran 75%+ Metsulfuron-methyl 5% WG
4	Fenoxaprop-P-ethyl 7.77% + Metribuzin 13.6% EC	12	Imazethapyr 2% + Pendimethalin 30% EC
5	Hexazinone 13.2%+Diuron 46.8% WP	13	Carfentrazone-ethyl 20% + Sulfosulfuron 25% WG
6	Imazamox 35%+Imazethapyr 35% WG	14	Sodium acefluorfen 16.5% + Clodinafop-propargyl 8% EC
7	Mesosulfuron-methyl 3% + Iodosulfuron-methyl sodium 0.6% WG	15	Clodinafop-propargyl 9% + Metribuzin 20% WP
8	Metsulfuron-methyl 10% + Chlorimuron ethyl 10% WP	16	Clodinafop-propargyl 12% + Metribuzin 42% WG
		17	Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% Gr

Source: Insecticides / Pesticides Registered under section 9(3) of the Insecticides Act, 1968 for use in the Country (as on 20/10/2015), Central Insecticides Board and Registration Committee, Ministry of Agriculture, GOI

Table 3.3 Banned, withdrawn, refused and restricted-in-use herbicides in India

Herbicides banned in India	Nitrofen, Paraquat dimethyl sulphate, Metoxuron
Herbicides withdrawn in India	Dalapon, Simazine
Herbicides with refused registration	2,4,5-T, Ammonium sulphamate, Calcium arsenate, TCA
Herbicide restricted in use	Dazomet (The use of dazomet is not permitted on tea)

India has more than 800 pesticide formulators. Herbicides under 9(4) registration are formulated and marketed by many companies. A few hundreds of formulations of registered herbicides are available in Indian market. Some major formulations with brand names are given in Table 3.4.

Table 3.4 Brand names and manufacturers of herbicides

Herbicide	Brand names and manufacturers
2,4-Dichlorophenoxy acetic acid	80% WP (sodium salt): Fernoxone (Syngenta), Weedmar-80 (Dhanuka Agritech Ltd.), Chem-D (Shaw Wallace), K-D (Krishi Rasayan), TCM 2,4-D sodium salt (TCM), Safaya (Devidayal), Weed Killer (Okruiti), Volvo (UPL Ltd.), Heera super (Hindustan Pulverising), Kaal (Plant Remedies), Cut Out (Crystal), Naagsol (Multiplex), Super hit (Insecticide India), 2,4-D Agan (ADAMA)
	58% SL (amine salt): Champion (Herbicide India), Chem-amine (Shaw Wallace), Naagmin (Multiplex), Heera (Hindustan Pulverising), Amine ester (Dhanuka Agritech Ltd.), Shaktiman amine eseter (Indo Gulf), Weed out (Bharat Rasayan), PC 2,4-D (Punjab Chemicals), Aminosol (Solas Crop Tech), Twister (Insecticide India), 2,4-D Main (ADAMA), Weedcel Super (Excel)
	38% EC (ethyl ester): Slash (Monsanto), Weedmar (Dhanuka Agritech Ltd.), Agni (FILnd), Chem-est (Shaw Wallace), Smash (Nagarjuna), Heera 44 (Hindustan Pulverising), Anu weed (Anu), Champion (Herbicide India), Weed burn (Dara Chem), Nagester (Multiplex), Goldiseed (Swaraj), Electron (Devidayal), Super star (JU Pesti), Plant 2,4-D (Plant Remedies),

Herbicide	Brand names and manufacturers
	Eleminator (Hem-an), Tusker (Shri Ram Agro), Cut out and Cut Short (Crystal), Kill Herb (Tropical Agro), Hit (Insecticide India)
	34% EC (ethyl ester): K-D (Krishi Rasayan)
	20% WP (ethyl ester): Anuweed (Anu), Kill herb (Tropical Agro), Champion (Herbicide India)
	4.5% Gr (ethyl ester): Smash (Nagarjuna), Cut Out (Crystal)
Alachlor	50% EC: Lasso (Monsanto), Alachlor (Dhanuka Agritech Ltd.), Attack
	25% EC: Catch (Isagro) (Nagarjuna), Allert (Tropical Agro), Dorado (PI Ind.);
	10% Gr : Lasso (Monsanto), Attack (Nagarjuna)
Anilophos	30% EC: Arozone (Bayer), Sumo (DuPont), Anilogourd (Gharda), Hilanil (HIL), Anilodhan (Dhanuka Agritech Ltd.), Surya (EID Parry), Anilohit (Hindustan Pulverising), Ricil (Dow), Anilostar (Shaw Wallace) Anilotaf (Rallis), Anugaurd (Anu), Anilophos (Nagarjuna), Anilex (FIL Ind.), Avail (Herbicide India), Tag guard (Tropical Agro), Anilon (Sulfur Mills), Anilocide and Quatar (Bharat Rasayan), Anilospeak (TAC), Anilovip (Godrej), Anilocide and Army (Insecticide India), Rainbow (Gujarat Krishi), Shreeramanilo (Shri Ram Chem), Strong (Dara Chem), Libra (PI Ind.), Angola (JU Pesticide), Hemilophos (Hem-an), Foster (Devidayal), Anilon and Aniloshree (Crystal), Nidan (Gujarat Insecticides Ltd.)
	18% EC: Rico (Bayer)
	60% LC: Bulk (Bayer)
	2% Gr: Arozone (Bayer)
Atrazine	50% WP: Solaro (PI Ind.), Atrataf (Rallis), Dhanuzine (Dhanuka Agritech Ltd.), Gesaprim (Syngenta), Atrafil (Indofil), Anutaf (Anu), Atrahit (Hindustan Pulverising), Rasayanzin (Krishi Rasayan), Surya (Nagarjun), Atravip (Godrej), Atrasul (Sulfur Mills), Tagtaf (Tropical Agro), Atrazine (EID Parry), Attack (Devi Dayal), Pearl (UPL Ltd.), Ultra (JU Pesti), Nagzine (Multiplex), Merkzine (Merk Fed), Atrazine (Coromondal), Tofa (Bharat Rasayan), SMP (FIL Industries), Atrazide (Hem-an), Sreejon and Reed off (Crystal), Ratrazine (Shri Ram Chem), Petra (Cheminova), Atranex (ADAMA), Atrea (Heranba), Xtrazine (GSP), Atracel (Excel), Citra (Punjab Chemicals), Attrastar (Shaw Wallace)
Azimsulfuron	50% DF: Segment (DuPont)
Bispyribac-sodium	10% SC: Nominee Gold (PL Ind), Adora (Bayer), TKS-PYRI (Tata Chemicals), Taarak (Rallis)
Butachlor	50% EC: Machete and Aristo (Monsanto), Check-out (UPL Ltd.), Trap (Isagro), Bilchlor (Bayer), Teer (Rallis), Dhanuchlor (Dhanuka Agritech Ltd.), Weedkill (Sudershan), Hiltachlor (HIL), Biochlor and Hunter (Hindustan Pulverising), Delchlor (Coromondal), Aimchlor (AIMCO), Rasayanchlor (Krishi Rasayan), Anuchlor (Anu), Weeper (Nagarjun), Estachlor (ECI), Starchlor (Shaw Wallace), Sterchlor (Stirling), Finish (FIL Ind.), Punch (Herbicide India), Nagchlor (Multiplex), Thunder (Tropical Agro), Weed out (Sulfur Mills), Goldchlor (Swaraj), Butacid and Guru (Bharat Rasayan), Tackchlor (TAC), Gamachlor (Andu), Cenchlor (Century), Butabic (Vikrant), Tarachlor (Tarama), Shaktiman butachlor (Indo-Gulf), Shrirambuta (Shri Ram Chem), Ratcheat (Plant Remedies), Vanchlor (Vantech), Megachlor (Meghmani), Currant (Somanil), Butadel (Del company), Darachlor (Dara Chem), Butavip (Godrej), Betaten

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Herbicide	Brand names and manufacturers
	(Devidayal), Cropchlor ((JU Pest), Merkchlor (Merkfed), Burnchlor (Heman), Bumper and Topper (Crystal), Millchlor (Insecticide India), TKS buta (Tata Chem.), Herachlor (Heranba)
	5% Gr: Machete (Monsanto), Trap (Isagro), Dhanuchlor (Dhanuka Agritech Ltd.), Hiltachlor (HIL), Delchlor (Coromandel), Rasayanchlor (Krishi Rasayan), Anuchlor (Anu), Weeper (Nagarjun), Estachlor (ECI), Sterchlor (Stirling), Finish granule (FIL Ind.), Punch (Herbicide India), Thunder (Tropical Agro), Weed out (Sulphur Mills), Butabic-G (Vikrant), Tarachlor (Tarama), Shaktiman butachlor (Indo-Gulf), Ratcheat (Plant Remedies), Vanchlor (Vantech), Butachlor (Dara Chem), Cropchlor ((JU Pest), Bumper (Crystal), Rajchlor (RPC), Millchlor (Insecticide India)
	50% EW: Fastmix (Monsanto), Superfirst (Bharat rasayan), Hunter super (Hindustan Pulverising), Don mix (Dhanuka Agritech Ltd.), Fastest (Anu), Millfast (Insecticide India)
Carfentrazone-ethyl	40% DF : Affinity (FMC India Pvt. Ltd.)
Chlorimuron-ethyl	25% WP: Kloben (DuPont), Rise (Hindustan Pulverising), Curin (Dhanuka Agritech Ltd.), Falone (Crystal), Blumen (ADAMA), Flat (Indofil)
Cinmethylin	10% EC : Argold (BASF)
Clodinafop-propargyl	15% WP : Topic (Syngenta), Dinofop (Dhanuka Agritech Ltd.) Award (Herbicide India), Jhatka (UPL Ltd.), Weeddout (Godrej), Aches (Biostadt), Cloudy (UPL Ltd.), Moolah (Chemtura), Ohm (Punjab Chemicals), Skipper (Coromandel), Rakshak (Cheminova), Topple (Shaw Wallace), Sartaj (Rallis)
Clomazone	50% EC : Command (FMC)
Cyhalofop-butyl	10% EC : Clincher (Dow), Wrap-up (Dhanuka Agritech Ltd.), Tata Cylo (Rallis), Cyhalofop-butyl (Excel), Dentil (Cheminova)
Diclofop-methyl	28% EC : Illoxan (Bayer)
Diuron	80% WP : Klass (Bayer), Diuron (Northern Min.), True (Herbicide India), Naguron (Multiplex), Diurex (ADAMA)
Diclosulam	84% WDG : Strongarm (Dow)
Ethoxysulfuron	15% WG : Sunrice (Bayer)
Fenoxaprop-P-ethyl	10% EC: Puma Power (Bayer), Phenox (Dhanuka Agritech Ltd.) Super Power (Herbicide India), Rider (Crystal), Nagfenop (Multiplex), Ficol (Rallis), Devi Slash (Devidayal)
	9.3% EC: Weepsuper (Bayer)
	6.9% EC: Ricestar (Bayer)
Fluazifop-P-butyl	9% EC: Fusilade Super (Syngenta)
Fluchloralin	45% EC: Basalin (BASF), Dhanulin (Dhanuka Agritech Ltd.), Nagflur (Multiplex), Anulin (Anu), Vicolin (Gujarat Krishi), Herbilin (Herbicide India), Flight (Devidayal)
Glufosinate-ammonium	13.5% SL: Basta (Bayer), Liberty (Bayer)

Herbicide	Brand names and manufacturers
Glyphosate	41% SL: Roundup (Monsanto), Glycel (Excel), Brake (Biostadt), Sweep (UPL Ltd.), Winner (Cheminova), Noweed (Northern Min.), PI Glypho (PI Ind.), Weedoff (Dow), Krup and Kriup (Krishi Rasayan), Vinash (Sulfur Mills), Catlus (Gujarat Krishi), Groundup (Hindustan Pulverising), Clean up (Indofil), Safal (Tropical Agro), Clear out (Anu), Wonder (Herbicide India), Glycovip (Godrej), Dryphosate (Shaw Wallace), Root Out (Bharat Rasayan), Nag Glypo (Multiplex), Gly-weed (Sabero), Trinnashi (HIL), Irador (Hem-an), Cleanton (Crystal), Touch down (Syngenta), Hijack (Insecticide India), Glycide (Shri Ram Chem), Bonus (JU Pest), Prepare (Bayer), Glyder (Gharda), Leanch (Isagro), Globus (Nagarjuna), Glyphogun (ADAMA), Popular (Aristo), Phosgly (Tata Chem), Glory (Heranba), Run out (GSP), Gladiator (Devidayal), Glycor (Coromandel), Veto (Punjab Chemicals), Glytaf (Rallis), Glyphos (Shri Ram Agro)
	71% SC: Urgent SG (Bayer), Glyphos Ducker (Cheminova), Andhi 71 (Bharat Rasayan), Excel Meera 71 (Excel), Veto Plus (Punjab Chemicals), Killshot (Coromandel), Star71 (Shaw Wallace)
	5% SL: Take-5 (Excel)
	20.2% SL: Gamboy (Excel)
Halosulfuron-methyl	75% SG : Sempra (Dhanuka Agritech Ltd.)
Imazethapyr	10% SL: Pursuit (BASF), Inro (PI Ind.), Shikhor (Bharat Rasayan), Cheetah (Hindustan Pulverising), Fervent (Coromandel), Spur (Shaw Wallace), Tata Vaar (Rallis)
	10% EC: Class
Isoproturon	75% WP: Record (DuPont), Bilon (Bayer), Rakshak (Cheminova), Tolcan and Erelon (Bayer), Isogourd (Gharda), Dhanulon (Dhanuka Agritech Ltd.), Isohit (Hindustan Pulverising), Nocilon (Dow), Graminon (Syngenta), Keturon and Krilon (Krishi Rasayan), Anulon (Anu), Norilon (Nagarjuna), Isoper (EID Parry), Isostar (Show Wallace), Miracle (FIL Ind.), Sarpanch (Herbicide India), Isoproturon (Devidayal), Wonder (Tropical Agro), Proton-75 (Sulfur Mills), Goldron (Swaraj), Isolon and Ghashmar (Bharat Rasayan), Isovip (Godrej), Sonaron (Gujarat Krishi), Shree Ram iso (Shree Ram Chem), Shaktiman isoproturon (Indo-Gulf), Passport (Isagro), Delkron (Coromandel), Somilon (Somanil), Kanak (Paushak), Meghalon (Meghmani), Dararon (Dara Chem), Josh (Sudershan), Eleminron (Hem-an), Sreelon and Kripan (Crystal), Dragon (JU Pesticides), Taurus (PI Ind.), Plant Iso (Plant Remedies), Merklon (Mark Fed), Milron and Skylark (Insecticide India)
	50% WP: Tolcan and Erelon (Bayer), Rakshak (Cheminova), Dhanulon (Dhanuka Agritech Ltd.), Isohit (Hindustan Pulverising), Krilon (Krishi Rasayan), Isostar (Show Wallace), Sarpanch (Herbicide India), Isoproturon (Devi Dayal), Wonder (Tropical Agro), Somilon (Somanil), Kanak (Paushak), Proton-50 (Sulfur Mills), Isolon (Bharat Rasayan) Taurus (PI Ind.), Sonaron (Gujarat Krishi), HIL-proturon (HIL)
Linuron	50% WP : Afalon (Aventice), Lorox (Rallis)
Mesosulfuron-methyl + Iodosulfuron-methyl sodium	3.6% WG : Atlantis (Bayer)
Methabenzthiazuron	70% WP : Dhanulin (Dhanuka Agritech Ltd.), Tribunil (Bayer)

Herbicide Regulation and Registration

Herbicide	Brand names and manufacturers
Methyl chlorophenoxy acetic acid (MCPA)	40% SL : MCPA amine-salt (Hindustan Pulverising)
Metolachlor	50% EC : Dual (Syngenta)
Metribuzin	70% WP : Sencor (Bayer), Tata Metri (Rallis), Barrier (Dhanuka Agritech Ltd.), Chase (Indofil), Krizine (Krishi Rasayan), Stump (Hindustan Pulverising), Desire (Tropical Agro), Macro (Sulfur Mills), Mohra (Anu), Zero weed (Bharat Rasayan), Jet Strike (Sudershan), Herbi Metri (Herbicide India), JU Merit (JU Pest), Laskar (UPL Ltd.), Shri Ram metrizine (Shri Ram Chem), Imetar (ECI), Merker (Markfed), Century (FIL Ind), Metshort (Hem-an), Shreecor and Tidemetri (Crystal), Genius (Shri Ram Agro), Hilmetri (HIL), Metribusvip (Godrej), Anchlor (Insecticide India), Metiherb (Cheminova), Metex (Excel), Emax (Nagarjuna), Weedclean (Super Agro), Encor (Devidayal), Metriagan (ADAMA), Grometri (Coromandel), Verdict (GSP)
Metsulfuron-methyl	20% WP: Algrip (DuPont), Metsy (UPL Ltd.), Freedom and Hygrip (Hindstan Pulverising), Bilgrip (Bharat Rasayan), Teg (Rallis), Volt (FIL Ind.), Rado and Algo (Crystal), Hook (Dhanuka Agritech Ltd.), Weed grip (Insecticide India), Metsil-M (Isagro), JU-grip (JU Pesticide), Dot (Nagarjuna), Nikanor (ADAMA), Metcil (Cheminova), Metro (Heranba), Siege (Punjab Chemicals), Metcil M (Cheminova), Metstar (Shaw Wallace)
Oxadiazyl	80% WP: Topstar (Bayer)
	6% EC: Raft (Bayer)
Oxadiazon	25% EC: Ronstar (Bayer)
Oxyfluorfen	23.5% EC: Goal (Bayer), Oxygold (Indofil), Oxykill (Dhanuka Agritech Ltd.), Crall (Krishi Rasayan), Alto (FIL Ind.), Herbigold (Herbicide India), Waada (Hindustan Pulverising), Honcho (Rallis)
Paraquat dichloride	24% EC: Gramoxone (Syngenta), Uniquat (UPL Ltd.), Hanuxone (Dhanuka Agritech Ltd.), Weedax (Coromandel), Swat (Shaw Wallace), Paralac (Rallis)
Pendimethalin	38.7% CS: Stomp xtra (BASF), Pendigold (Syngenta), Tata Ponida (Rallis), Bunker (PI Ind.), Stop (Krisi Rasayan), Gaadar (Hindustan Pulverising), Anustorm (Anu), Pendiguard (Gharda), Penadril (Crystal), Pendiherb (Cheminova), Dhanustomp (Dhanuka Agritech Ltd.), Penda (Bharat Insecticide), Excel Plus (Excel), Speed (Indofil), Nagastra (Nagarjuna), Eezykill (Coromandel), Swalpendi (Shaw Wallace)
	5% Gr : Prowl (BASF), Klean up (Punjab Chemicals)
Pretilachlor	50% EC: Rifit (Syngenta), Pretiherb (Cheminova), Remove (Biostadt), Delete (Godrej), Erase (Nagarjuna), Offset (Indofil), Tatapreet (Rallis), Hifit (Hindustan Pulverising), Blade (Gharda), Sureshot (Sulfur Mills), Shri Ram pretilachlor (Shri Ram Chem), Alchor (PI Ind.), Pretit (FIL Ind.), Pilot (EID Parry), Pilot (Coromandel), Excel merit (Excel), Errant (Bharat Rasayan), Razor (Plant Remedies), HIL-Preti (HIL), Fiesta (FMC), Prince (Krishi Rasayan), Sift and Growfit (Crystal), Weep (Hem-an), Pretobest (DuPont),

Herbicide	Brand names and manufacturers
	Craxe (Dhanuka Agritech Ltd.), Giant (ECI), Nag Pretichlor (Multiplex), Racer (Insecticides India), Profit (Devidayal), Phenom (Sudershan), Sicle (GSP), Lorette (Coromandel), Zinta (Heranba), Dismiss (Isagro), Pretigan (Makhsteshim-Agan), TKS Pretila (Tata Chem), Klean Out (Punjab Chemicals), Pitla (Shaw Wallace), Preet (Rallis), Vinia (Atul)
	30.7%EC: Erase-N (Nagarjuna), Errant-N (Bharat Rasayan), Sofit (Syngenta), Pretigan-S (ADAMA), Wranglar (Super Agro)
	30% EW: Erasan (Syngenta)
Pinoxaden	5% EC: Axial (Syngenta)
Propanil	35% EC: Stam F-34 (Indofil), Dhanustam (Dhanuka Agritech Ltd.), Melsa (PI Ind.)
Propaquizafop	10% EC: Society (Indofil)
Pyrazosulfuron-ethyl	10% WP: Saathi (UPL Ltd.)
Pyrithiobac-sodium	10% EC: Theme (DuPont), Rife (Cheminova)
Quizalofop-ethyl	5% EC: Targa Super (Dhanuka Agritech Ltd.), Assure (DuPont)
Quizalofop-P-tefuryl	4% EC: Pantara (DuPont)
Sulfosulfuron	75% WP: Sulfo and SF 10 (UPL Ltd.), Safal (Gharda), Décor (Indofil), Don (Herbicide India), Leader (Sumitomo), Nagsuron (Multiplex), Target (Hindustan Pulverising), Fateh (Rallis), Wazir (Bharat Rasayan), Arrow (Sulfur Mills), Top shot (Hem-an), Kaizer and Guru (Insecticide India), Safari (Devidayal), Clear (GSP), Razor or Kripon (Crystal), Sumet (Cheminova), Excel-Lolkar (Excel), Toss (JU Pesticide), Sulfomen (ADAMA), sultop (Dhanuka Agritech Ltd.), Image (Heranba), Blanket (Punjab Chemicals), Unik (Shaw Wallace), Loxo (Atul)
Tembotrione	34.4% SC: Laudis (Bayer)
Thiobencarb (Benthiocarb)	50% EC: Sattern (PI Ind.), Dhanustern (Dhanuka Agritech Ltd.)
	10% Gr: Thiobencarb (Vimal)
Topramezone	33.6% SC: Tynzer (BASF)
Triallate	50% EC: Avadex-BW (Monsanto)
Trifluralin	48% EC: Flora (UPL Ltd.), Clean (Bayer), Tiptop (Gharda)
Triasulfuron	20% WG: Logran (Syngenta)
Chlorimuron-ethyl + Metsulfuron-methyl	20% WP: Almix (DuPont), Pimix (PI Ind.), Cormix (Coromandel)
Anilophos + 2,4-D ethyl ester	56% EC: Arozine D (Bayer), Topshort (Gharda)
Bensulfuron + Pretilachlor	6.6% G: Londex Power (DuPont), Rizal (Super Agro)
Clodinafop + Metsulfuron-methyl	16% WP: Sandesh (Shaw Wallace), Vesta (UPL Ltd.)
Hexazinone + Diuron	60% WP: Velpar K-4 (DuPont)
Sulfosulfuron + Metsulfuron-methyl	80% WG: Total (UPL Ltd.), SataSat (Shaw Wallace)

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Herbicide	Brand names and manufacturers
Imazamox + Imazethapyr	70% WG: Bingo (PI Ind.), Pyramox (Coromandel)
Carfentrazone-ethyl + Sulfosulfuron	45% WG: (FMC India Pvt. Ltd.)
Sodium acefluorfen + Clodinafop-propargyl	24.5% EC: Irish (UPL Ltd.)
Imazethapyr + Pendimethalin	32% EC: Valor (BASF)

4. Herbicide Recommendations

During registering an herbicide, the registrant company declares its use in the label claim. The crop(s) and the application rate(s) mentioned in the label claim are selected on the basis of its bioefficacy data obtained from the experiments conducted by SAUs, ICAR institutes or any other recognized laboratories. The actual recommendations on use of pesticides are developed out of their evaluation in the laboratory and in the fields against the target species. Such studies also take care of their metabolism, persistence and degradation so as to develop a proper dose regime, which reduce risk to target crops and users. Consciousness of consumerism has enhanced the significance of residue risks of pesticides in commodities. Pesticides have to be used on those crops where the data generation has been done. There have been issues countrywide about the inadequate knowledge on the label claims and their utilization. A large portion of usage of pesticides is without approved label claims. These lead to presence of residues of those pesticides, which are not approved for use on particular crops. The stakeholders need the awareness of the potential risk due to the injudicious application of herbicides. The Registration Committee, constituted by the Central Government brought out a compilation of approved uses of pesticides in the best possible way. Here, recommendations of herbicide use are given crop-wise in the following tables :

Table 4.1 Approved use of herbicides in wheat

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Carfentrazone-ethyl 40% DF (25-30 DAS)	<i>Chenopodium album</i> , <i>Melilotus indica</i> , <i>Melilotus alba</i> , <i>Medicago denticulata</i> , <i>Lathyrus aphaca</i> , <i>Anagallis arvensis</i> , <i>Vicia sativa</i> , <i>Cirsium arvense</i> , <i>Rumex</i> sp., <i>Malwa</i> sp.	20 g	50 g	400	80
Clodinafop-propargyl 15% WP (25-30 DAS)	<i>Phalaris minor</i>	60 g	400 g	375-400	110
2,4-D dimethyl amine salt 58% SL (30-35 DAS)	<i>Chenopodium album</i> , <i>Fumaria parviflora</i> , <i>Melilotus alba</i> , <i>Vicia sativa</i> , <i>Asphodelus tenuifolius</i> , <i>Convolvulus arvensis</i>	0.50-0.75 kg	0.86-1.29 kg	500-600	-

* Waiting period is the period of time after the application of a pesticide to a crop during which harvest of that crop is prohibited. This interval is necessary to ensure that the crop will meet the established pesticide residue tolerances.

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
2,4-D sodium salt technical (having 2,4-D acid 80% w/w) (earlier registered as 80% WP) (30-35 DAS)	<i>Leucas aspera</i> , <i>Chenopodium album</i> , <i>Vicia sativa</i> , <i>Argemone mexicana</i> , <i>Fimbristylis miliacea</i> , <i>Anagallis arvensis</i> , <i>Amaranthus spinosus</i>	0.5-0.84 kg	0.625-1.0 kg	500	90
2,4-D ethyl ester 38 % EC (having 2,4-D acid 34% w/w) (30-35 DAS)	<i>Chenopodium album</i> , <i>Asphodelus tenuifolius</i> , <i>Fumaria parviflora</i> , <i>Melilotus alba</i> , <i>Spergula arvensis</i>	0.45-0.75 kg	1.32-2.20 L	450-500	-
Diclofop-methyl 28% EC (post-em)	<i>Avena fatua</i> , <i>Phalaris minor</i>	0.7-1.0 kg	2.5-3.5 L	500	90
Fenoxaprop-P-ethyl 10% EC (4-6 WAS)	<i>Phalaris minor</i>	100-120 g	1.0-1.20 L	250-300	110
Isoproturon 50% WP (25-30 DAS)	<i>Phalaris minor</i> , <i>Avena fatua</i> , <i>Poa annua</i>	1.0 kg	2.0 kg	750	-
Isoproturon 75% WP (25-30 DAS)	<i>Phalaris minor</i> , <i>Avena fatua</i> , <i>Poa annua</i>	1.0 kg	1.33 kg	750	60
MCPA, amine salt 40% WSC (post-em)	<i>Chenopodium album</i> , <i>Asphodelus tenuifolius</i> , <i>Fumaria parviflora</i> , <i>Carthamus oxyacantha</i> , <i>Launea sp.</i> , <i>Pluchea lanceolata</i> , <i>Melilotus indica</i> , <i>Vicia hirsuta</i> , <i>Lathyrus aphaca</i> , <i>Medicago denticulata</i> , <i>M. lupulina</i> , <i>Spergula arvensis</i> , <i>Argemone mexicana</i> , <i>Phyllanthus niruri</i>	1.0 kg	2.5 kg	300-600	
Methabenzthiazuron 70% WP (pre-em, 2 DAS)	<i>Phalaris minor</i> , <i>Avena fatua</i> , <i>Avena ludoviciana</i> , <i>Poa annua</i>	1.05-1.40 kg	1.5-2.0 kg	700-1000	100
Methabenzthiazuron 70% WP (post-em, 30 DAS)	<i>Polypogon monspiliensis</i> , <i>Anagallis arvensis</i> , <i>Chenopodium album</i>	1.05-1.75 kg	2.0-2.5 kg	700-1000	100
Methabenzthiazuron 70% WP (early post-em, 16-18 DAS)	<i>Phalaris minor</i> , <i>Avena fatua</i> , <i>Avena ludoviciana</i> , <i>Chenopodium album</i>	0.70-0.87 kg	1.0-1.25 kg	700-1000	100
Metribuzin 70% WP (pre-em, post-em)	<i>Phalaris minor</i> , <i>Chenopodium album</i> , <i>Melilotus spp.</i>	Medium soil: 0.175 kg Heavy soil: 0.21 kg	0.25 kg 0.30 kg	500-750	120

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Metsulfuron-methyl 20% WP (post-em, 25-30 DAS)	<i>Chenopodium album</i> , <i>Melilotus indica</i> , <i>Lathyrus aphaca</i> , <i>Anagallis arvensis</i> , <i>Vicia sativa</i> , <i>Cirsium arvense</i>	4 g	20 g	500-600 + surfactant (iso-octyl phenoxy-poloxethanol 12.5%) @ 500 mL/ha	80
Metsulfuron-methyl 20% WG (post-em, 25-30 DAS)	<i>Chenopodium album</i> , <i>Melilotus indica</i> , <i>Melilotus alba</i> , <i>Lathyrus aphaca</i> , <i>Anagallis arvensis</i> , <i>Vicia sativa</i> , <i>Rumex denticulata</i> , <i>Convolvulus arvensis</i> , <i>Medicago denticulata</i>	4 g	20 g	500-600 + surfactant (iso-octyl phenoxy-poloxethanol 12.5%) @ 0.2%	76
Pendimethalin 30% EC (pre-em, 0-3 DAS)	<i>Phalaris minor</i> , <i>Chenopodium album</i> , <i>Melilotus alba</i> , <i>Portulaca oleracea</i> , <i>Anagallis arvensis</i> , <i>Fumaria parviflora</i> , <i>Poa annua</i>	Light soil-1.0 kg Medium soil-1.25 kg Heavy soil-1.5 kg	3.3 L 4.2 L 5.0 L	500-700 500-700 500-700	-
Pinoxaden 5.1% EC (post-em, 25-30 DAS)	<i>Phalaris minor</i> , <i>Avena ludoviciana</i>	40-45 g	800-900 mL 30-35 DAS	225-300	90
Paraquat dichloride 24% SL (pre-plant, minimum tillage before sowing)	Grassy and broad leaf weeds	1.0 kg	4.25 L	500	120-150
Sulfosulfuron 75% WG (post-em, 25-30 DAS)	<i>Phalaris minor</i> , <i>Chenopodium sp.</i> , <i>Melilotus alba</i>	25 g	33.3 g	200-250 + cationic surfactant 1250 ml/ha	110
Triallate 50% EC (pre-em)	<i>Avena fatua</i>	1.25 kg	2.5 kg	250-500	150
Clodinafop-propargyl 15% + Metsulfuron-methyl 1% WP (post-em, 35 DAS)	<i>Phalaris minor</i> , <i>Avena fatua</i> , <i>Chenopodium album</i> , <i>Melilotus sp.</i> , <i>Fumaria parviflora</i> , <i>Vicia sativa</i> , <i>Rumex sp.</i> , <i>Anagallis arvensis</i> , <i>Coronopus didymus</i> , <i>Lathyrus sp.</i> , <i>Convolvulus arvensis</i>	(60 + 4) g	400 g	375 (Add 1250 mL surfactant at the time of sparying)	100
Fenoxaprop-P-ethyl 7.77% + Metribuzin 13.6% EC	<i>Phalaris minor</i> , <i>Chenopodium album</i> , <i>Lathyrus aphaca</i> , <i>Rumex sp.</i> , <i>Melilotus spp.</i> , <i>Avena ludoviciana</i>	(100+175) g	1250 g	375	110

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Mesosulfuron-methyl 3% + Iodosulfuron-methyl sodium 0.6% WG (post-em, 25-30 DAS)	<i>Phalaris minor</i> , <i>Medicago denticulata</i> , <i>Chenopodium album</i> , <i>Melilotus</i> sp., <i>Rumex</i> sp., <i>Anagallis arvensis</i> , <i>Coronopus didymus</i> , <i>Lathyrus aphaca</i> , <i>Fumaria parviflora</i>	(12 + 2.4) g	400 g	400-500 + surfactant (Genopol LRO fluid) @ 500 mL/ha	96
Sulfosulfuran 75% + Metsulfuron-methyl 5% WG (post-em, 25-30 DAS)	<i>Phalaris minor</i> , <i>Chenopodium</i> sp., <i>Medicago denticulata</i> , <i>Coronopus didymus</i> , <i>Rumex</i> spp., <i>Melilotus alba</i> , <i>Anagallis arvensis</i>	(30+2) g	40 g	250-500 + surfactant 1250 mL/ha	110

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.2 Approved use of herbicides in rice

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Anilofos 30% EC (transplanted rice) (pre-em, early post-em, 3-5 DAT)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colonum</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Eclipta alba</i> , <i>Ischaemum rugosum</i> , <i>Fimbristylis</i> sp., <i>Marsilea quadrifolia</i>	0.3-0.45 kg	1.5 L	375-500	30
Anilophos 2% Gr (transplanted rice) (pre-em, early post-em)	<i>Echinochloa crus-galli</i> <i>Echinochloa colonum</i> , <i>Ischaemum rugosum</i> , <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Fimbristylis</i> sp.	0.4-0.5 kg	20-25 kg	-	30
Azimsulfuron 50% DF (transplanted rice) (20 DAT)	<i>Echinochloa colonum</i> , <i>E. crus-galli</i> , <i>Cyperus</i> spp., <i>Fimbristylis miliacea</i> , <i>Ludwigia parviflora</i> , <i>Eclipta alba</i> , <i>Bergia capensis</i> , <i>Marsilea quadrifolia</i> , <i>Ammannia baccifera</i> , <i>Sphenoclea zeylanica</i>	35 g	70 g	300	59

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Bensulfuron-methyl 60% DF (transplanted rice) (pre-em 3 DAT)	<i>Marsilea quadrifolia</i> , <i>Eclipta alba</i> , <i>Ammannia baccifera</i> , <i>Ludwigia parviflora</i> , <i>Sphenoclea zeylanica</i> , <i>Monochoria vaginalis</i> , <i>Alternanthera sessilis</i> , <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Fimbristylis miliacea</i> , <i>Scirpus roylei</i>	60 g	100 g	300	88
Bensulfuron-methyl 60% DF (transplanted rice) (post-em 20 DAT)	<i>Marsilea quadrifolia</i> , <i>Eclipta alba</i> , <i>Ammannia baccifera</i> , <i>Ludwigia parviflora</i> , <i>Sphenoclea zeylanica</i> , <i>Monochoria vaginalis</i> , <i>Alternanthera sessilis</i> , <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Fimbristylis miliacea</i> , <i>Scirpus roylei</i>	60 g	100 g	300	71
Bispyribac-sodium 10% SC rice (nursery)	<i>Echinochloa crus-galli</i> <i>Echinochloa colonum</i>	20 g	200 mL	300	-
Bispyribac-sodium 10% SC (transplanted rice)	<i>Ischaemum rugosum</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i>	20 g	200 mL	300	78
Bispyribac-sodium 10% SC (direct seeded rice) 20 DAS	<i>Fimbristylis miliacea</i> , <i>Eclipta alba</i> , <i>Ludwigia parviflora</i> , <i>Monochoria vaginalis</i> , <i>Alternanthera philoxeroides</i> , <i>Sphenoclea zeylanica</i>	20 g	200 mL	300	78
Butachlor 50% EC (transplanted rice) (pre-em, 1-3 DAT)	<i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Eleusine indica</i> , <i>Eclipta alba</i> , <i>Fimbristylis miliacea</i> , <i>Ludwigia parviflora</i> , <i>Sphenoclea zeylanica</i>	1.25-2.00kg	2.5-4 L	250-500	90-120
Butachlor 5% Gr	<i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Eleusine indica</i> , <i>Eclipta alba</i> , <i>Fimbristylis miliacea</i> , <i>Ludwigia parviflora</i> , <i>Sphenoclea zeylanica</i>	1.25-2.0 kg	25-40 kg	-	90-120

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Butachlor 50% EW (transplanted rice) Pre-em, 3-4 DAT	<i>Echinochloa colonum</i> , <i>Echinochloa crus-galli</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Eclipta alba</i> , <i>Fimbristylis miliacea</i> <i>Ludwigia parviflora</i> , <i>Sphenoclea zeylanica</i> <i>Monochoria vaginalis</i>	1.25-1.5 kg	2.5-3.0 L	2.50-500	-
Chlorimuron-ethyl 25% WP (transplanted rice) (post-em, 2-6 leaf stage of weed)	<i>Echinochloa crus-galli</i> , <i>Eclipta alba</i> , <i>Commelina benghalensis</i> , <i>Chenopodium album</i> , <i>Cyperus rotundus</i> , <i>Echinochloa colona</i>	6 g	24 g	500-600	60
Cinmethylin 10% EC (transplanted rice)	<i>Cyperus iria</i> , <i>Fimbristylis miliacea</i> , <i>Monochoria vaginalis</i> , <i>Commelina benghalensis</i> , <i>Echinochloa crus-galli</i> , <i>Marsilea minuta</i>	75-100 g	0.75-1.0 L	500-700	110
Clomazone 50%EC (transplanted rice)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colonum</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Ludwigia parviflora</i> , <i>Eclipta alba</i>	0.4 - 0.5 kg	0.8-1.0 L	500-750	90
Cyhalofop-butyl 10% EC (directed-seeded rice)	<i>Echinochloa</i> spp.	75-80 g	0.75-0.80 L	500-600	90
2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w) (transplanted rice)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i>	0.85 kg	2.5 L	400	-
2,4-D ethyl ester 4.5% Gr (having 2,4-D acid 4% w/w) (transplanted rice) (20-25 DAT)	<i>Echinochloa Colona</i> , <i>Echinochloa crus-galli</i> , <i>Panicum ischaemum</i> , <i>Cynodon dactylon</i> (germinating), <i>Cyperus rotundus</i> (germinating), <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Ludwigia parviflora</i> , <i>Monochoria vaginalis</i> , <i>Marsilea quadrifolia</i> <i>Cyanotis cucullata</i> <i>Eclipta alba</i> , <i>Ammannia baccifera</i>	1.0 kg	25 kg	-	-
Ethoxysulfuron 15% WDG (transplanted rice) (10-15 DAT)	<i>Fimbristylis miliacea</i> , <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Scirpus</i> sp., <i>Eclipta alba</i> , <i>Marsilea quadrifolia</i> , <i>Ammannia baccifera</i> , <i>Monochoria vaginalis</i>	12.5-15 g	83.3-100 g	500	110

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Fenoxaprop-P-ethyl 9.3% w/w EC (9% w/v) (transplanted rice) (25-30 DAT)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i>	56.25 g	625 mL (10-15 DAT)	300-375	70
Fenoxaprop-P-ethyl 6.7% w/w EC (transplanted and direct-seeded rice) (25-30 DAT)	<i>Echinochloa</i> sp.	56.6-60.38 g	812.5-875 mL	375-500	61
MCPA, amine salt 40% WSC (transplanted rice) (post-em)	<i>Cyperus rotundus</i> , <i>Ipomoea reptans</i> , <i>Ammannia baccifera</i> , <i>Lippia nodiflora</i> , <i>Alternanthera</i> sp., <i>Ludwigia parviflora</i> , <i>Marsilea quadrifolia</i>	0.8-2.0 kg	2-5 kg	400-600	
Metsulfuron-methyl 20% WP (transplanted rice) (post-em, 25-35 DAT)	<i>Cyperus rotundus</i> , <i>Sphenoclea</i> spp., <i>Fimbristylis</i> sp., <i>Ludwigia parviflora</i> , <i>Marsilea quadrifolia</i>	4 g	20 g	500-600	60
Metsulfuron-methyl 20% WG (transplanted rice) (post-em, 25-35 DAT)	<i>Monochoria vaginalis</i> , <i>Ludwigia parviflora</i> , <i>Ludwigia adscendens</i> , <i>Marsilea quadrifolia</i> , <i>Eclipta alba</i> , <i>Oxalis minima</i> , <i>Dopatrium junceum</i> , <i>Commelina benghalensis</i> , <i>Ammannia baccifera</i> , <i>Sphenoclea zeylanica</i> , <i>Caesulia axillaris</i>	4 g	20 g	500-600 + surfactant (Iso-octyl phenoxy- poloxet hanol 12.5%) @ 0.2%	71
Orthosulfamuron 50% WG (transplanted rice) (pre-em, post-em, 3 DAT)	<i>Echinochloa</i> spp., <i>Cyperus</i> spp., <i>Scirpus</i> spp., <i>Ludwigia parviflora</i> , <i>Fimbristylis</i> spp., <i>Rotala</i> spp.	60-75 g	120-150 g	500	65
Oxadiargyl 80% WP (transplanted rice) (pre-em, 0-5 DAS)	<i>Echinochloa crus-galli</i> , <i>Echinochloa Colona</i> , <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Eclipta alba</i> , <i>Ludwigia quadrifolia</i>	100 g	0.125 kg	500	97
Oxadiargyl 6% EC (transplanted rice) (pre-em, 0-5 DAT)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i>	100 g	1.66 L	500	97

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Oxadiazon 25% EC (transplanted rice) (pre-em)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Marsilea quadrifolia</i> , <i>Eclipta alba</i> , <i>Ludwigia</i> sp.	0.5 kg	2.0 L	500	-
Oxyflourfen 0.35% Gr (direct-sown puddled or transplanted rice)	<i>Echinochloa</i> sp. <i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Eclipta alba</i> , <i>Ludwigia parviflora</i> , <i>Fimbristylis miliacea</i> , <i>Marsilea</i> spp.	100-150 g	30-40 kg	-	-
Oxyflourfen 23.5% EC (direct-sown rice as pre-em)	<i>Echinochloa</i> sp., <i>Cyperus iria</i> , <i>Eclipta alba</i>	150-240 g	650-1000 mL	500	-
Pendimethalin 30% EC (transplanted and direct-sown upland rice) (pre-em, 6-7 DAT)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Fimbristylis miliacea</i> , <i>Marsilea quadrifolia</i> , <i>Alternanthera sessilis</i> , <i>Ammannia baccifera</i> , <i>Ludwigia parviflora</i> , <i>Eclipta alba</i> , <i>Cyperus difformis</i>	light to heavy soil: 1.0-1.5 kg	3.3 –5.0 L	500-700	
Pendimethalin 5% Gr (direct sown puddled or transplanted rice)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Fimbristylis miliacea</i> , <i>Marsilea quadrifolia</i> , <i>Alternanthera sessilis</i> , <i>Ammannia baccifera</i> , <i>Ludwigia parviflora</i> , <i>Eclipta alba</i> , <i>Cyperus difformis</i>	1.0-1.5 kg	20-30 kg	-	-
Pretilachlor 37% EW (transplanted rice) (pre-em, 3-7 DAT)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Digitaria sanguinalis</i> , <i>Fimbristylis miliacea</i> , <i>Eclipta alba</i> , <i>Ludwigia parviflora</i> , <i>Monochoria vaginalis</i>	0.60-0.75 kg	1.5-1.875 L	500	90
Pretilachlor 30.7% EC (direct-sown puddled rice)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i>	0.45-0.60 kg	1.5-2.0 L	500	110

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Pretilachlor 50% EC (transplanted rice) (pre-em, 3-7 DAT)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Cyperus difformis</i> , <i>Cyperus iria</i> , <i>Fimbristylis miliacea</i> , <i>Eclipta alba</i> , <i>Ludwigia parviflora</i> , <i>Monochoria vaginalis</i> , <i>Leptochloa chinensis</i> , <i>Panicum repens</i>	0.50-0.75 kg	1.0-1.5 L	500-700	75-90
Paraquat dichloride 24% SL [pre-plant (minimum tillage) before sowing/ transplanting rice for controlling standing weeds]	<i>Echinochloa crus-galli</i> , <i>Cyperus iria</i> , <i>Ageratum conyzoides</i> , <i>Commelina benghalensis</i> , <i>Marsilea quadrifolia</i> , <i>Brachiaria mutica</i>	0.3-0.8 kg	1.25-3.5 L	500	N.A.
Pyrazosulfuron-ethyl 10% WP (transplanted rice) (8-10 DAT)	<i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Fimbristylis miliacea</i> , <i>Monochoria vaginalis</i> , <i>Ludwigia parviflora</i>	10-15 g	100-150 g	500-600	95
Anilofos 24% +2,4-D ethyl ester 32% EC (transplanted rice)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Ischaemum rugosum</i> , <i>Fimbristylis miliacea</i>	(0.24+ 0.32) to (0.36 + 0.48) kg	1-1.5 L	300	90
Bensulfuron-methyl 0.6% + Pretilachlor 6% Gr (transplanted rice) (0-3 DAT)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Cynodon dactylon</i> , <i>Cyperus</i> <i>iria</i> , <i>Cyperus difformis</i> , <i>Cyperus rotundus</i> , <i>Fimbristylis miliacea</i> , <i>Ludwigia parviflora</i> , <i>Marselia quadrifolia</i> , <i>Enhydra fluctuans</i> , <i>Sphenoclea zeylanica</i> , <i>Eclipta</i> <i>alba</i> , <i>Ammannia baccifera</i>	60 + 600 g	10 kg	-	88
Clomazone 20% + 2,4-D ethyl ester 30% EC (transplanted rice)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Cyperus iria</i> , <i>Cyperus</i> <i>difformis</i> , <i>Eclipta alba</i> , <i>Leptochloa chinensis</i> , <i>Panicum repens</i> , <i>Fimbristylis miliacea</i> , <i>Marsilea quadrifolia</i> , <i>Ludwigia parviflora</i>	0.250-0.375 kg	1.25 L	500	100-110

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Metsulfuron-methyl 10% + Chlorimuron-ethyl 10% WP (transplanted rice) (pre-em, 3 DAT)	<i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Fimbristylis miliacea</i> , <i>Eclipta alba</i> , <i>Ludwigia parviflora</i> , <i>Cyanotis axillaris</i> , <i>Monochoria vaginalis</i> , <i>Marsilea quadrifolia</i>	4 g	20 g	300	90

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.3 Approved use of herbicides in cotton

Herbicide	Weed species	Dosage/ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Alachlor 50% EC (pre-em)	<i>Digera arvensis</i> , <i>Echinochloa colona</i> , <i>Eragrostis major</i> , <i>Euphorbia hirta</i> , <i>Phyllanthus niruri</i> , <i>Portulaca oleracea</i> , <i>Trianthema portulacastrum</i> , <i>Flaveria australasica</i> , <i>Gynandropsis pentaphylla</i>	2-2.5 kg	4-5 L	250-500	210-240
Alachlor 10% Gr	<i>Dactyloctenium aegyptium</i>	2.0-2.5 kg	20-25 kg	-	-
Diuron 80% WP (pre-em)	<i>Amaranthus</i> spp., <i>Chenopodium album</i> , <i>Convolvulus arvensis</i> , <i>Setaria glauca</i> , <i>Digitaria</i> sp., <i>Portulaca oleracea</i> , <i>Xanthium strumarium</i> , <i>Anagallis arvensis</i> , <i>Asphodelus tenuifolius</i> , <i>Euphorbia</i> sp., <i>Visia sativa</i> , <i>Paspalum conjugatum</i>	0.75-1.5 kg	1-2.2 kg	625	-
Fenoxaprop-P-ethyl 9.3% w/w EC (9% w/v) (20 -25 DAS)	<i>Echinochloa</i> sp., <i>Eleusine indica</i> , <i>Dactyloctenium aegyptium</i> , <i>Eragrostis minor</i>	67.5 g	750 mL	375-500	87

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Fluchloralin 45% EC (pre-plant)	<i>Acanthospermum hispidum</i> , <i>Cleome viscosa</i> , <i>Datura</i> sp., <i>Trianthema monogyna</i> , <i>Tridax procumbens</i> , <i>Cynodon dactylon</i> (germinating), <i>Amaranthus</i> spp., <i>Portulaca</i> spp., <i>Achyranthes aspera</i> , <i>Euphorbia hirta</i> , <i>Cenchrus catharticus</i> , <i>Digitaria sanguinalis</i> , <i>Eleusine</i> sp., <i>Panicum</i> sp., <i>Lagascea mollis</i> , <i>Gynandropsis pentaphylla</i> , <i>Achalypha indica</i>	0.9-1.2 kg	2.0-2.68 L	500-800	180
Glufosinate-ammonium 13.5% SL (15% w/v) (post-em)	<i>Echinochloa</i> sp., <i>Cynodon dactylon</i> , <i>Cyperus rotundus</i> , <i>Digitaria marginata</i> , <i>Dactyloctenium aegyptium</i>	375-450 g	2.5-3.0 L	500	96
Pendimethalin 30% EC (pre-plant or pre-em, before sowing or 2-3 DAS)	<i>Echinochloa</i> spp., <i>Euphorbia hirta</i> , <i>Amaranthus viridis</i> , <i>Portulaca oleracea</i> , <i>Trianthema</i> spp., <i>Eleusine indica</i>	0.75-1.25 kg	2.5-4.165 L	500-700	150
Pyrithiobac-sodium 10% EC (post-em)	<i>Trianthema</i> spp., <i>Amaranthus</i> spp., <i>Chenopodium</i> spp., <i>Digera</i> spp., <i>Celosia argentea</i>	62.5-75 g	625-750 mL	500	160
Quizalofop-ethyl 5% EC (post-em)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Dinebra retroflexa</i> , <i>Digitaria marginata</i>	50.5 g	1000 g	500	94

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.4 Approved use of herbicides in maize

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Alachlor 50% EC (0-3 DAS)	<i>Echinochloa colona</i> , <i>Euphorbia hirta</i> , <i>Eleusine indica</i> , <i>Amaranthus viridis</i> , <i>Digitaria</i> spp., <i>Echinochloa</i> spp., <i>Euphorbia hirta</i> , <i>Phyllanthus niruri</i> , <i>Portulaca oleracea</i> , <i>Trianthema portulacastrum</i>	2.5 kg	5 L	250-500	90
		2.5 kg	5 L	250-500	120-150

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Alachlor 10% Gr	<i>Digitaria</i> spp., <i>Echinochloa</i> spp., <i>Chenopodium album</i>	1.5-2.5 kg	15-25 kg	-	-
Atrazine 50% WP (early post-em, 0-3 DAS)	<i>Trianthema monogyna</i> , <i>Digera arvensis</i> , <i>Echinochloa</i> spp., <i>Eleusine</i> spp., <i>Xanthium strumarium</i> , <i>Brachiaria</i> sp., <i>Digitaria</i> sp., <i>Amaranthus viridis</i> , <i>Cleome viscosa</i> , <i>Polygonum</i> spp.	0.5-1.0 kg	1-2 kg	500-700	-
2,4-D dimethyl amine salt 58% SL (pre-em, post-em)	<i>Trianthema monogyna</i> , <i>Amaranthus</i> sp., <i>Tribulus terrestris</i> , <i>Boerhavia diffusa</i> , <i>Euphorbia hirta</i> , <i>Portulaca oleracea</i> , <i>Cyperus</i> sp.	0.5 kg	0.86 L	400-500	50-60
2,4-D sodium salt technical (having 2,4-D acid 80% w/w)(earlier registered as 80% WP) (pre-em, post-em)	<i>Amaranthus viridis</i> , <i>Trianthema portulacastrum</i> , <i>Phyllanthus niruri</i> , <i>Euphorbia geniculata</i> , <i>Amaranthus spinosus</i> , <i>Cleome chelidonii</i> , <i>Lagascea mollis</i>	1.00 kg	1.25 kg	500	120 (pre-em) 90 (post-em)
2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w) (pre-em, post-em)	<i>Trianthema monogyna</i> , <i>Amaranthus</i> sp., <i>Portulaca oleracea</i> , <i>Tribulus terrestris</i> , <i>Boerhavia diffusa</i> , <i>Euphorbia hirta</i> , <i>Cyperus</i> sp.	0.9 kg	2.65 L	400-450	50-60
Diuron 80% WP (pre-em, post-em)	<i>Cyperus iria</i> , <i>Echinochloa</i> spp, <i>Digitaria</i> spp., <i>Chenopodium album</i> , <i>Eleusine</i> sp., <i>Amaranthus</i> sp., <i>Phyllanthus niruri</i>	0.8 kg	1.0 kg	600	-
Paraquat dichloride 24% SL [pre-plant (minimum tillage) before sowing]	<i>Cyperus rotundus</i> , <i>Commelina benghalensis</i> , <i>Trianthema monogyna</i> , <i>Amaranthus</i> sp., <i>Echinochloa</i> sp.,	0.2-0.5 kg	0.8-2.0 L	500	90-120
Paraquat (post-em directed inter row application at 2-3 leaf stage of weeds)	<i>Cyperus iria</i> , <i>Cyperus rotundus</i> , <i>Commelina benghalensis</i> , <i>Amaranthus</i> sp., <i>Echinochloa</i> sp., <i>Trianthema monogyna</i>	0.2-0.5 kg	0.8-2.0 L	500	90-120

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.5 Approved use of herbicides in soybean

Herbicide	Weed species	Dosage/ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Alachlor 50% EC (0-3 DAS)	<i>Amaranthus viridis</i> , <i>Cleome viscosa</i> , <i>Cyperus iria</i> , <i>Dactyloctenium aegyptium</i> , <i>Echinochloa</i> spp., <i>Eleusine indica</i> , <i>Setaria glauca</i>	2.5 kg	5 L	250-500	-
Alachlor 10% Gr	<i>Digitaria</i> spp., <i>Echinochloa</i> spp., <i>Chenopodium album</i>	1.5-2.5 kg	15-25 kg	-	-
Anilofos 30% EC (pre-em or early post-em)	<i>Echinochloa colona</i> , <i>Commelina benghalensis</i> , <i>Cyanotis axillaris</i> , <i>Ageratum conyzoides</i>	1.25-1.5 kg	4.20-5.0 L	500	100-120
Chlorimuron-ethyl 25% WP (15-20 DAS)	<i>Eclipta alba</i> , <i>Commelina benghalensis</i> , <i>Chenopodium album</i> , <i>Cyperus rotundus</i> , <i>Cyperus iria</i> , <i>Parthenium hysterophorus</i> , <i>Acalypha indica</i> , <i>Phyllanthus niruri</i> , <i>Trianthema portulacastrum</i> , <i>Caesulia auxillaris</i>	9 g	36 g	300 L +surfactant 0.2 % (Iso-octyl phenoxy-poloxethanol 12.5%)	45
Clomazone 50% EC	<i>Digitaria</i> spp., <i>Echinochloa</i> spp., <i>Parthenium hysterophorus</i> , <i>Commelina</i> spp.	0.75-1.00 kg	1.5-2.0 L	500-600	90
Fenoxaprop-P-ethyl 9.3% w/w EC (9% w/v) (20-25 DAS)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Digitaria</i> sp., <i>Eleusine indica</i> , <i>Setaria</i> sp., <i>Brachiaria</i> sp.	100 g	1111 mL (15-20 DAS)	250-300	100
Fluazifop-P-butyl 13.4% EC (post-em)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Eleusine indica</i> , <i>Cynodon dactylon</i> , <i>Dactyloctenium aegyptium</i> , <i>Digitaria</i> sp., <i>Setaria</i> sp.	125-250 g	1000-2000 mL	500	90
Fluchloralin 45% EC (pre-planting)	<i>Eragrostis</i> sp., <i>Boerhavia hispida</i> , <i>Cyperus campestris</i>	1.0-1.5 kg	2.22-3.33 L	500-800	120-150

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Imazethapyr 10% SL (pre-em, early post-em)	<i>Cyperus difformis</i> , <i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Euphorbia hirta</i> , <i>Croton sparsiflorus</i> , <i>Digera arvensis</i> , <i>Commelina benghalensis</i>	100 g	1.0 L	500-600	75
Metolachlor 50% EC (pre-em)	<i>Echinochloa</i> sp., <i>Eleusine indica</i> <i>Digitaria</i> sp., <i>Panicum</i> sp., <i>Cyperus</i> sp., <i>Amaranthus viridis</i>	1.0 kg	2.0 L	600-750	-
Metribuzin 70% WP (pre-em, early post-em)	<i>Digitaria</i> spp., <i>Cyperus esculentus</i> , <i>Cyperus campestris</i> , <i>Borreria</i> spp., <i>Eragrostis</i> spp.	0.35-0.525 kg	0.5-0.75 kg	750-1000	30
Pendimethalin 30% EC (pre-plant or pre-em)	<i>Echinochloa</i> spp., <i>Euphorbia</i> spp., <i>Amaranthus viridis</i> , <i>Portulaca oleracea</i> , <i>Trianthema</i> spp., <i>Eleusine indica</i>	0.75-1.0 kg	2.5-3.3 L	500-700	110
Pendimethalin 38.7% CS (pre-planting or pre-em)	<i>Echinochloa colonum</i> , <i>Dinebra arabica</i> , <i>Digitaria sanguinalis</i> , <i>Brachiaria mutica</i> , <i>Dactyloctenium aegyptium</i> , <i>Portulaca oleracea</i> , <i>Amaranthus viridis</i> , <i>Euphorbia geniculata</i> , <i>Cleome viscosa</i>	580.5-677.25 g	1500-1750 mL	500	40
Propaquizafop 10% EC	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Digitaria sanguinalis</i> , <i>Dactyloctenium aegyptium</i> , <i>Eleusine indica</i>	50-75 g	500-750 mL	500-750	21
Quizalofop-ethyl 5% EC (20-25 DAS)	<i>Echinochloa crus-galli</i> , <i>Echinochloa coloma</i> , <i>Eragrostis</i> sp.	37.5-50 g	0.75-1.0 L	500-600	95
Quizalofop-P-tefuryl 4.41% EC (20-25 DAS)	<i>Echinochloa</i> spp., <i>Dinebra arabica</i> , <i>Digitaria sanguinalis</i> , <i>Cynodon dactylon</i> , <i>Hemarthria compressa</i> , <i>Eleusine indica</i>	30-40 g	750-1000 mL	400	30
Imazamox 35% + Imazethapyr 35% WG (pre-em, early post-em)	<i>Echinochloa</i> sp., <i>Dinebra arabica</i> , <i>Digitaria</i> sp., <i>Brachiaria mutica</i> , <i>Commelina benghalensis</i> , <i>Euphorbia hirta</i>	70 g	100 g	375-500 + surfactant (Cyspread) @ 1.5ml/ litre of water + Ammonium sulphate @ 2.0 gm/ litre of water	56

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Pendimethalin 30% + Imazethapyr 2% EC	<i>Echinochloa crus-galli</i> , <i>Digera arvensis</i> , <i>Commelina benghalensis</i> , <i>Amaranthus viridis</i> , <i>Portulaca oleracea</i>	(750+50) to (900+60) g	2.5-3.0 L	500-600	90

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.6 Approved use of herbicides in sugarcane

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
2,4-D dimethyl amine salt 58% SL (pre-em, post-em)	<i>Cyperus iria</i> , <i>Digitaria</i> sp., <i>Dactyloctenium aegyptium</i> , <i>Digera arvensis</i> , <i>Portulaca oleracea</i> , <i>Commelina benghalensis</i> , <i>Convolvulus arvensis</i>	3.5 kg	6.3 L	500	-
2,4-D sodium salt technical (having 2,4-D acid 80% w/w) (earlier registered as 80%WP) (pre-em, post-em)	<i>Boerhavia diffusa</i> , <i>Chenopodium album</i> , <i>Tribulus terrestris</i> , <i>Portulaca oleracea</i> , <i>Xanthium</i> spp., <i>Convolvulus arvensis</i> , <i>Amaranthus spinosus</i> , <i>Digera arvensis</i> , <i>Celosia argentea</i>	2.0-2.6 kg	2.5-3.25 kg	600-900	300
2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w) (pre-em, post-em)	<i>Cyperus iria</i> , <i>Digitaria</i> sp., <i>Dactyloctenium aegyptium</i> , <i>Digera arvensis</i> , <i>Portulaca oleracea</i> , <i>Commelina benghalensis</i> , <i>Amaranthus</i> sp., <i>Convolvulus arvensis</i>	1.2 to 1.8 kg	3.53- 5.29 L	500	300-330
Diuron 80% WP (pre-em)	<i>Cyperus iria</i> , <i>Portulaca oleracea</i> , <i>Echinochloa crus-galli</i> , <i>Cyanotis</i> spp., <i>Amaranthus</i> spp., <i>Convolvulus</i> spp., <i>Digitaria</i> spp.	1.6-3.2 kg	2.0-4.0 kg	600	-
Metribuzin 70% WP (early post-em 3-5 DAP or post-em, 20-25 Days after planting)	<i>Cyperus esculentus</i> , <i>Amaranthus viridis</i> , <i>Portulaca oleracea</i> , <i>Parthenium hysterophorus</i> , <i>Trianthema</i> sp., <i>Cleome viscosa</i> , <i>Solanum</i> sp., <i>Commelina benghalensis</i> , <i>Euphorbia</i> sp., <i>Digera</i> sp.	6 kg	30 kg	500-600 + (non-ionic surfactant Iso-octyl phenoxy-poloxethanol 12.5% @ 2mL per liter of spray volume (0.2%))	346

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Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Hexazinone 13.2% + Diuron 46.8% WP (pre-em, post-em)	<i>Echinochloa colonum</i> , <i>Dactyloctenium aegyptium</i> , <i>Trianthema monogyna</i> , <i>Amaranthus viridis</i> , <i>Ipomoea</i> spp., <i>Cyperus rotundus</i> , <i>Cyperus esculentus</i> , <i>Setaria</i> spp., <i>Parthenium hysterophorus</i> , <i>Euphorbia hirta</i>	(264+936) g	2 kg	500	282-306

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.7 Approved use of herbicides in tea

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Glufosinate-ammonium 13.5% SL (15% w/v) (post-em)	<i>Panicum repens</i> , <i>Borreria hispida</i> , <i>Imperata cylindrica</i> , <i>Digitaria sanguinalis</i> , <i>Commelina benghalensis</i> , <i>Ageratum conyzoides</i> , <i>Eleusine indica</i> , <i>Paspalum conjugatum</i>	0.375-0.500 kg	2.5-3.3 L	375-500	15
Glyphosate IPA salt 41% SL (post-em)	<i>Axonopus compressus</i> , <i>Cynodon dactylon</i> , <i>Imperata cylindrica</i> , <i>Polygonum perfoliatum</i> , <i>Paspalum scrobiculatum</i> , <i>Arundinella bengalensis</i>	0.820-1.230 kg	2.0-3.0 L	450	21
Glyphosate ammonium salt 5% SL	<i>Cynodon dactylon</i> , <i>Digitaria sanguinalis</i> , <i>Paspalum conjugatum</i> , <i>Ageratum conyzoides</i> , <i>Biden pilosa</i> , <i>Cyperus rotundus</i> , <i>Borreria latifolia</i> , <i>Euphorbia</i> spp., <i>Imperata cylindrica</i>	1.5 kg	30 L	500	7
Glyphosate ammonium salt 71% SG	<i>Acalypha indica</i> , <i>Sida acuta</i> , <i>Ipomoea digitaria</i> , <i>Cychorium intybus</i> , <i>Digera arvensis</i> , <i>Digitaria sanguinalis</i> , <i>Paspalum conjugatum</i> , <i>Ageratum conyzoides</i> , <i>Cynodon dactylon</i> , <i>Cyperus rotundus</i> , <i>Eragrostis</i> spp.	2.13 kg	3.0 kg	500	7

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g/kg)	Formulation (g,kg,mL,L)		
Oxyfluorfen 23.5% EC	<i>Digitaria</i> sp., <i>Imperata</i> sp., <i>Paspalum</i> sp., <i>Borreria hispida</i>	150-250 g	650-1000 mL	500-750	15
Paraquat dichloride 24% SL (post-em directed inter row application at 2-3 leaf stage of weeds)	<i>Imperata</i> sp., <i>Setaria</i> sp., <i>Commelina benghalensis</i> , <i>Borreria hispida</i> , <i>Paspalum conjugatum</i>	0.2-1.0 kg	0.8-4.25 L (for season long weed control, use 2.5-5.0 L for initial application. For subsequent repeat spot application use 1 L)	200-400	Not necessary (For season-long weed control, use 2.5 to 5 L for initial application. For subsequent repeat spot application use 1 L)

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad

Table 4.8 Approved use of herbicides in other crops

Herbicide and crop	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g/kg)	Formulation (g,kg,mL,L)		
Alachlor 50% EC					
Groundnut (pre-em)	<i>Acanthosermum hispidum</i> , <i>Flaveria australasica</i>	1.5-2.5 kg	3-5 L	250-500	20-150
Greengram/Blackgram/Pigeonpea (0-3 DAS)	<i>Cynodon dactylon</i> , <i>Echinochloa</i> spp., <i>Digitaria</i> spp., <i>Cyperus rotundus</i> , <i>Commelina benghalensis</i> , <i>Chenopodium album</i>	2.0-2.5 kg	4-5 L	250-500	-
Sunflower (0-3 DAS)	<i>Digitaria sanguinalis</i> , <i>Echinochloa crus-galli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	1.0-1.5 kg	2-3 L	250-500	-
Tomato/Brinjal/Chilli (pre-plant)	<i>Chenopodium album</i> , <i>Anagalis arvensis</i> , <i>Convolvulus arvensis</i> , <i>Cyperus iria</i> , <i>Portulaca oleracea</i>	2.0 kg	4 L	250-500	-
Alachlor 10% Gr					
Groundnut (pre-em)	<i>Digitaria</i> spp., <i>Echinochloa</i> spp., <i>Chenopodium album</i>	1.5-2.5 kg	15-25 kg	-	-
2,4-D dimethyl amine salt 58% SL					
Sorghum (pre-em, post-em)	<i>Cyperus iria</i> , <i>Digera arvensis</i> , <i>Convolvulus arvensis</i> , <i>Trianthema</i> sp., <i>Tridax procumbens</i> , <i>Euphorbia hirta</i> , <i>Phyllanthus niruri</i>	1.8 kg	3.1 L	500-600	-

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Potato (pre-em, post-em)	<i>Chenopodium album</i> , <i>Asphodelus tenuifolius</i> , <i>Anagallis arvensis</i> , <i>Convolvulus arvensis</i> , <i>Cyperus iria</i> , <i>Portulaca oleracea</i>	2.0 kg	3.44 L	400	-
Aquatic weeds Non-crop area	<i>Eichhornia crassipes</i>	0.5-1.0 kg	0.86-1.72 L	600-700	15-20
	<i>Parthenium hysterophorus</i>	2.65 kg	4.56 L	300-400	15-20
	<i>Cyperus rotundus</i>	2.5 kg	4.30 L	300-400	-
2,4-D sodium salt technical (having 2,4-D acid 80% w/w) (earlier registered as 80% WP)					
Citrus (pre-em, post-em)	<i>Euphorbia</i> spp., <i>Convolvulus arvensis</i> , <i>Coronopus didymus</i> , <i>Amaranthus viridis</i> , <i>Oxalis corniculata</i> , <i>Tribulus terrestris</i> , <i>Fumaria parviflora</i> , <i>Sonchus arvensis</i>	1.00-2.5 kg	1.25-3.2 kg	600	> 180
Grapes (pre-em, post-em)	<i>Convolvulus</i> spp., <i>Tridax procumbens</i>	2.0 kg	2.5 kg	500	> 90
Aquatic weeds	<i>Boerhavia hispida</i> , <i>Eichhornia crassipes</i>	1.5 kg	1.85 kg	600-1000	-
Non-crop land	<i>Parthenium hysterophorus</i>	2.5-6.0 kg	3.2-7.5 kg	600-1000	-
	<i>Cyperus rotundus</i>	4-8 kg	5-10 kg	500-600	-
	<i>Solanum elaeagnifolium</i>	1.8 kg	2.25 kg	500-600	-
2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w)					
Sorghum (35 DAS)	<i>Cyperus iria</i> , <i>Striga</i> sp., <i>Digera arvensis</i> , <i>Convolvulus arvensis</i> , <i>Trianthema</i> sp., <i>Tridax procumbens</i> , <i>Euphorbia hirta</i> , <i>Phyllanthus niruri</i>	1.0 kg	2.94 L	425	-
Aquatic weeds	<i>Eichhornia crassipes</i>	2.5 kg	7.5 L	700-1000	-
Diuron 80% WP					
Banana (pre-em, post-em)	<i>Cyperus iria</i> , <i>Commelina benghalensis</i> , <i>Digitaria</i> sp., <i>Amaranthus</i> spp., <i>Dactyloctenium</i> , <i>Chloris barbata</i> , <i>Eragrostis zeylanica</i>	1.60 kg	2 kg	625	-
Rubber (pre-em, post-em)	Grasses and non-grasses	1.6-3.2 kg	2-4 kg	625	-
Citrus (sweet orange) (pre-em, post-em)	<i>Cyperus iria</i> , <i>Tribulus terrestris</i> , <i>Digera arvensis</i> , <i>Commelina nudiflora</i> , <i>Cocumis trigonus</i>	2.0-4.0 kg	2.5-5.0 kg	600	-
Grapes (pre-em, post-em)	<i>Cleome viscosa</i> , <i>Chenopodium album</i> , <i>Cyperus iria</i> , <i>Euphorbia hirta</i> ,	1.6 kg	2.0 kg	625	-

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
	<i>Alternanthera echinata</i> , <i>Amaranthus</i> spp., <i>Argemone mexicana</i> , <i>Ipomoea</i> spp., <i>Xanthium strumarium</i> , <i>Fumeria parviflora</i> , <i>Asphodelus tenuifolius</i> , <i>Medicago denticulata</i> , <i>Eleusine aegyptiaca</i> , <i>Dactyloctenium aegyptium</i>				
Fenoxaprop-P-ethyl 9.3% w/w EC (9% w/v)					
Blackgram (post-em) (15-20 DAS)	<i>Echinochloa crus-galli</i> , <i>Echinochloa colona</i> , <i>Digitaria</i> sp., <i>Dactyloctenium aegyptium</i>	56.25-67.5 g	625-750 mL (15-20 DAS)	375-500	43
Fluchloralin 50% EC					
Green gram/Black gram/Pigeonpea (pre-plant incorporation into the soil)	<i>Digitaria sanguinalis</i> , <i>Echinochloa crus-galli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	1.5-2.0 L	750-1000	-
Chickpea/Lentil /Field peas (pre-plant incorporation into the soil)	<i>Digitaria sanguinalis</i> , <i>Echinochloa crus-galli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	1.5-2.0 L	750-1000	-
Sunflower (pre-plant)	<i>Digitaria sanguinalis</i> , <i>Echinochloa crus-galli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	1.0 kg	2.0 kg	750-1000	-
Rapeseed/ Mustard (pre-plant)	<i>Digitaria sanguinalis</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	1.0 kg	2.0 kg	750-1000	-
Linseed/ Sesamum/Niger (pre-plant)	<i>Digitaria sanguinalis</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	1.0 kg	2.0 kg	750-1000	-
Jute (pre-plant)	<i>Digitaria sanguinalis</i> , <i>Echinochloa crus-galli</i>	1.0 kg	2.0 kg	750-1000	-
Potato (pre-plant)	<i>Anagallis arvensis</i> , <i>Chenopodium</i> sp., <i>Portulaca oleracea</i> , <i>Fumeria parviflora</i> , <i>Commelina</i> sp., <i>Trianthema</i> sp., <i>Parthenium hysterophorus</i> , <i>Amaranthus spinosus</i>	1.0 –1.5 kg	2.0-3.0 kg	750-1000	-
Tomato/Brinjal/ Chilli (pre-transplant)	<i>Anagallis arvensis</i> , <i>Chenopodium</i> sp., <i>Portulaca oleracea</i> , <i>Fumeria parviflora</i> , <i>Commelina</i> sp., <i>Trianthema</i> sp., <i>Amaranthus spinosus</i> ,	1.0 kg	2.0 kg	750-1000	-

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Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Cabbage/Cauliflower/Onion/Garlic (pre-or post-transplanting)	<i>Anagallis arvensis</i> , <i>Chenopodium</i> sp., <i>Portulaca oleracea</i> , <i>Fumeria parviflora</i> , <i>Commelina</i> sp., <i>Trianthema</i> sp., <i>Amaranthus spinosus</i>	1.0 kg	2.0 kg	750-1000	
Cumin/Corriander/Fennel/Fenugreek (pre-plant)	<i>Anagallis arvensis</i> , <i>Chenopodium</i> sp., <i>Portulaca oleracea</i> , <i>Fumeria parviflora</i> , <i>Commelina</i> sp., <i>Trianthema</i> sp., <i>Amaranthus spinosus</i>	1.0 kg	2.0 kg	750-1000	
Glyphosate IPA salt 20.2% SL					
Non-crop area	<i>Phyllanthus niruri</i> , <i>Ageratum conyzoides</i> , <i>Parthenium hysterophorus</i> , <i>Sorghum halepense</i> , <i>Amaranthus spinosus</i> , <i>Alternanthera sessilis</i> , <i>Cynodon dactylon</i> , <i>Cyperus rotundus</i> , <i>Echinochloa colona</i> , <i>Trianthema portulacastrum</i>	0.82-1.23 kg	4.1-6.15 L	400-500	-
Glyphosate IPA salt 41% SL					
Non-crop area	<i>Sorghum halepense</i> and other dicot and monocot weeds in general	0.82-1.23 kg	2.0-3.0 L	500	-
Glyphosate IPA salt 54% SL					
Non-crop area	<i>Ageratum conyzoides</i> , <i>Alternanthera sessilis</i> , <i>Echinochloa</i> spp., <i>Eclipta alba</i> , <i>Ischaemum rugosum</i> , <i>Setaria</i> spp, <i>Commelina</i> spp., <i>Cyperus</i> spp.	1.8 kg	3.33 L	400-500	-
Glyphosate ammonium salt 5% SL					
Non-crop area	<i>Digitaria sanguinalis</i> , <i>Eragrostis minor</i> , <i>Cynodon dactylon</i> , <i>Digera arvensis</i> , <i>Euphorbia</i> spp., <i>Parthenium hysterophorus</i> , <i>Cyperus rotundus</i> , <i>Xanthium strumarium</i> , <i>Tribulus terrestris</i>	2 kg	40 L	500	-
Glyphosate ammonium salt 71% SG					
Non-crop area	<i>Acalypha indica</i> , <i>Sida acuta</i> , <i>Ipomoea digitata</i> , <i>Cychorium intybus</i> , <i>Digera arvensis</i> , <i>Digitaria sanguinalis</i> ,	2.13 kg	3.0 kg	500	7

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
	<i>Paspalum conjugatum</i> , <i>Ageratum conyzoides</i> , <i>Cynodon dactylon</i> , <i>Cyperus rotundus</i> , <i>Eragrostis</i> spp.				
Imazethapyr 10% SL					
Groundnut	<i>Cyperus difformis</i> , <i>Commelina benghalensis</i> , <i>Trianthema portulacastrum</i> , <i>Eragrostis pilosa</i>	100-150 g	1.0-1.5 L	500-700	90
Linuron 50% WP					
Pea (pre-em)	<i>Anagallis arvensis</i> , <i>Chenopodium album</i> , <i>Chenopodium murale</i> , <i>Portulaca oleracea</i> , <i>Melilotus indica</i> , <i>Melilotus alba</i> , <i>Medicago denticulata</i> , <i>Fumaria parviflora</i> , <i>Echinochloa crus-galli</i> , <i>Poa annua</i>	0.625-1.0 kg	1.25-2.0 kg	500	80-90
Metribuzin 70% WP					
Field peas (0-3 DAS or 15-20 DAS)	<i>Anagallis arvensis</i> , <i>Chenopodium</i> sp., <i>Portulaca oleracea</i> , <i>Fumaria parviflora</i> , <i>Commelina</i> sp., <i>Trianthema</i> sp., <i>Avena fatua</i> , <i>Parthenium hysterophorus</i> , <i>Amaranthus spinosus</i> , <i>Euphorbia</i> sp.	0.25 kg	0.35 L	400-600	-
Potato (pre-em, early post-em, 3-4 DAP)	<i>Chenopodium album</i> , <i>Asphodelus tenuifolius</i> , <i>Anagallis arvensis</i> , <i>Convolvulus arvensis</i> , <i>Cyperus iria</i> , <i>Portulaca oleracea</i> , <i>Fumaria parviflora</i> , <i>Portulaca oleracea</i>	0.525 kg	0.750 L	400-600	-
Tomato/Brinjal/Chilli (pre-transplanting or early post-em)	<i>Anagallis arvensis</i> , <i>Chenopodium</i> sp., <i>Portulaca oleracea</i> , <i>Fumaria parviflora</i> , <i>Commelina</i> sp., <i>Trianthema</i> sp., <i>Avena fatua</i> , <i>Parthenium hysterophorus</i> , <i>Amaranthus spinosus</i> , <i>Euphorbia</i> sp.	0.525 kg	0.750 L	400-600	-
Oxadiargyl 6% EC					
Cumin (pre-em, early post-em)	<i>Cyperus iria</i> , <i>Cyperus difformis</i> , <i>Eclipta alba</i> , <i>Ludwigia quadrifolia</i> ,	60-75 g	1.0-1.25 L	500	87

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
	<i>Chenopodium album</i> , <i>Rumex</i> sp., <i>Melilotus indica</i> , <i>Asphodelus tenuifolius</i>				
Mustard	<i>Chenopodium album</i> , <i>Melilotus</i> sp.	90 g	1.50 L	500	35
Oxyfluorfen 23.5% EC					
Onion (pre-em)	<i>Chenopodium album</i> , <i>Amaranthus viridis</i>	100-200 g	425-850 mL	500-750	-
Potato (pre-em)	<i>Chenopodium</i> sp., <i>Coronpus</i> sp., <i>Trianthema</i> sp., <i>Cyperus</i> sp., <i>Heliotropium</i> sp.	100-200 g	425-850 mL	500-750	-
Groundnut (pre-em)	<i>Echinochloa colona</i> , <i>Digitaria marginata</i>	100-200 g	425-850 mL	500-750	-
Paraquat dichloride 24% SL					
Potato (post-em, inter-row application at 5-10% emergence)	<i>Chenopodium</i> sp., <i>Anagallis arvensis</i> , <i>Trianthema monogyna</i> , <i>Cyperus rotundus</i> , <i>Fumaria parviflora</i>	0.5 kg	2.0 L	500	100
Rubber (post-em, inter row application at 2-3 leaf stage of weeds)	<i>Digitaria</i> sp., <i>Eragrostis</i> sp., <i>Fimbristylis</i> sp.	0.3-0.6 kg	1.5-2.5 L	600	-
Grapes (post-em, inter row application at 2-3 leaf stage of weeds)	<i>Cyperus rotundus</i> , <i>Cynodon dactylon</i> , <i>Convolvulus</i> sp., <i>Portulaca</i> sp., <i>Tridax</i> sp.	0.5 kg	2.0 L	500	90
Apple (post-em, inter row application at 2-3 leaf stage of weeds)	<i>Rosa moschata</i> , <i>Rosa eglantheria</i> , <i>Rubus ellipticus</i>	0.75 kg	3.25 L	700-1000	-
Pendimethalin 30% EC					
Sorghum/ Pearl millet (0-3 DAS)	<i>Digitaria sanguinalis</i> , <i>Echinochola crus-galli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	2.5-3.0 L	400-600	-
Greengram/Black gram/Pigeonpea (0-3 DAS)	<i>Digitaria sanguinalis</i> , <i>Echinochola crus-galli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	2.5-3.0 L	400-600	-

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Chickpea/Lentil /Field peas (0-3 DAS)	<i>Digiteria sanguinalis</i> , <i>Echinochola crusgalli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	2.5-3.0 L	400-600	-
Sunflower (0-3 DAS)	<i>Digiteria sanguinalis</i> , <i>Echinochola crusgalli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	2.5-3.0 L	400-600	-
Rapeseed/Mustard (pre-em) (untimely rain immediately after the application of the herbicide may damage the crop)	<i>Digiteria sanguinalis</i> , <i>Echinochola crusgalli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	0.75-1.00 kg	2.5-3.0 L	400-600	-
Linseed/Sesamum/Niger (0-3 DAS)	<i>Digiteria sanguinalis</i> , <i>Chenopodium</i> Sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> Sp.,	0.75-1.00 kg	2.5-3.0 L	400-600	-
Jute (0-3 DAS)	<i>Digiteria sanguinalis</i> , <i>Chenopodium</i> Sp., <i>Argemone mexican</i> , <i>Echinochloa crus-galli</i> , <i>amaranthus spinosus</i> , <i>Portulaca</i> Sp.,	0.75-1.00 kg	2.5-3.0 L	400-600	-
Potato (pre-em)	<i>Chenopodium album</i> , <i>Asphodelus tenuifolius</i> , <i>Anagalis arvensis</i> , <i>Convolvulus arvensis</i> , <i>Cyperus iria</i> , <i>Portulaca oleracea</i> , <i>Fumeria parviflora</i> , <i>Portulaca oleracea</i>	1.0 kg	3.0 L	400-600	-
Tomato/Brinjal/Chilli/Onion/Garlic/Beet root/Radish/Carrot (pre-or post-transplant)	<i>Digiteria sanguinalis</i> , <i>Echinochola crusgalli</i> , <i>Chenopodium</i> sp., <i>Argemone mexicana</i> , <i>Amaranthus spinosus</i> , <i>Portulaca</i> sp.	1.0 kg	3.0 L	400-600	-
Cumin/Corriander/Fennel/Fenugreek (pre-plant)	<i>Chenopodium album</i> , <i>Asphodelus tenuifolius</i> , <i>Anagalis arvensis</i> , <i>Cyperus iria</i> , <i>Portulaca oleraces</i> , <i>Fumaria parviflora</i>	1.0-1.5 kg	3.0-5.0 L	400-600	-

Herbicide Recommendations

Herbicide	Weed species	Dosage /ha		Dilution in water (L)	Waiting period (days)
		a.i. (g,kg)	Formulation (g,kg,mL,L)		
Propaquizafop 10% EC					
Blackgram (post-em)	<i>Echinochloa colona</i> , <i>Echinochloa crus-galli</i> , <i>Digitaria sanguinalis</i> , <i>Dactyloctenium aegyptium</i> , <i>Eleusine indica</i>	75-100 g	750-1000 mL	500-750	21
Quizalofop-ethyl 5% EC					
Groundnut (post-em)	<i>Echinochloa colona</i> , <i>Dinebra retroflexa</i> , <i>Dactyloctenium sp.</i>	37.5-50.0 g	750-1000 mL	500	89
Black gram (post-em)	<i>Eleusine indica</i> , <i>Dactyloctenium aegyptium</i> , <i>Digitaria sanguinalis</i> , <i>Eragrostis sp.</i> , <i>Paspalidium sp.</i> , <i>Echinochloa sp.</i> , <i>Dinebra retroflexa</i>	37.5-50.0 g	750-1000 mL	500	52
Onion (post-em)	<i>Digitaria sp.</i> , <i>Eleusine indica</i> , <i>Dactyloctenium aegyptium</i> , <i>Eragrostis sp.</i>	37.5-50.0 g	750-1000 mL	375-450	7

Source: Central Insecticide Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Faridabad; Dixit and Varshney

5. Herbicide Consumption

In our country, the use of pesticides was started with the import of DDT during World War II. Thereafter, the use of insecticides became a popular tool to manage insect-pests in agricultural crops. During late 1970s and early 1980s, the introduction of a number of insecticides of different groups, viz. organochlorin, organophosphate, carbamate and synthetic pyrethroid imparted a different dimension to crop protection. But the use of herbicides did not receive that impetus what insecticides received, though the first synthetic herbicide 2,4-D had been introduced in Indian agriculture during the decade of 1950s. In 1960s and 1970s, the major use of herbicides was restricted to tea plantations. In many advanced countries, the average annual consumption of herbicides is 675 to 1350 g/ha. It is as high as 5000 g/ha in Japan. Against these high figures, in India at present the average annual herbicide use is hardly 40 g/ha (www.agriinfo.in). This is largely because of the poor purchasing power of most of our farmers and also due to lack of technical knowledge about the use of herbicides. The cost of certain herbicides is also very high as the basic ingredients for manufacturing herbicides are imported from the developed countries. But the situation has rapidly been changed during the previous decade due to urbanization. Higher wage in construction sector and industries led to the labour crisis in agriculture sector. Farming community started opting for technologies which require less manpower. The use of herbicides has been escalated during this period and is still going up.

During early 1990s, global agrochemical market research indicated that the crop protection market was approaching maturity and it was becoming increasingly difficult to discover new agrochemicals with significant advantages over existing products. Indeed, annual global turnover of crop protection products reached a maximum in the mid-1990s, and has fluctuated between US\$25 and \$35 billion per year over the last 15 years, with herbicides representing almost 50% of this amount (Fig. 5.1). But in India it was completely reverse. During 1995, herbicide use in India was quantified as 6040 t (technical grade) whereas in 2010 it was more than 7000 t (Table 5.1 and 5.2). Due to the increased use of low-dose herbicides replacing the conventional high-dose herbicides like 2,4-D, butachlor, isoproturon etc., the amount of consumed herbicides decreased, but the acreage under weed management through herbicide application increased. Two major high-dose herbicides, viz., butachlor in rice and isoproturon in wheat, are being replaced by low-dose herbicides, viz. pyrazosulfuron in rice, and sulfosulfuron in wheat. The consumption of butachlor came down from 2699 t in 2005-06 to 372 t (technical grade) in 2009-10, i.e. a reduction of 85%. Pretilachlor grabbed a large share from butachlor in the rice market. Now, low-dose herbicides, viz. pyrazosulfuron-ethyl, bispyribac-sodium and orthosulfamuron are being used in place of butachlor and pretilachlor. Similarly, a reduction of 40% took place in the case of isoproturon use in wheat within 5 years, from 2005-06 to 2009-10 (Table 5.3). This reduction in isoproturon use in wheat was caused due to the resistance development in *Phalaris*. Farmers shifted from isoproturon to sulfosulfuron and more recently to combination products like mesosulfuron + iodosulfuron.

The increasing demand of herbicide is being met by the various production units in our country. At present, the production of technical grade herbicides is more than 5000 t (Table 4), albeit the actual production can be much higher as there are many companies manufacturing pesticides in the unorganised sector, for which the data are not available. The production trends have not much changed over the period from 2005 to 2010 (Table 5). This is because many of the recently developed low-dose herbicides are being imported from different countries. Technical grade materials of some of the sulfonyl ureas and imidazolinones are not manufactured in our country. They are imported

and then formulated in India. Recently registered bispyribac-sodium and orthosulfamuron are being imported as formulation grade materials. Accurate data on the import of herbicides are not available. The information obtained from the office of Commercial Intelligence and Statistics, Kolkata does not mention specifically about the import of sulfonyl ureas and others (Table 5.6). But the list on the source of import and indigenously manufactured herbicides published by the Directorate of Plant Protection, Quarantine and Storage, Faridabad depicts that many herbicides are being imported in the form of technical grade as well as formulation grade (Table 5.8). In the report of Standing Committee 2013 on 'Production and availability of pesticides', it has been mentioned that our country imported 25.92, 38.99, and 22.28 t under the head 'Weedicides and weed killing products', and 3,775.36, 4,689.01, and 5,739.84 t under the head 'Other herbicides-anti-sprouting products' during 2010-11, 2011-12 and 2012-13, respectively. But there was no mention of export or import value for any individual herbicide. Even the list obtained from the Zonal Conference on Inputs 2010, does not say anything about the newer herbicides actually imported from other countries. India earned foreign currency by exporting 'me-too' herbicides like 2,4-D, MCPA and isoproturon over the years (Table 5.9). Our country exported 4632.24, 4222.37 and 2589.95 t under the head 'Weedicides and weed killing products' and 10535.31, 14,971.12 and 10,048.73 t under the head 'Other herbicides-anti-sprouting products' during 2010-11, 2011-12 and 2012-13, respectively (Standing Committee 2012-13). During the financial year 2012-13, India exported technical grade 2,4-D to USA, Brazil, Argentina, Thailand, and Ethiopia; and isoproturon to the Netherlands, Belgium and Thailand (Table 5.10). The average price of individual herbicides has increased over the years mainly due to inflation (Table 5.11).

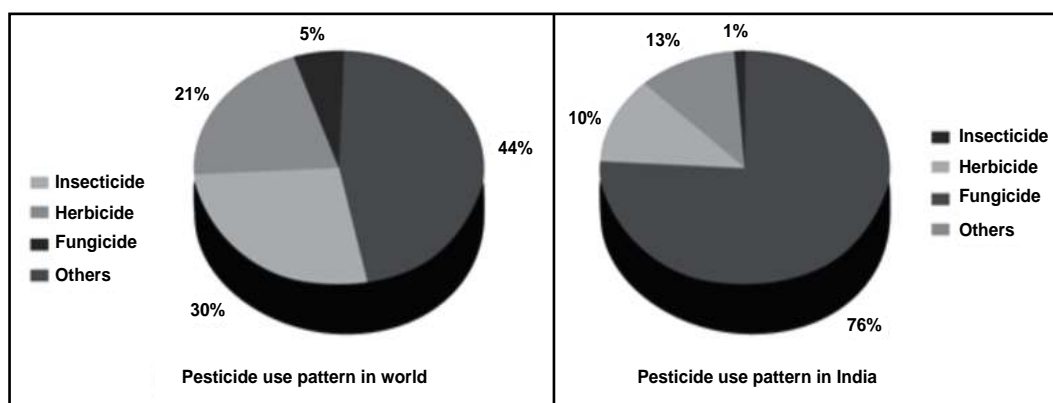


Fig. 5.1 A comparison in pesticide use pattern between India and world (based on market value) (Bhattacharya et al. 2009)

Table 5.1 Consumption of technical grade pesticides (group-wise) (in t) during 1995-96 to 2004-05

Pesticide group	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05
Insecticide	38788	34665	33379	30469	28926	26756	29839	28197	25627	25929
Fungicide	10563	9969	10054	10428	8435	8307	9222	10712	9087	6397
Herbicide	6040	7060	7103	7292	7369	7299	6979	7857	5610	7364
Others	5869	4420	1703	968	1465	1222	1308	1398	438	1660
Total	61260	56114	52239	49157	46195	43584	47348	48146	40762	41350

Source: TERI Energy Data Directory and Yearbook (2007)

Table 5.2 Pesticides consumption in India (formulated products in t)

Pesticide group	2003	2004	2005	2006	2007	2008	2009	2010
Insecticide	22694	21489	21783	16913	14617	3278	14810	20618
Fungicide	11028	8435	6566	13367	8297	7491	9626	13055
Herbicide	7500	5154	6959	6304	11972	3813	4557	6704

Source: FAO Stat (2014)

Table 5.3 Consumption of indigenous herbicides from 2005-06 to 2009-10 (technical grade in t)

Herbicide	2005-06	2006-07	2007-08	2008-09	2009-10
Alachlor	50.00	55.00	35.26	70.00	117.00
Anilophos	243.00	255.00	103.05	253.00	1421.00
Atrazine	0.00	240.00	239.00	337.00	370.00
Butachlor	2699.00	1197.00	1236.00	1246.00	372.15
Dalapon	34.00	19.00	11.02	9.00	3.00
2,4-D	565.00	446.00	412.41	555.40	662.00
Diuron	29.00	16.06	10.36	11.00	333.00
Fluchloralin	82.00	98.00	81.04	49.26	71.24
Glyphosate	216.00	358.00	324.34	644.17	1397.00
Isoproturon	2140.00	1314.01	1126.04	1154.47	1429.35
Paraquat dichloride	148.00	256.24	137.1	169.12	383.00
Propanil	16.00	9.35	17.01	9.30	75.00

Source: States/UTs, Zonal Conference on Inputs, 2010 (In: Standing Committee on Chemicals and Fertilisers (2012-13). 2013. Production and Availability of Pesticides. 36th Report, 15th Lok Sabha, Dept. of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilisers, Govt. of India. August, 2013.)

Table 5.4 Production of herbicides in India from 2005-06 to 2009-10 (technical grade in t)

Herbicide	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10
2,4 -D	329	0	270	214	NA
Alachlor	NA	NA	NA	NA	0
Anilophos	197	21	0	NA	0
Atrazine	0	93	218	263	263
Butachlor	254	182	330	119	239
Dalapon	0	NA	NA	NA	NA
Diuron	0	0	52	12	126
Fluchloralin	119	101	0	NA	0
Glyphosate	1517	2100	1517	2331	1697
Isoproturon	4295	3150	2962	2979	2910
Paraquat	0	NA	0	NA	NA
Total	6711	5647	5349	5918	5235

Herbicide Consumption

Table 5.5 Performance in the indigenous production of selected major herbicides during 2005-06 to 2012-13 (in thousand t)

Major Groups / Products	Installed capacity						Production				
	2010-11	2011-12	2012-13	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
2, 4-D	12.00	17.00	17.00	8.07	8.36	8.90	9.57	10.64	11.52	12.37	12.95
Butachlor	0.50	0.50	0.50	0.32	0.18	0.03	0.12	0.24	0.29	0.11	0.18
Isoproturon	6.25	6.25	6.25	4.30	3.15	2.96	2.98	2.91	3.68	2.53	4.05
Glypho sate	7.64	9.26	9.26	1.52	2.89	2.58	4.39	4.66	4.86	5.25	6.12
Diuron	0.05	0.05	0.05	0.00	0.00	0.08	0.01	0.13	0.23	0.31	0.14
Atrazine	0.50	0.50	0.50	0.00	0.09	0.22	0.26	0.26	0.25	0.66	0.65

Table 5.6 Imports of herbicides and their CIF values from 2005-06 to 2009-10

Pesticides	2005-06 Qty*	2005-06 CIF Value**	2006-07 Qty	2006-07 CIF value	2007-08 Qty	2007-08 CIF value	2008-09 Qty	2008-09 CIF value	2009-10 Qty	2009-10 CIF value
Isoproturon	144.00	426.00	145.00	427.00	0.00	0.00	0.006	0.25	-	-
MCPA	1.00	38.00	2.00	40.00	0.00	0.00	8.20	8.0	16.00	15.00
TCA	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
2,4-D	0.15	22.00	1.00	24.00	1.00	83.00	4.10	12.4	62.00	72.00

*Quantity (Qty.) in t technical grade); **Cost, insurance and freight (CIF) value in Rs. lakhs

Source: Director General of Commercial Intelligence & Statistics, Kolkata

Table 5.7 Consumption of imported herbicides from 2005-06 to 2009-10 (technical grade in t)

Herbicide	2005-06	2006-07	2007-08	2008-09	2009-10
Atrazine	0.00	0.00	0.00	0.00	0.26
Benthiocarb	0.10	0.10	32.00	8.40	3.00
Methabenzthiazuron	0.00	0.00	0.00	1.00	8.00
Metribuzin	2.00	2.00	2.00	88.00	126.00
Meto lachlor	2.00	27.00	3.00	2.00	3.00
Oxadiazon	14.00	0.10	0.00	0.00	0.00
Oxadiargyl	12.00	90.20	3.00	5.00	7.00
Oxyfluorfen	26.00	26.10	4.00	16.40	33.00
Pendimethalin	9.00	10.00	72.00	101.48	114.31
Pretilachlor	0.00	0.00	8.00	95.10	209.10
Simazine	0.00	0.00	0.00	1.00	2.00
Triallate	9.00	68.35	0.00	0.00	1.00
Trifluralin	7.00	6.00	0.00	42.00	3.10

Source: Directorate of Plant Protection, Quarantine & Storage (2015) (<http://ppqs.gov.in>)

Table 5.8 Source of import and list of indigenous manufacturers of herbicides (as on dated 20th August, 2014)

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
1.	2,4-D ethyl ester technical 97% min	---	1. Insecticides India Ltd., Delhi 2. Swati Chlorides Pvt. Ltd., Vadodara 3. Ambey Laboratories Pvt. Ltd., New Delhi 4. Crystal Phosphates, Delhi. 5. Atul Ltd., Valsad 6. Bharat Rasayan Ltd. , Delhi 7. Meghmani Organics Ltd., Ahmedabad
2.	2,4-D sodium salt technical 94.5% min	---	1. Insecticides India Ltd., Delhi 2. Atul Ltd., Valsad 3. Meghmani Organics Ltd., Ahmedabad 4. Bharat Rasayan Ltd., Delhi (80%)
3.	2,4-D sodium salt 80.3% acid		1. Atul India Limited, Valsad 2. Artee Minerals, Faridabad 3. Dhanuka Pesticides 4. Meghmani Organics Ltd. 5. Heranba Industries Ltd.
4.	Alachlor technical 90% min.	1. Monsanto Agricultural Products Co., USA. Supplier-Sinochem International (Overseas) Pvt. Ltd., 9 Raffles Place, No. 50-01 Republic Plaza, Singapore 048619	1. Siris India Ltd., Hyderabad
5.	Anilophos technical 93% min	1. Bayer Cropscience AG, Germany	1. Bayer Crop Science Ltd., Mumbai 2. Gharda Chemicals Ltd., Mumbai 3. Hyderabad Chemical Pvt. Ltd.
6.	Atrazine technical 80%, 92% and 95% min	1. Agan Chemical Manufacturers. Ltd., Israel 2. Makhteshim Agan Beer -Sheva, Israel. 3. Intrachem, SA, Switzerland 4. Fisons Ltd., Houston, UK 5. Oxon Italia, Italy 6. Zhejiang Zhongshan Chemical Industry Group Co. Ltd. Zhongshan, Xiaopu, Changxing, Zhejiang Province, 313 116, China (for 95%min)	1. Rallis India Ltd., Bangalore 2. Pesticides India, Udaipur 3. Nagarjuna Agrichem, Hyderabad 4. GSP Crop Science Pvt. Ltd. Ahmedabad 5. Insecticide India Ltd 6. Meghmani Industries Ltd.
7.	Azimsulfuron 50% DF [without registering technical (WRT)]	1. DuPont de Nemours (France) S.A.S.82, Cerney Cedex France through Du Pont International Operations, Geneva, Switzerland	---
8.	Bensulfuron-methyl technical 96% min	1. DuPont Agricultural Chemicals Ltd., Shangai, P.R. China through supplier DuPont Company Singapore Pvt. Ltd., Singapore	
9.	Bensulfuron-methyl 60% DF	1. DuPont Nemours Australia, 179 Magowor Road, Girraween NSW, Australia 2145, through Supplier DuPont Company Singapore Pvt. Ltd., 1, Harbour Trust Place, 11-01, Harbour trust, Tower One, Singapore 098633	

Herbicide Consumption

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
10.	Benthiocarb technical 93% min (Thiobencarb)	1. Kumaiai Chemical Industries Co. Ltd., Japan	
11.	Bispyribac-sodium 10% SC	1. Kumaiai Chemical Industry Co. Ltd., 4-26, Ikenohata 1-chome, Taitoh-Tokyo, Japan	---
12.	Butachlor technical 85% min	1. Monsanto Agricultural Products Co., USA Supplier - Sinochem International (Overseas) Pvt. Ltd., 9 Raffles Place, 50-01 Republic Plaza, Singapore 048619 2. Shen Hong Chemical Corporation, Taiwan. 3. Shinung Corporation Taichung, Taiwan.	1. Hindustan Insecticides Ltd., Delhi 2. Montari Industries Ltd., Delhi 3. Siris India Ltd., Hyderabad 4. Insecticides India Ltd. 5. Jaishree Agro Industries Ltd, Delhi 6. Hyderabad Chemical Products Ltd. 7. Coromandel International Ltd., Secunderabad 8. Bharat Rasayan Ltd., Delhi 9. Sudarshan Chemical Industries Ltd., Pune
13.	Carfentrazone-ethyl 40% DF	1. FMC Corporation Agricultural Product Group, Philadelphia, PA 19103, USA	
14.	Carfentrazone-ethyl 53% manufacturing use products (MUP)	1. FMC Corporation Agricultural Product Group, 1735 Market Street, Philadelphia, PA 19103, USA	
15.	Clodinafop-propargyl technical 93% min. (Piroxofop-propinyl)	1. Cheminova A/S, P. O. Box 9, DK-7620, Lemvig, Denmark 2. Syngenta Grimsby Pyewipe, GB, Grimsby South Humbeside, UK	1. UPL Ltd., Gujarat 2. Atul Limited, Gujarat 3. Bhagiradha Chemicals & Industries Ltd., Prakasham District (A.P.) 4. Hyderabad Chemical Products Ltd. 5. Crystal phosphate Limited, Delhi 6. Rotam India Ltd., Mumbai 7. Ravi Organics Ltd. 8. Bharat Rasayan Ltd. 9. Punjab Chemicals & Crop Protection Ltd. 10. Sharda Worldwide Exports Pvt. Ltd. 11. Meghmani Industries Ltd. 12. Modern Insecticides Ltd., Ludhiana 13. Chemtura Chemical India Pvt. Ltd., New Delhi 14. GSP Crop Science Pvt. Ltd., Ahmedabad 15. Insecticides India Ltd. 16. Sundew Life Science Pvt. Ltd., Coimbatore 17. Sabero Organics Gujarat Ltd. 18. Gharda Chemicals Ltd. 19. HPM Chemicals & Fertilizers Ltd.
	Clodinafop-propargyl technical 95% min. (Piroxofop-propinyl)	1. Agan Chemical Manufacturers Ltd., P.O.B. 262, Ashdod, Israel	
16.	Clomazone technical 90%	1. FMC Corporation, Philadelphia, USA	
17.	Chlorpropham technical	1. UPL Ltd., Chadwick House, Birchwood Park, Warriton, WA 36AE, UK	
18.	Chlorimuron-ethyl technical 95% min	1. DuPont Agricultural Caribe Industries Ltd., Box 30,000, State Road, HWY, 686 Km. 2.3 Manati Puerto Rico - 00701, USA	1. Atul Ltd., Valsad, Gujarat

Herbicide Use in Indian Agriculture

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
19.	Cynmethylin technical 90% min	1. Dimminico Ltd. Switzerland	
20.	Dazomet technical 94% min	1. BASF Atkiengesll Shaft , D-67056 Ludwigshafen, Germany	1. Margo Bio Controls Pvt. Ltd., Bangalore
21.	Dalapon technical 85% min and TK	1. Veb Chemical Kombunat, Bitterfield, GDR 2. Dow Agro Sciences LLC, USA 3. Diamond Shamrock, USA	
22.	Diclofop-methyl technical 93% min	1. Bayer Crop Science, AG, Germany	
23.	Dinocap technical 90% min	1. Dow Agro Sciences, Italy 2. Dow Agro Sciences, USA	
24.	Diuron technical 95% min. and 98% min	1. E.I Dupont de Nemours & Co., Inc. USA 2. Makhteshim Agan, Israel 3. Agan Chemical Manufacturers Ltd., Israel	1. Bayer Crop Science Ltd., Mumbai 2. Atul Ltd., Valsad 3. Hikal Ltd., Mumbai 4. Crew Chemicals 9(3)-98% min. 5. Siris Crop Science, N. Delhi 6. Bharat Rasayan Ltd., Delhi (98%)
25.	Ethoxysulfuron 15% WDG	1. Manufactured by Bayer Crop Science AG, Germany and formulation supplied by through Bayer Vietnam Ltd., Lot 118/14, Amata, IP Bien Hoa City, Dong Nai Province, Vietnam	
26.	Fenoxaprop-P-ethyl technical 88% min	1. Bayer Crop Science, AG, Germany 2. Hangzhou Udragoan Chemical Co. Ltd. 172, Zhangjiadun Road, Tangxi, Yuhang, Hangzhou, Zhejiang, P.R. China. Through Supplier: M/s. Willwodd (Hangzhou) Co. Limited, Room No. 2003, Golden Plaza, No. 118, Qingchun Road, Xiacheng District, Hangzhou City, Zhejiang Province, China	
27.	Fluazifop-P-butyl technical	1. Syngenta Ltd., Huddersfield, United Kingdom	
28.	Fluchloralin technical 55% min and 65% min	1. BASF Wayandotte Corpn, USA 2. BASF, West German	
29.	Glufosinate ammonium technical 50% min	1. Bayer Crop Science AG, Frankfurt, Germany 2. Bayer Crop Science LP, Michigan, USA	
30.	Glyphosate technical 95% min	1. Monsanto Chemicals Co. Ltd., USA 2. Hebei Golhil Chemical. Co. Ltd., Tongda Road, Jinzhou City, 052260, Hebei, China Through supplier Hebei Bestar commerce and Tradel co. Ltd., 148, East Yuhua Road, Shejiashuang, 050031, China (95% min)	1. Atul Ltd., Valsad 2. Excel Crop Care Ltd., Mumbai 3. Gharda Chemicals Ltd., Mumbai 4. Chemtura Chemicals India Pvt. Ltd. 5. Ravi Organics Ltd. 6. Meghmani Industries Ltd. 7. Insecticide India Ltd. 8. Crystal Phosphates Ltd. 9. Hyderabad Chemicals Products Ltd., Hyderabad

Herbicide Consumption

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
	Glyphosate IPA salt technical 62% min	3. Cheminova A/s P.O Box 9, DK-7620, Lemvig, Denmark	10. Krishi Rasayan Pvt. Ltd., Kolkata 11. UPL Ltd., Vapi 12. Punjab Chemicals & Crop Protection Ltd. 13. Rotam India Ltd. 14. GSP Crop Science Ltd. 15. Siris Crop Science Ltd., New Delhi 16. Jai Shree Rasayan Udyog Ltd., Nathupur, Sonapat (Haryana) 17. Heranba Industries Ltd., Mumbai 18. Shivalik Rasayan Ltd., New Delhi 19. Sharda worldwide Exports Pvt. Ltd., Mumbai 20. Cheminova Inida Ltd., Gujarat 21. Sabero Organics Gujarat Ltd. 22. Bharat Rasayan Ltd., Delhi (95%) 23. Exel Industries Ltd., ROHA (Maharastra) 24. HPM Chemicals & Fertilizers Ltd., New Delhi
31.	Hexazinone 13.2% + Diuron 46.8% WP	1. E.I. DuPont de Nemours and Company, USA with the manufacturing address van Diest Supply Co., Webster City, Iowa, USA	
32.	Imazethapyr technical 90% min, 93% min	1. BASF Corporation, Hannibal, Missouri, USA 2. BASF Corporation, 14385 West Port, Arthur road, Route# 4, Box 327, Beaumont TX 99905, USA (90% min) 3. Milenia Agro Science S/A, Londrina, Brazil (93% min) 4. Shenyang Research Institute of Chemical Industry, No. 8, Shenliaodong Road, Shenyang, Liaoning Province, P.R. China. Through Supplier: Willowood Limited, 17 th Floor, Seaview Plaza, 283-Shau Kei Wan Road, Shau Kei Wan, Hong Kong 5. Jiangsu Flag Chemical Industry Co. Ltd. Changheng Road, Nanjing Chemical Industrial Park, Luhe district, Nanjing, China 210047	1. Astec Life Sciences Ltd., Mumbai
33.	Imazamox 35%+ Imazethapyr 35% WG	1. BASF Agriculture Products de Puerto Rico Route No. 2 km 47.3. P. O. Box 43, Manati, Puerto Rico 006704 USA	
34.	Imazethapyr 70%WG	1. BASF Agriculture Products de Puerto Rico Route No. 2 km 47.3. P. O. Box 43, Manati, Puerto Rico 006704 USA	

Herbicide Use in Indian Agriculture

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
35.	Isoproturon technical 95% min	1. Novartis Crop Protection, AG, Switzerland 2. Ventis Crop Science, GmbH, Frankfurt, Germany 3. Bayer CropScience AG, Germany	1. Agrevo India Ltd., Mumbai 2. Atul Ltd., Valsad 3. Gharda Chemicals Ltd., Mumbai 4. Montari Industries Ltd., Delhi 5. Siris India Ltd., Hyderabad 6. Agrico Organics Ltd., New Delhi 7. Cheminova India Ltd., Bangalore 8. Bharat Rasayan Ltd., Delhi 9. Bayer Crop Science Ltd., Mumbai
36.	Linuron technical 94% min	Not available	
37.	Mesosulfuron-methyl 3% + Iodosulfuron-methyl-sodium 0.6% WG	1. Bayer CropScience AG, Germany	
38.	Metsulfuron-methyl technical 93% min.	1. Rotam Crop Science Ltd., China 2. DuPont Agriculture Caribe Industries Ltd. DACI Highways Manati, Puerto Rico 3. DuPont Agriculture Chemicals Ltd., Shanghai, Pudong Shanghai, China	1. Atul Ltd., Valsad 2. GSP Crop Science Pvt. Ltd., Ahmedabad 3. Siris Crop Science Limited, New Delhi 4. Indofil Industries Ltd, Andheri (E) 5. Meghmani Industries Ltd. 6. Punjab Chemicals and Crop Protection Pvt. Ltd. 7. Sharda Worldwide Pvt. Ltd. 8. Insecticides India Ltd. 9. Hindustan Pulversing Mills, Delhi 10. Bharat Rasayan Ltd., Delhi
39.	Metsulfuron-methyl 20% WG	1. PT DuPont Agricultural Products Indonesia, Beltway Office Park Building A Lt. 5, Jl, Ampera Raya 9-10, Jakarta, 12550, Indonesia	1. Crystal Phosphates Ltd., Delhi.
40.	Methabenzthiazuron technical 90%	1. Bayer Crop Science A.G., Germany 2. Agrimont SPA, Italy	
41.	Metolachlor technical 95% min	Novartis Crop Protection, AG, Switzerland	
42.	Metoxuron technical 97% min	Novartis Crop Protection, AG, Switzerland	1. Atul Ltd., Valsad
43.	Metribuzin technical 88% min	1. Bayer Crop Science A.G. Germany 2. Miles Inc., USA 3. Changzhou Wujin Henglong Pesticide Co. Ltd., Commercial Development zone, Ximenboyi Town, Changzhou City, Jiangsu, P.R. China (supplied through its supplier - M/s. Willwood Ltd. 17-F, Seaview Plaza, 283 Shau Kei Wan Road, Hong Kong	1. Rallis India Ltd., Mumbai 2. Meghmani Industries Ltd. 3. Siri Crop Science Ltd., New Delhi 4. Punjab Chemicals and Pharmaceutical Ltd., Chandigarh 5. Ravi Organics Ltd. 6. GSP Crop Science Pvt. Ltd. Ahmedabad 7. Bharat Rasayan Ltd., Delhi
44.	Orthosulfamuron 50% WG	1. Isoagro SPA Sentro Uffiei San Siro Fabbricato D-ala 3, Via Caldera-21, 20153, Milano, Italy	
45.	Oxadiargyl technical 96% min	1. Bayer, S.A.S, 16 rue JeanMarie Leclair 69009, Lyon, France	1. Bayer Crop Science Ltd., Mumbai
46.	Oxadiazon technical 92% min	1. Bayer S.A.S, 16 rue Jean-Marie Leclair 69009, Lyon, France	1. Bayer India Ltd., Mumbai

Herbicide Consumption

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
47.	Oxyfluorfen technical 70% min	1. Dow Agro Sciences, USA 2. Agan Chemicals Manufacturer Ltd., Israel	
	Oxyfluorfen technical 97% min	1. Yifen Biotechnology Group Co. Ltd., No. 136, Zhongxing Road, Wenshou Industrial Zone, Zhejiang, PR China Through supplier: Willowood(Hangzhou) co. Ltd., Room No. 2003, golden Plaza, No.-118, Quingchun Road, Xiacheng district, Honzhou City, Zhejiang Province, China	
48.	Paraquat dichloride technical 40% min	1. Zeneca, ICI, UK 2. Comlets Chemical Industrial Co. Ltd., Taiwan	1. Syngenta India, Mumbai 2. Crystal Phosphate Ltd., New Delhi 3. UPL Ltd., Mumbai
49.	Paraquat dichloride technical 42% min	1. Syngenta Limited, Huddersfield, West Yorkshire HD2 1FF, United Kingdom 2. Sinon Corporation, Taiuchung, Taiwan (Supplier : Sinon Corporation, Taiuchung)	
50.	Pendimethalin technical 90% min	1. BASF Corporation, Hannibal , Missouri, USA	1. Shivalik Rasayan Ltd., New Delhi 2. Siris Crop Science Ltd., New Delhi 3. Punjab Chemicals & Crop Protection Limited, Chandigarh 4. Magma Industries Ltd. 5. Heranba Industries Ltd. 6. UPL Ltd., Mumbai 7. Megmani Industries Ltd. 8. Bharat Rasayan Ltd., Delhi 9. Rallis India Limited 10. GSP Crop Science Pvt. Ltd., Ahmedabad
51.	Pendimethalin 38.7% CS	1. BASF Corporation, Agricultural Products Group, Hannibal Plant, 3150 Highway, JJ, Palmyra, Missouri, USA	
52.	Penoxsulam 21.7% SC	1. Dow AgroSciences LLC, 9330 Zionsville Road, Indianapolis, IN 46268, USA.	
53.	Pinoxaden technical	1. Syngenta Grangemouth Works, Earls Road, Grangemouth, UK 2. Zeneca ICI, UK.	
54.	Pretilachlor technical 94% min., 96% min	1. Syngenta Produkte AG, Switzerland 2. Hangzhou Qingfeng Agrochemicals Co. ltd. Formerly known as - (Hangzhou General Pesticide Plant) No 177, Jichang Road, Hangzhou , China Supplier : Willowood Ltd., unit 2314, Wellborne, Commercial Center 8, Java Road, North Point, Hongkong	1. Nagarjuna Agrichem Ltd., Hyderabad. 2. GSP Crop Science (P) Ltd., Ahmedabad 3. Hyderabad Chemical Product Ltd., Hyderabad 4. Siris Crop Science Ltd., New Delhi 5. Atul Ltd., Vapi 6. Sudarshan Chemical Industries Ltd., Pune 7. UPL Ltd. 8. Chemtura Chemicals India Pvt. Ltd. 9. Crystal phosphate Ltd. 10. Meghmani Industries Ltd. 11. Indofil Indutries Ltd., Mumbai 12. Ravi Organics Ltd

Herbicide Use in Indian Agriculture

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
			13. GSP Crop Science (P) Ltd., 14. Deccan Fine Chemicals (India) Ltd., 15. Insecticides India Ltd. 16. Punjab Chemicals and Crop Protection Ltd., Mumbai 17. Bharat Rasayan Ltd., Delhi 18. HPM Chemicals & Fertilizers Ltd., New Delhi
55.	Propanil technical 88% min	1. Monsanto Agricultural Products Co., USA 2. Makhteshim Agan Beer-Sheva, Israel 3. Rohm & Hass Co., USA	
56.	Propaquizafop 10% EC	1. Agan Chemical Manufacturers Ltd., Northern Industrial Zone, Ashdod-77102, Israel and source of supply Quenna Plant Protection NV, kaya WFG, Mensing 34, P.O. Box-403, Curacao, Netherlands, Antilles	
57.	Pyrazosulfuron-ethyl technical	1. LG chemicals limited, LG twin Tower, 20 Yoido-Dong, Youngdungpo-gu, Seoul	
58.	Pyrithiobac-sodium 95% min		1. Goldmuhar Agrochem & Field Ltd., Vikhroli (Mumbai)
59.	Quizalofop-ethyl 5% EC 10% EC	1. Nisan Chemical Industries Ltd, Kowa, Hitotsubashi Building, 7 -1, 3-Chome, Kanda -Nishikicho, Chiyoda-Ku, 101-0054Tokyo, Japan Through Supplier - Nissei Corporation,10-5, Nihonbashi-Honcho,1-Chome, Chou-Ku Tokyo, 103-0023Japan	
60.	Quizalofop-P-tefuryl 4% EC	1. Chemtura Europe Ltd. , Chemark Kft, Hungary	
61.	Sirmate	Not available	
62.	Sulfosulfuron technical 98% min	1. Monsanto Company, USA Supplier – Sumitomo Chemical Company, Japan	1. UPL Ltd. 2. Gharda Chemicals, Mumbai 3. Hyderabad Chemical Products Ltd., Hyderabad 4. Atul Limited, Gujarat 5. Tagros India Ltd., Chennai 6. Meghmani Industries Ltd., Ahmedabad 7. Crystal Phosphate Ltd, Delhi 8. GSP Crop Science Private Limited, Ahmedabad 9. Insecticide India Limited 10. Indofil Industries Ltd., Andheri (E) 11. Bharat Rasayan Ltd. 12. Sharda Worldwide Exports Pvt. Ltd.
63.	Sulfosulfuron technical 98.5% min		1. Excel Crop Care Ltd., Mumbai 2. Punjab Chemicals and Crop Protection Ltd., Mumbai 3. Heranba Industries Ltd. 4. Indofil Industries Ltd. Andheri (E), Mumbai 5. HPM Chemicals & Fertilizers Ltd., New Delhi

Herbicide Consumption

S. No.	Herbicide	Approved source for import	Indigenous manufacturers
64.	Triallate technical 90% min	1. Monsanto Chemicals Co. Ltd., Belgium	
65.	Triasulfuron technical 94% min	1. Syngenta Crop Protection AG CH-4002, Basle, Monthey, Switzerland	
66.	Trifluralin technical 85% min, 95% min	1. Dow Elanco, USA 2. Agan Chemical Manufacturer Ltd., Northern Industrial Zone, P.O.Box 262, Ashdod 77102, Israel 3. Eli Lilly & Co., USA	1. De-Nocil Crop Protection Ltd., Mumbai 2. Sudarshan Chemicals Industries Ltd.

Source: Directorate of Plant Protection Quarantine & Storage, (2015)

Table 5.9 Exports of herbicides and their CIF values from 2005-06 to 2009-10

Pesticides	2005-06 Qty*	2005-06 CIF value**	2006-07 Qty	2006-07 CIF value	2007-08 Qty	2007-08 CIF value	2008-09 Qty	2008-09 CIF value	2009-10 Qty	2009-10 CIF value
2,4-D	4138	4719	14670	29612	739	766	3096	4349	702	8817
Isoproturon	1078	2041	1157	2191	1009	1675	1447	3542	1812	3761
MCPA	1021	2113	889	2592	554	763	195	627	95	174

*Quantity (Qty.) in t technical grade; **Cost, insurance and freight (CIF) value in Rs. lakhs

Source: (Director General of Commercial Intelligence & Statistics, Kolkata)

Table 5.10 Top five export destinations of selected chemicals during 2012-13

Product	Country	Quantity (t)	Value (₹ in lakhs)
2,4-D	U S A	4315	8393
	Argentina	1566	2684
	Brazil	4194	8069
	Thailand	2700	4277
	Ethiopia	596	816
Isoproturon	Netherland	4026	12707
	Belgium	142	437
	Thailand	13	44

Source: Standing Committee on Chemicals and Fertilisers (2012-13) 2013. Production and Availability of Pesticides. 36th Report, 15th Lok Sabha, Dept. of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilisers, Government of India August, 2013

Table 5.11 Average prices of the key herbicides from 2005-06 to 2009-10 (in ₹ per kg or L)

Herbicide	2005-06	2006-07	2007-08	2008-09	2009-10
2,4-D sodium salt 80%	118	176	215	272	226
Alachlor EC	58	284	262	300	340
Alachlor Gr	-	152	100	50	-
Anilophos 30% EC	109	264	272	249	256
Atrazine	151	289	232	259	290
Butachlor 5% Gr	52	46	198	48	163
Butachlor 50% EC	138	152	202	194	174
Glyphosate	29	296	449	347	348
Isoproturon 75% EC	167	266	717	287	266
Metsulfuron-methyl	-	-	77	3563	4558
Pretilachlor	-	-	462	513	428

(-) Not available

Source: State Department of Agriculture. (In: Standing Committee on Chemicals and Fertilisers (2012-13). 2013. Production and Availability of Pesticides. 36th Report, 15th Lok Sabha, Dept. of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilisers, Government of India August (2013)

Herbicide consumption (unpublished data)

This unpublished information regarding the state-wise and crop-wise herbicide consumptions during the year 2007 was collected from industry source. CLI compiled this information supplied by each registered company. This information helped industry houses to forecast their future sell, on the basis of which procurement of technical grade materials, other raw materials needed in formulating the technicals and even formulated products was made.

Consumption of different herbicides

During this period 2007, butachlor and glyphosate were the leaders in herbicide market (Table 5.12). Butachlor grabbed the market of labour-intensive transplanted paddy. Pretilachlor, a relatively new molecule gained importance among rice farmers and was not far away from butachlor. But the most remarkable thing was the use of glyphosate in crops other than tea. During 1990s, glyphosate started replacing paraquat in tea. But now it is becoming an integral part of weed management in many field crops like cotton, sugarcane, vegetables, fruit orchards, and non-cropped situations (Table 5.13). It was interesting to notice the acceptance of low-dose herbicides by the farmers of different crop-sectors. They are adopting these chemicals to manage the weeds more efficiently. For example, in wheat, clodinafop, sulfosulfuron, combination formulation of mesosulfuron and iodosulfuron, and metsulfuron-methyl are replacing isoproturon particularly in Punjab and Haryana, where *Phalaris minor* developed resistance against isoproturon. Combination products are getting popularity due to their versatility in managing weeds of broad spectrum.

Table 5.12 Consumption of herbicides during 2007

Herbicide	Total (t)	Herbicide	Total (t)
2,4-D	756.00	Isoproturon	624.63
Alachlor	154.00	Metribuzin	195.08
Anilophos	631.33	Metsulfuron-methyl	25.63
Atrazin	1200.92	Oxadiargyl	71.68
Butachlor	6032.00	Oxyfluorfen	227.06
Chorimuron-ethyl	9.00	Paraquat	2608.00
Clodinafop	562.84	Pendimethalin	1444.02
Cyhalofop	35.00	Pretilachlor	2417.91
Diuron	34.75	Bispyribac-sodium	5.00
Ethoxysulfuron	1.02	Sufosulfuron	41.34
Fenoxaprop	333.22	Imazethapyr + Pendimethalin	152.00
Glyphosate	6002.74	Mesosulfuron + Iodosulfuron	22.08
Glufosinate-ammonium	5.00	Metsulfuron + Sulfosulfuron	13.13
Imazethapyr	705.00	Metsulfuron-methyl + Chlorimuron-ethyl	3.00

Table 5.13 Crop-wise herbicide consumption (2007)

Crop/Herbicide	Consumption (t)	Crop/Herbicide	Consumption (t)
Rice		Glufosinate	1.93
2,4-D	233.52	Oxyfluorfen	6.74
Anilophos	631.10	Paraquat	708.57
Butachlor 5 Gr	2000.00	Soybean	
Butachlor 50 EC	3647.39	2,4-D sodium salt	0.88
Butachlor 50 EW	385.00	Alachlor	153.35
Cyhalofop-butyl	35.00	Chlorimuron	9.00
Ethoxysufuron	0.80	Fenoxaprop	159.73
Fenoxaprop	33.54	Glyphosate	4.76
Glyphosate 41 SL	28.77	Imazethapyr + Pendimethalin	145.00
Glyphosate 71 SL	22.57	Imazethapyr	671.50
Metsulfuron-methyl	3.00	Paraquat	18.18
Oxadiargyl	40.70	Pendimethalin	155.11
Paraquat	194.96	Cotton	
Pendimethalin	73.86	Fenoxaprop	25.59
Pretilachlor 30 EC	295.41	Glyphosate	225.74
Pretilachlor 50 EC	2122.50	Glufosinate	1.20
Wheat		Metribuzin	0.02
Clodinafop	562.84	Pendimethalin	245.59
Fenoxaprop-P-ethyl	21.02	Bispyribac	5.00
Glyphosate 41 SL	25.67	Maize	
Isoproturon	624.63	2,4-D	119.74
Mesosulfuron + Iodosulfuron	22.08	Atrazine	387.00
Metsulfuron + Sulfosulfuron	13.13	Metribuzin	1.94
Metribuzin	34.32	Oxadiargyl	0.08
Metsulfuron-methyl	25.63	Paraquat	48.59
Oxadiargyl	0.10	Sugarcane	
Pendimethalin	18.47	2,4-D	283.22
Sulfosulfuron	41.34	Atrazine	779.23
Tea		Diuron	0.27
2,4-D	104.11	Glyphosate	60.70
Diuron	11.80	Metribuzin	87.12
Glyphosate	1112.33	Paraquat	491.92

State- and crop-wise herbicide consumption

The consumption pattern of herbicides in a state or region is dictated by the crops cultivated there, the product positioning by the industrial house and the functioning of the different extension wings. During this period (2007) of the case study, the highest consumption of herbicides was in Punjab, followed by Uttar Pradesh, Andhra Pradesh, Maharashtra and West Bengal (Fig. 5.2). The rice growing states obviously have a higher consumption of rice herbicides like 2,4-D, butachlor and pretilachlor (Table 5.14 and Fig. 5.3, 5.4, 5.5). But in Maharashtra, 2,4-D is mainly used in sugarcane

and maize to control broad leaf weeds (Table 5.14 and Fig. 5.3). The major consumers of atrazine are Punjab, Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat where it is used in sugarcane and cotton (Fig. 5.6). The consumptions of fenoxaprop-P-ethyl (Fig. 5.7) and imazethapyr (Fig. 5.8) are highest in Madhya Pradesh. These two herbicides are very popular among the soybean farmers of this state. Glyphosate was highly accepted by the tea planters in the past two decades. It has a very good market size in the tea sector of West Bengal and Assam (Fig. 5.9). Presently, the consumption of glyphosate is highest in Maharashtra as it is becoming a key herbicide in sugarcane, maize and many fruit crops including mango, banana, grapes, pomegranate and citrus. Similarly, another non-selective herbicide paraquat was also introduced for the weed management in tea and some other plantation crops. The consumption of this product in tea of Assam and West Bengal is very high (Fig. 5.10). Presently, it is being used in sugarcane, cotton and fruit crops in Maharashtra. The major contributors of metribuzine consumption are Punjab, Uttar Pradesh, Tamil Nadu and Maharashtra (Fig. 5.11). Farmers of these states are using metribuzine mainly in sugarcane, potato and wheat. The formulations of oxadiargyl have the major market in Andhra Pradesh, Gujarat and Rajasthan for the weed management in onion, garlic and rice (Fig. 5.12). But on onion and garlic in Maharashtra, oxyfluorfen is more popular than oxadiargyl (Fig. 5.13). Being a broad spectrum herbicide, pendimethalin is very popular amongst farmers for weed management in several crops. Gujarat is the highest consumer of pendimethalin (Fig. 5.14) and the major crops where it is being used are cotton and cumin (Table 5.10).

Table 5.14 State- and crop-wise herbicide consumption

1. Chhattisgarh

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Tea	6.93	1.04	Glyphosate 71 SL	Other Veg.	4.27	2.14
	Rice	6.12	0.92		Glufosinate-ammonium 15 SL	All other crops	0.01
Alachlor 50 EC	Soybean	14.95	3.51	Glufosinate-ammonium 15 SL	Rice	1.20	13.20
Anilophos 30 EC	Rice	5.16	1.12	Oxadiargyl 6% EC	Onion	0.12	0.06
Atrazine 50 WP	Maize	0.63	0.13		Other veg.	0.01	0.00
Butachlor 50 EC	Rice	5.45	0.73	Oxadiargyl 80 WP	Rice	0.37	1.43
Chlorimuron-ethyl 25 WP	Soybean	0.30	3.00	Oxyfluorfen 23.5 EC	Onion	0.19	0.29
Ethoxysulfuron	Rice	0.39	1.54	Paraquat 24 SL	Tea	52.88	11.23
Fenoxaprop-P-ethyl 10 EC	Soybean	0.09	0.06		Rice	6.70	1.42
Fenoxaprop-P-ethyl 9EC	Rice	15.04	14.30		Banana	3.91	0.83
	Soybean	4.48	4.26		Cole Crops	7.60	1.61
Ethoxysulfuron	Rice	0.39	1.54	Pendimethalin 30 EC	Soybean	7.39	2.19
Glyphosate 41 SL	Other veg.	23.23	5.63	Pretilachlor 50 EC	Rice	29.23	9.36
	All other crops	18.90	4.58		Total	219.85	84.64

Herbicide Consumption

2. Haryana

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Anilophos 30 EC	Rice	205.76	44.69	Metsulfuron-methyl 10% + Chlorimuron-ethyl 10% WG	Rice	0.15	1.65
Atrazine 50 WP	Sugarcane	29.72	5.99	Metsulfuron-methyl	Wheat	7.07	57.48
	Bajra	4.19	0.84	Oxadiargyl 6 EC	Other veg.	0.12	0.06
	Maize	4.19	0.84	Oxadiargyl 80 WP	Rice	4.33	16.52
Butachlor 50 EC	Rice	327.58	44.17	Oxyfluorfen 23.5 EC	Onion	3.37	5.08
Butachlor 50 EW	Rice	100.00	16.20		Other veg.	0.01	0.01
		Wheat	185.07	356.71	Paraquat 24 SL	Cotton	73.90
Ethoxysulfuron	Sugarcane	0.06	0.22	Rice		2.65	0.56
	Rice	0.13	0.49	Potato		24.49	5.20
Fenoxaprop-P-ethyl 10 EC	Wheat	5.55	3.86	Other veg.		0.77	0.16
Fenoxaprop-P-ethyl 9EC	Rice	2.32	2.21	Pendimethalin 30 EC	Cotton	11.08	3.29
Glyphosate 41 SL	Cotton	15.10	3.66		Rice	7.20	2.14
	Sugarcane	2.32	0.56		Onion	1.85	0.55
	Rice	19.74	4.79		Other veg.	1.85	0.55
	Wheat	7.55	1.83		Guar Gum	1.85	0.55
	Other veg.	2.32	0.56		All other crops	36.93	10.97
	All other crops	119.30	28.92		Mustard	3.69	1.10
Glyphosate 71 SL	Cotton	5.26	2.63	Pretilachlor 30 EC	Rice	28.99	9.72
	Rice	7.89	3.94	Pretilachlor 50 EC	Rice	448.80	143.72
	Other veg.	3.94	1.97	Pyriothiac-sodium 10 EC	Cotton	0.38	0.69
Glufosinate-ammonium 15 SL	Cotton	0.01	0.01	Sulfosulfuron 75 WDG	Wheat	10.93	211.37
	Other veg.	0.17	0.10		Total	1,812.37	1,158.79
Imazethapyr 10 SL	Guargum	13.00	16.03				
	Soybean	0.90	1.11				
Isoproturon 75 WP	Wheat	62.46	13.95				
Mesosulfuron-methyl 3%+ Iodosulfuron-methyl Sodium 6% WDG	Wheat	5.27	14.22				
Metsulfuron+Sulfosulfuron	Wheat	4.62	92.38				
Metribuzin 70 WP	Sugarcane	0.34	0.40				
	Wheat	2.96	3.47				
	Potato	4.24	4.97				

3. Jammu & Kashmir and Himachal Pradesh

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	
2,4-D 80 WP (sodium salt)	Rice	5.42	0.82	Metribuzin 70 WP	Wheat	0.69	0.81	
	Other fruits	7.30	1.10	Paraquat 24 SL	Rice	4.70	1.00	
Butachlor 5 G	Rice	800.00	16.00		Other fruits	16.75	3.56	
	Glyphosate 41 SL	Rice	10.10		2.45	Cole crops	2.66	0.57
		Other fruits	1.74		0.42	Other veg.	2.70	0.57
	Other veg.	0.58	0.14	Pendimethalin 30 EC	Other crops	1.85	0.55	
Glyphosate 71 SL	Rice	0.53	0.27	Pretilachlor 50 EC	Rice	9.47	3.03	
	Veg.	0.53	0.27		Total	865.04	31.55	

4. Punjab

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Alachlor 50 EC	Soybean	2.00	0.47	Metsulfuron + Sulfosulfuron	Wheat	7.21	144.12
Anilophos 30 EC	Rice	128.68	27.95	Metribuzin 70 WP	Sugarcane	0.69	0.81
Atrazine 50 WP	Sugarcane	23.02	4.64		Wheat	18.86	22.08
	Maize	82.26	16.59		Potato	12.81	15.00
Butachlor 50 EC	Rice	670.02	90.35	Metsulfuron-methyl10% + Chlorimuron - ethyl 10%WG	Rice	0.17	1.87
Butachlor 50 EW	Rice	248.00	40.18	Metsulfuron-methyl 20 WP	Wheat	9.95	80.85
Clodinafop 15WP	Wheat	360.48	694.80	Oxadiargyl 6 EC	Onion	0.02	0.01
Cyhalofop-butyl 10 EC	Rice	2.30	3.09		Other veg.	0.01	0.00
Ethoxysulfuron	Rice	0.05	0.20	Oxadiargyl 80 WP	Rice	5.79	22.05
Fenoxaprop-P-ethyl 10 EC	Wheat	12.57	8.73	Oxyfluorfen 23.5 EC	Onion	3.93	5.92
Fenoxaprop-P-ethyl 9 EC	Rice	0.48	0.45		Other veg.	0.11	0.17
Glyphosate 41 SL	Cotton	55.37	13.42	Paraquat 24 SL	Cotton	127.33	27.04
	Sugarcane	5.81	1.41		Rice	4.42	0.94
	Rice	58.60	14.21		Potato	37.01	7.86
	Wheat	17.42	4.22		Other veg.	1.29	0.27
	Citrus	5.74	1.39	Pendimethalin 30 EC	Cotton	5.54	1.65
	Other veg.	5.74	1.39		Rice	8.68	2.58
	Other crops	202.50	49.09		Peas	22.16	6.58
Glyphosate 71 SL	Cotton	8.84	4.42		Other veg.	3.69	1.10
	Rice	14.14	7.07		Other crops	27.70	8.23
	Other veg.	2.65	1.33	Pretilachlor 30EC	Rice	96.56	32.36
Glufosinate-ammonium 15 SL	Cotton	1.04	0.62	Pretilachlor 50 EC	Rice	825.66	264.41
	Rice	0.29	0.18	Pyriithiobac-sodium 10 EC	Cotton	0.88	1.62
	Other crops	0.10	0.06	Sulfosulfuron 75 WDG	Wheat	22.40	433.09
Imazethapyr 10 SL	Soybean	1.30	1.60		Total	2,010.17	2,100.58
Mesosulfuron-methyl 3% + Iodosulfuron-methyl sodium 6% WDG	Wheat	11.89	32.11				

5. Rajasthan

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Anilophos 30 EC	Rice	17.51	3.80	Fenoxaprop-P-ethyl 9EC	Rice	0.12	0.11
Atrazine 50 WP	Bajra	10.47	2.11		Blackgram	0.06	0.05
	Maize	2.30	0.46		Soybean	6.25	5.94
Butachlor 50 EC	Rice	4.48	0.60	Glyphosate 41 SL	Wheat	0.58	0.14
Chlorimuron-ethyl 25 WP	Soybean	0.50	5.00		Other pulses	0.73	0.18
Fenoxaprop-P-ethyl 10 EC	Wheat	0.72	0.50		Chillies	0.73	0.18
	Soybean	0.12	0.08		Fruits	1.45	0.35
					Other crops	2.47	0.60

Herbicide Consumption

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Fenoxaprop-P-ethyl 9EC	Rice	0.12	0.11		Other veg.	0.02	0.01
	Blackgram	0.06	0.05		Groundnut	0.01	0.00
	Soybean	6.25	5.94		Mustard	1.07	0.54
			Other crops		0.72	0.36	
Glyphosate 41 SL	Wheat	0.58	0.14	Oxadiargyl 80 WP	Rice	0.31	1.16
	Other pulses	0.73	0.18	Oxyfluorfen 23.5 EC	Garlic	0.56	0.85
	Chillies	0.73	0.18		Onion	1.45	2.19
	Fruits	1.45	0.35		Other veg.	0.04	0.06
	Other crops	2.47	0.60	Paraquat 24 SL	Cotton	47.51	10.09
Glyphosate 71 SL	Other veg.	4.27	2.14		Rice	2.02	0.43
Imazethapyr 10 SL	Guargum	6.00	7.40		Potato	1.10	0.23
	Soybean	23.80	29.34		Other veg.	0.52	0.11
Mesosulfuron-methyl 3%+Iodosulfuron-methyl sodium 6% WDG	Wheat	0.52	1.41	Pendimethalin 30 EC	Cumin	81.25	24.14
				Rice	2.77	0.82	
Metribuzin 70 WP	Wheat	0.14	0.17	Mustard	22.16	6.58	
	Potato	0.15	0.18	Pretilachlor 30EC	Rice	2.03	0.68
Metsulfuron-methyl 20WP	Wheat	1.25	10.18	Pretilachlor 50 EC	Rice	65.41	20.95
Oxadiargyl 6 EC	Cumin	7.94	3.97	Sulfosulfuron 75 WDG	Wheat	0.00	0.06
	Onion	2.63	1.32		Total	324.14	145.47

6. Uttar Pradesh and Uttarakhand

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Sugarcane	0.17	0.03	Glyphosate 41 SL	Wheat	0.12	0.03
	Rice	8.00	1.20		Chillies	26.13	6.34
Alachlor 50 EC	Soybean	14.00	3.29		Other veg.	15.68	3.80
Anilophos 30 EC	Rice	18.39	3.99		Other crops	48.41	11.74
Atrazine 50 WP	Sugarcane	20.93	4.22	Glyphosate 71 SL	Chillies	20.51	10.25
	Bajra	4.19	0.84	Other veg.	5.13	2.56	
	Maize	10.67	2.15	Imazethapyr + Pendimethalin	Soybean	140.00	60.57
Butachlor 50 EC	Rice	1,359.07	183.26	Other oilseeds	7.00	3.03	
Butachlor 50 EW	Rice	30.00	4.86	Imazethapyr 10 SL	Groundnut	6.00	7.40
Clodinafop 15WP	Wheat	17.11	32.98	Soybean	7.00	8.63	
Ethoxysulfuron	Sugarcane	0.05	0.20	Isoproturon 75 WP	Wheat	562.17	125.53
	Rice	0.00	0.02	Mesosulfuron-methyl 3% + Iodosulfuron-methyl sodium 6% WDG	Wheat	4.30	11.60
Fenoxaprop-P-ethyl 10 EC	Wheat	0.03	0.02	Metasulfuron + Sulfosulfuron	Wheat	1.29	25.87
	Soybean	0.01	0.00				
Fenoxaprop-P-ethyl 9EC	Rice	0.04	0.04				
	Chillies	0.02	0.02				
	Onion	0.18	0.17				
	Other veg.	0.03	0.03				
	Soybean	0.31	0.30				

Herbicide Use in Indian Agriculture

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Metribuzin 70 WP	Sugarcane	0.04	0.05	Paraquat 24 SL	Rice	7.85	1.67
	Wheat	11.60	13.58		Potato	58.65	12.45
	Tomato	0.09	0.1		Other veg.	1.55	0.33
	Potato	22.45	26.29	Pendimethalin 30 EC	Garlic	46.16	13.71
Metsulfuron-methyl 10% + Chlorimuron-ethyl 10%WG	Rice	0.50	5.50		Peas	20.31	6.03
Metsulfuron-methyl 20%WP	Wheat	0.89	7.21		Tomato	1.85	0.55
	Oxadiargyl 6 EC	Onion	0.05		0.03	Mustard	36.93
Other veg.		0.37	0.19	Pretilachlor 30EC	Rice	8.31	2.78
Oxadiargyl 80 WP	Rice	2.42	9.22	Pretilachlor 50 EC	Rice	63.86	20.45
Oxyfluorfen 23.5 EC	Garlic	0.56	0.85	Sulfosulfuron 75 WDG	Wheat	8.01	154.89
	Onion	1.45	2.18		Total	2,620.83	803.99

7. Bihar and Jharkhand

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Rubber	2.12	0.32	Metribuzin 70 WP	Wheat	0.03	0.03
	Tea	6.93	1.04		Potato	4.68	5.48
	Maize	6.37	0.96	Oxadiargyl 6 EC	Onion	0.05	0.02
	Rice	6.12	0.92	Oxadiargyl 80 WP	Rice	0.46	1.74
Atrazine 50 WP	Maize	8.58	1.73	Oxyfluorfen 23.5 EC	Onion	1.12	1.69
Butachlor 50 EC	Rice	164.58	22.19	Paraquat 24 SL	Tea	53.21	11.30
Ethoxysulfuron	Rice	0.01	0.03		Rice	6.70	1.42
Fenoxaprop-P-ethyl 9EC	Jute	0.71	0.68		Banana	3.91	0.83
	Brinjal	0.01	0.01		Cole crops	7.60	1.61
	Onion	0.03	0.03		Potato	11.35	2.41
Glyphosate 41 SL	Other fruits	8.20	1.99	Pendimethalin 30 EC	Onion	73.86	21.94
	Other veg.	4.72	1.14		Peas	12.93	3.84
	Other crops	38.88	9.43		Tomato	3.69	1.10
Glyphosate 71 SL	Fruits	2.40	1.20		Other veg.	1.85	0.55
	Other veg.	2.40	1.20	Pretilachlor 30EC	Rice	3.51	1.18
Mesosulfuron-methyl 3%+Iodosulfuron-methyl sodium 6%WDG	Wheat	0.01	0.02	Pretilachlor 50 EC	Rice	18.81	6.03
				Total	455.84	104.07	

Herbicide Consumption

8. Assam and North-East states

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Tea	44.98	6.77	Metribuzin 70 WP	Potato	0.07	0.08
	Rice	8.13	1.22	Oxadiargyl 80 WP	Rice	0.01	0.02
	Fruits	1.46	0.22	Oxyfluorfen 23.5 EC	Tea	3.37	5.08
Butachlor 50 EC	Rice	49.36	6.66	Paraquat 24 SL	Tea	324.36	68.88
Diuron 80 WP	Tea	11.77	6.14		Rice	4.70	1.00
Fenoxaprop-P-ethyl 9EC	Rice	0.37	0.36		Fruits	5.58	1.19
Glyphosate 41 SL	Tea	641.70	155.57		Cole crops	2.66	0.57
	Turmeric	5.81	1.41		Other veg.	4.05	0.86
	Rice	5.81	1.41	Pendimethalin 30 EC	Rice	0.18	0.05
	Other veg.	11.61	2.82	Pretilachlor 30EC	Rice	0.55	0.19
Other crops	26.71	6.48	Pretilachlor 50 EC	Rice	3.79	1.21	
Glyphosate 71 SL	Tea	2.14	1.07		Total	1,163.45	271.37
	Other veg.	2.14	1.07				
	Other crops	2.14	1.07				

9. Odisha

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Rice	10.84	1.63	Oxadiargyl 80 WP	Rice	0.18	0.69
	Fruits	1.46	0.22	Paraquat 24 SL	Rice	7.05	1.50
Atrazine 50 WP	Sugarcane	0.21	0.04		Fruits	2.79	0.59
	Maize	4.19	0.84		Cole Crops	1.33	0.28
Butachlor 50 EC	Rice	34.75	4.69		Other veg.	4.05	0.86
Ethoxysulfuron	Rice	0.04	0.17		Pendimethalin 30 EC	Rice	0.18
Fenoxaprop-P-ethyl 9 EC	Rice	0.80	0.76	Pretilachlor 30EC	Rice	7.02	2.35
Glyphosate 41 SL	Rice	2.32	0.56	Pretilachlor 50 EC	Rice	18.94	6.07
	Other crops	16.71	4.05		Total	112.86	25.36

10. West Bengal and Sikkim

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	
2,4-D 80 WP (sodium salt)	Tea	27.71	4.17	Fenoxaprop-P-ethyl 9EC	Jute	15.67	14.90	
	Rice	24.48	3.69		Bengal gram	0.05	0.05	
Atrazine 50 WP	Sugarcane	4.19	0.84		Cucurbits	0.03	0.03	
	Maize	2.09	0.42		Other veg.	0.11	0.10	
	Potato	3.35	0.68		Other crops	0.76	0.72	
Butachlor 5 G	Rice	1,000.00	20.00		Groundnut	0.05	0.05	
Butachlor 50 EC	Rice	283.58	38.24		Oilseeds	1.60	1.52	
Butachlor 50 EW	Rice	3.00	0.49		Glyphosate 41 SL	Tea	260.00	63.03
Cyhalofop-butyl 10 EC	Rice	0.20	0.27			Fruits	22.10	5.36
Ethoxysulfuron	Rice	0.06	0.24					

Herbicide Use in Indian Agriculture

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
	Other veg.	16.39	3.97	Oxadiargyl 6 EC	Onion	0.05	0.03
	Other crops	87.69	21.26		Groundnut	0.19	0.09
					Mustard	0.02	0.01
Glyphosate 71 SL	Tea	1.53	0.76	Oxadiargyl 80 WP	Rice	0.70	2.67
	Fruits	1.53	0.76	Oxyfluorfen 23.5 EC	Tea	3.37	5.08
	Cole crops	1.53	0.76	Paraquat 24 SL	Tea	211.54	44.92
	Cucurbits	2.29	1.14		Rice	26.80	5.69
	Other veg.	3.81	1.91		Banana	15.63	3.32
			Cole Crops		30.41	6.46	
Glufosinate-ammonium 15 SL	Tea	1.93	1.16	Pendimethalin 30 EC	Rice	1.29	0.38
Metribuzin 70 WP	Potato	12.98	15.20		Other veg.	3.69	1.10
	Other crops	0.17	0.20		Groundnut	3.69	1.10
Metsulfuron-methyl10%+Chlorimuron-ethyl 10%WG	Rice	0.10	1.10	Pretilachlor 30EC	Rice	24.00	8.04
				Pretilachlor 50 EC	Rice	92.61	29.66
					Total	3,192.97	311.55

11. Andhra Pradesh

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Sugarcane	61.02	9.19	Glyphosate 41 SL	Cotton	48.60	11.78
	Maize	14.86	2.24		Sugarcane	11.53	2.79
	Rice	71.25	10.72		Turmeric	6.92	1.68
	Soybean	0.88	0.13		Rice	15.01	3.64
Alachlor 50 EC	Soybean	29.95	7.04		Bengal gram	6.92	1.68
Anilophos 30 EC	Rice	113.74	24.71		Pulses	9.22	2.24
Atrazine 50 WP	Sugarcane	240.70	48.54		Chillies	46.10	11.18
	Maize	123.70	24.95		Banana	24.21	5.87
Butachlor 50 EC	Rice	271.73	36.64		Citrus	57.63	13.97
Butachlor 50 EW	Rice	1.00	0.16		Grapes	1.16	0.28
Cyhalofop-butyl 10 EC	Rice	15.70	21.12		Mango	70.31	17.05
Ethoxysulfuron	Rice	0.02	0.07		Fruits	83.09	20.14
Fenoxaprop-P-ethyl 10 EC	Soybean	0.00	0.00		Brinjal	0.23	0.06
Fenoxaprop-P-ethyl 9 EC	Cotton	3.25	3.09		Other veg.	99.17	24.04
	Rice	0.06	0.05		Other crops	207.79	50.38
	Blackgram	32.08	30.51	Soybean	1.51	0.37	
	Red gram	0.28	0.27	Glyphosate 71 SL	Pulses	2.00	1.00
	Chillies	3.33	3.17		Chillies	6.01	3.00
	Other crops	0.04	0.04		Fruits	10.01	5.01
	Groundnut	0.25	0.24		Other veg.	10.01	5.01
	Soybean	0.16	0.15		Other crops	4.01	2.00
	Oilseeds	0.07	0.07				

Herbicide Consumption

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Glufosinate-ammonium 15 SL	Cotton	0.15	0.09	Oxyfluorfen 23.5 EC	Onion	10.70	16.12
	Sugarcane	0.00	0.00	Paraquat 24 SL	Cotton	25.07	5.32
	Rice	0.03	0.02		Sugarcane	142.31	30.22
	Bengal gram	0.30	0.18		Maize	48.59	10.32
	Chillies	0.09	0.05		Rice	77.69	16.50
	Banana	0.02	0.01		Chillies	9.10	1.93
	Grapes	0.22	0.13		Banana	20.93	4.44
	Other crops	0.34	0.20		Fruits	28.65	6.08
Imazethapyr 10 SL	Blackgram	3.30	4.07		Cole Crops	1.59	0.34
	Soybean	28.00	34.52		Tomato	1.94	0.41
Metribuzin 70 WP	Sugarcane	9.60	11.24		Other Veg.	1.93	0.41
	Maize	1.94	2.28	Soybean	6.57	1.39	
	Tomato	0.78	0.91	Cotton	24.01	7.13	
	Potato	0.21	0.24	Pendimethalin 30 EC	Rice	12.56	3.73
	Other veg.	0.21	0.24		Chillies	27.70	8.23
	Other crops	0.03	0.03		Onion	1.85	0.55
Oxadiazyl 6 EC	Onion	0.31	0.16		Other crops	1.85	0.55
	Other oilseeds	0.05	0.02	Pretilachlor 30 EC	Rice	83.64	28.03
Oxadiazyl 80 WP	Rice	18.51	70.56	Pretilachlor 50 EC	Rice	317.63	101.72
	Chillies	0.02	0.09	Pyriithiobac-sodium 10 EC	Cotton	0.63	1.16
				Total		2,614.52	775.86

12. Karnataka and Goa

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	
2,4-D 80 WP (sodium salt)	Sugarcane	37.68	5.67	Fenoxaprop-P-ethyl 10 EC	Soybean	0.00	0.00	
	Maize	10.62	1.60	Fenoxaprop-P-ethyl 9EC	Cotton	0.51	0.48	
	Rice	0.36	0.05		Bengal Gram	0.20	0.19	
	Banana	0.13	0.02		Black gram	0.18	0.17	
	Fruits	0.09	0.01		Chillies	0.22	0.21	
Alachlor 50 EC	Soybean	12.00	2.82		Onion	1.92	1.82	
Anilophos 30 EC	Rice	35.84	7.78		Groundnut	0.03	0.03	
Atrazine 50 WP	Sugarcane	54.84	11.06		Soybean	0.24	0.23	
	Maize	15.70	3.17		Glyphosate 41 SL	Cotton	10.33	2.50
Butachlor 5 Gr	Rice	200.00	4.00			Coffee	71.50	17.33
Butachlor 50 EC	Rice	204.71	27.60			Tea	8.13	1.97
Butachlor 50 EW	Rice	2.00	0.32	Turmeric		4.67	1.13	
Cyhalofop-butyl 10 EC	Rice	2.90	3.90	Rice		3.11	0.75	
Diuron 80 WP	Sugarcane	0.24	0.13	Pulses		7.78	1.89	
	Other crops	2.66	1.39	Chillies		23.33	5.66	
Ethoxysulfuron	Sugarcane	0.02	0.09	Banana		1.16	0.28	
	Rice	0.07	0.28	Grapes		1.16	0.28	

Herbicide Use in Indian Agriculture

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	
	Mango	1.16	0.28	Metsulfuron-methyl 10% + Chlorimuron-ethyl 10% WG	Rice	0.10	1.10	
	Fruits	29.74	7.21		Oxadiargyl 80 WP	Rice	4.11	15.67
	Brinjal	0.58	0.14	Onion		0.02	0.08	
	Other veg.	25.65	6.22	Oxyfluorfen 23.5 EC	Onion	7.25	10.92	
	Other crops	252.63	61.25	Paraquat 24 SL	Cotton	0.64	0.14	
	Soybean	1.16	0.28		Coffee	39.49	8.39	
Glyphosate 71 SL	Coffee	2.19	1.10		Sugarcane	52.90	11.23	
	Sugarcane	1.10	0.55		Rice	1.88	0.40	
	Rubber	2.19	1.10		Banana	5.23	1.11	
	Tobacco	1.10	0.55		Grapes	17.87	3.79	
	Red gram	2.19	1.10		Fruits	12.99	2.76	
	Chillies	3.29	1.64		Cole Crops	2.86	0.61	
	Grapes	14.24	7.12		Peas	0.03	0.01	
	Pomegranate	4.38	2.19		Potato	1.04	0.22	
	Fruits	2.19	1.10		Other veg.	1.06	0.23	
	Other veg.	9.86	4.93		Pendimethalin 30 EC	Onion	9.23	2.74
	Glufosinate-ammonium 15 SL	Sugarcane	0.02			0.01	Tomato	1.85
		Pomegranate	0.02	0.01		Groundnut	9.23	2.74
Other crops		0.09	0.05	Other crops		1.85	0.55	
Imazethapyr 10 SL	Groundnut	3.00	3.70	Pretilachlor 30 EC	Rice	32.31	10.83	
Metribuzin 70 WP	Sugarcane	0.83	0.97	Pretilachlor 50 EC	Rice	76.34	24.45	
	Tomato	0.50	0.58		Total	1,358.13	307.31	
	Potato	1.61	1.88					
	Other crops	0.01	0.01					

13. Kerala

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Tea	17.57	2.64		Banana	2.32	0.56
	Rice	16.26	2.45		Grapes	1.16	0.28
	Other fruits	1.46	0.22		Fruits	8.13	1.97
Cyhalofop-butyl 10 EC	Rice	12.90	17.35		Brinjal	0.58	0.14
					Other veg.	2.32	0.56
Glyphosate 41 SL	Coffee	5.81	1.41		Other crops	50.78	12.31
	Tea	72.01	17.46		Glyphosate 71 SL	Rubber	0.53
	Cardamom	3.48	0.84	Metsulfuron-methyl 10% + Chlorimuron-ethyl 10% WG	Rice	0.40	4.40
	Turmeric	2.32	0.56				
	Rice	0.35	0.08				

Herbicide Consumption

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Paraquat 24 SL	Coffee	9.73	2.07		Cole crops	1.33	0.28
	Rubber	38.76	8.23		Other veg.	2.70	0.57
	Tea	51.09	10.85	Pretilachlor 50 EC	Rice	20.84	6.67
	Rice	9.39	1.99	Total		335.03	94.78
	Fruits	2.79	0.59				

14. Tamilnadu

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	
2,4-D 80 WP (Sodium salt)	Sugarcane	38.41	5.78		Chillies	12.67	3.07	
	Maize	38.22	5.75		Banana	34.80	8.44	
	Rice	69.73	10.50		Citrus	7.92	1.92	
Alachlor 50 EC	Soybean	30.00	7.05		Grapes	17.23	4.18	
Anilophos 30 EC	Rice	39.55	8.59		Mango	17.00	4.12	
Atrazine 50 WP	Sugarcane	175.81	35.46		Other fruits	81.73	19.81	
	Maize	120.14	24.23		Brinjal	0.81	0.20	
Butachlor 50 EC	Rice	246.98	33.30		Other veg.	82.65	20.04	
Butachlor 50 EW	Rice	1.00	0.16		All other crops	485.70	117.75	
Cyhalofop-butyl 10 EC	Rice	1.00	1.35		Oilseeds	15.83	3.84	
Diuron 80 WP	Sugarcane	0.03	0.02		Glyphosate 71 SL	Tea	1.73	0.86
	Tea	0.03	0.02			Pulses	1.73	0.86
	Other crops	20.02	10.45			Chillies	3.46	1.73
Fenoxaprop-P-ethyl 9EC	Cotton	0.04	0.04	Fruits		4.32	2.16	
	Rice	0.19	0.18	Other veg.		6.92	3.46	
	Blackgram	2.62	2.49	Glufosinate-ammonium 15 SL		Rice	0.05	0.03
	Chillies	0.16	0.15			All other crops	0.03	0.02
	Brinjal	0.01	0.01	Imazethapyr 10 SL	Black gram	2.20	2.71	
	Okra	0.08	0.08		Metribuzin 70 WP	Sugarcane	27.09	31.72
	Onion	1.20	1.14	Tomato		4.91	5.75	
	Tomato	0.13	0.12	Potato		0.66	0.77	
	Other veg.	0.14	0.14	Other veg.		0.69	0.81	
	Other crops	0.11	0.11	Metsulfuron-methyl10%+Chlorimuron-ethyl 10%WG	Rice	0.38	4.18	
	Groundnut	0.65	0.62		Oxadiargyl 80 WP	Maize	0.08	0.30
	Other oilseeds	0.04	0.04	Rice		2.42	9.24	
				Black Gram		0.01	0.04	
Glyphosate 41 SL	Cotton	7.92	1.92					
	Coffee	5.81	1.41					
	Sugarcane	7.92	1.92					
	Rubber	23.23	5.63					
	Tea	125.10	30.33					
	Cardamom	4.41	1.07					
	Turmeric	2.09	0.51					
	Rice	7.92	1.92					
	Pulses	11.66	2.83					

Herbicide Use in Indian Agriculture

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
	Chillies	0.03	0.12		Sugarcane	7.74	1.64
	Onion	0.57	2.15		Rubber	1.94	0.41
	Other veg.	0.06	0.21		Tea	15.49	3.29
	All other crops	0.06	0.21		Rice	28.03	5.95
	Groundnut	0.06	0.21		Chillies	1.94	0.41
	Other oilseeds	0.04	0.13		Banana	16.35	3.47
					Potato	63.88	13.56
Oxyfluorfen 23.5 EC	Onion	26.13	39.37	Pendimethalin 30 EC	Rice	2.03	0.60
	Other veg.	0.31	0.47		Onion	27.70	8.23
Paraquat 24 SL	Cotton	13.55	2.88	Pretilachlor 30EC	Rice	4.80	1.61
	Coffee	1.94	0.41	Pretilachlor 50 EC	Rice	6.84	2.19
				Pyrithiobac-sodium 10%EC	Cotton	0.63	1.16
					Total	2,015.48	532.01

15. Gujarat

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Sugarcane	2.09	0.31		Banana	7.91	1.92
Alachlor 50 EC	Groundnut	0.65	0.15		Mango	21.40	5.19
Anilophos 30 EC	Rice	56.05	12.17		Other fruits	30.85	7.48
Atrazine 50 WP	Sugarcane	125.16	25.24		Other veg.	29.69	7.20
	Maize	7.33	1.48		Other crops	212.30	51.47
Butachlor 50 EC	Rice	6.91	0.93		Groundnut	13.50	3.27
Ethoxysulfuron	Rice	0.01	0.03		Glyphosate 71 SL	Cotton	3.32
Fenoxaprop-P-ethyl 10 EC	Cotton	1.46	1.02	Fruits		5.53	2.76
	Wheat	0.26	0.18	Veg.		49.73	24.86
	Groundnut	0.13	0.09	Other crops		1.11	0.55
Fenoxaprop-P-ethyl 9 EC	Cotton	15.33	14.58	Groundnut	4.42	2.21	
	Cumin	0.12	0.11	Glufosinate-ammonium 15 SL	Cotton	0.00	0.00
	Red gram	0.02	0.02		Banana	0.03	0.02
	Chillies	0.01	0.01	Metribuzin 70 WP	Sugarcane	2.38	2.79
	Okra	0.02	0.02		Potato	2.18	2.55
	Onion	0.83	0.79	Metsulfuron-methyl 20 WP	Wheat	1.44	11.74
	Other veg.	0.02	0.02	Oxadiargyl 6% EC	Cumin	10.34	5.17
Groundnut	8.19	7.79	Wheat		0.10	0.05	
Other oilseeds	0.06	0.05	Onion		1.01	0.50	
Glyphosate 41 SL	Cotton	28.59	6.93	Oxadiargyl 80 WP	Rice	0.58	2.20
	Sugarcane	9.07	2.20	Oxyfluorfen 23.5 EC	Cumin	3.45	5.19
	Cumin	4.05	0.98		Onion	12.02	18.11
	Garlic	4.05	0.98				
	Rice	5.81	1.41				
	Chillies	13.50	3.27				

Herbicide Consumption

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Paraquat 24 SL	Cotton	130.66	27.74		Chillies	9.23	2.74
	Sugarcane	57.50	12.21		Onion	36.93	10.97
	Banana	6.54	1.39		Other crops	92.33	27.43
	Cole Crops	0.32	0.07		Groundnut	49.86	14.81
	Potato	1.95	0.41		Mustard	81.25	24.14
Pendimethalin 30 EC	Cotton	193.89	57.60		Pretilachlor 30EC	Rice	3.69
	Cumin	169.88	50.46	Pretilachlor 50 EC	Rice	12.82	4.10
	Rice	33.24	9.87	Pyrithiobac-sodium 10 EC	Cotton	1.25	2.31
	Wheat	18.47	5.49	Total		1,602.78	490.65

16. Maharashtra

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	
2,4-D 80 WP (sodium salt)	Sugarcane	143.84	21.65		Grapes	210.78	51.10	
	Maize	49.67	7.48		Mango	26.23	6.36	
	Rice	2.12	0.32		Pomegranate	57.44	13.93	
	Banana	0.29	0.04		Fruits	18.26	4.43	
	Fruits	0.21	0.03		Other Veg.	35.70	8.65	
Anilophos 30 EC	Rice	5.38	1.17		Other Crops	577.05	139.90	
Atrazine 50 WP	Sugarcane	104.65	21.10	Glyphosate 71 SL	Cotton	3.51	1.75	
	Maize	5.23	1.06		Sugarcane	7.02	3.51	
	Chillies	1.65	0.33		Chillies	3.51	1.75	
	Grapes	4.19	0.84		Banana	1.75	0.88	
Chlorimuron-ethyl 25 WP	Soybean	1.20	12.00		Grapes	7.02	3.51	
Ethoxysulfuron	Sugarcane	0.09	0.36		Pomegranate	5.26	2.63	
Fenoxaprop-P-ethyl 10 EC	Soybean	0.40	0.28		Fruits	10.53	5.26	
Fenoxaprop-P-ethyl 9 EC	Cotton	3.67	3.49		Other Veg.	157.94	78.97	
	Chillies	0.04	0.04		Glufosinate-ammonium 15 SL	Grapes	0.05	0.03
	Citrus	0.08	0.08			Other veg.	0.00	0.00
	Grapes	0.04	0.04	Imazethapyr 10 SL	Soybean	78.50	96.78	
	Cucurbits	0.01	0.01	Metribuzin 70 WP	Cotton	0.02	0.02	
	Okra	0.02	0.02		Sugarcane	46.08	53.95	
	Onion	14.61	13.90		Tomato	1.64	1.92	
	Other Veg.	0.02	0.02	Metsulfuron-methyl 20 WP	Wheat	3.65	29.65	
Soybean	20.92	19.90	Oxadiargyl 6 EC	Onion	0.12	0.06		
Glyphosate 41 SL	Cotton	32.69	7.93	Oxadiargyl 80 WP	Rice	0.48	1.83	
	Sugarcane	15.94	3.86		Onion	0.03	0.12	
	Redgram	3.99	0.97		Other veg.	0.00	0.01	
	Chillies	19.93	4.83	Oxyfluorfen 23.5 EC	Garlic	3.37	5.08	
	Banana	29.14	7.06		Onion	140.16	211.13	
	Citrus	39.85	9.66					

Herbicide Use in Indian Agriculture

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Paraquat 24 SL	Cotton	19.17	4.07		Tomato	0.39	0.08
	Sugarcane	230.69	48.98		Potato	2.42	0.51
	Rice	4.38	0.93		Other veg.	2.48	0.53
	Chillies	1.53	0.32	Pendimethalin 30 EC	Cotton	5.54	1.65
	Banana	12.19	2.59		Rice	0.55	0.16
	Grapes	47.54	10.09		Onion	9.23	2.74
	Fruits	30.32	6.44		Soybean	1.85	0.55
	Cole crops	6.68	1.42	Pretilachlor 50 EC	Rice	108.67	34.80
	Peas	0.08	0.02	Pyriithiobac-sodium 10 EC	Cotton	1.25	2.31
	Tomato	0.39	0.08		Total	2,380.96	979.89

17. Madhya Pradesh

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
2,4-D 80 WP (sodium salt)	Rice	4.69	0.71	Glyphosate 41 SL	Cotton	4.76	1.15
Alachlor 50 EC	Soybean	50.45	11.86		Bengal Gram	2.09	0.51
Anilophos 30 EC	Rice	5.04	1.10		Chillies	6.27	1.52
	Other crops	0.22	0.05		Grapes	0.58	0.14
Atrazine 50 WP	Chillies	2.48	0.50		Mango	0.58	0.14
	Onion	0.63	0.13		Fruits	5.34	1.30
	Tomato	0.63	0.13		Other veg.	5.34	1.30
	Potato	2.93	0.59		Other crops	7.79	1.89
Butachlor 50 EC	Rice	18.18	2.45		Soybean	2.09	0.51
Chlorimuron-ethyl 25 WP	Soybean	7.00	70.00		Glyphosate 71 SL	Cotton	1.46
Clodinafop 15WP	Wheat	0.17	0.33	Chillies		5.83	2.91
Ethoxysulfuron	Rice	0.03	0.12	Fruits		1.46	0.73
Fenoxaprop-P-ethyl 10 EC	Wheat	1.87	1.30	Other		5.83	2.91
	Soybean	2.38	1.65	Other veg.			
Fenoxaprop-P-ethyl 9 EC	Cotton	1.33	1.27	Other crops	1.46	0.73	
	Rice	14.12	13.43	Imazethapyr+ Pendimethalin	Soybean	5.00	2.16
	Blackgram	0.80	0.76	Imazethapyr 10 SL	Soybean	532.00	655.87
	Red gram	0.42	0.40	Mesosulfuron-methyl 3%+Iodosulfuron-methyl sodium 6% WDG	Wheat	0.09	0.24
	Chillies	0.66	0.62	Metribuzin 70 WP	Sugarcane	0.07	0.08
	Brinjal	0.10	0.09		Wheat	0.04	0.04
	Cole crops	0.27	0.25		Tomato	0.03	0.03
	Cucurbits	0.03	0.03		Potato	0.36	0.42
	Okra	0.02	0.02		Other crops	0.23	0.27
	Onion	0.39	0.37		Metsulfuron-methyl 20 WP	Wheat	1.38
	Tomato	0.28	0.27				
	Other veg.	1.75	1.67				
	Other crops	1.36	1.29				
	Soybean	124.37	118.29				

Herbicide Consumption

Formulation	Crop	Volume (t or kL)	Value (₹ in crore)	Formulation	Crop	Volume (t or kL)	Value (₹ in crore)
Oxadiargyl 6 EC	Onion	4.69	2.35		Tomato	0.55	0.12
Oxadiargyl 80 WP	Rice	0.04	0.16		Potato	1.16	0.25
	Other crops	0.01	0.04		Soybean	11.61	2.47
Oxyfluorfen 23.5 EC	Garlic	1.12	1.69	Pendimethalin 30 EC	Cotton	5.54	1.65
	Onion	3.00	4.52		Rice	5.17	1.54
Paraquat 24 SL	Cotton	47.54	10.09		Peas	11.08	3.29
	Sugarcane	0.77	0.16		Soybean	145.88	43.33
	Chillies	11.81	2.51	Pretilachlor 50 EC	Rice	2.78	0.89
					Total	1,085.43	991.48

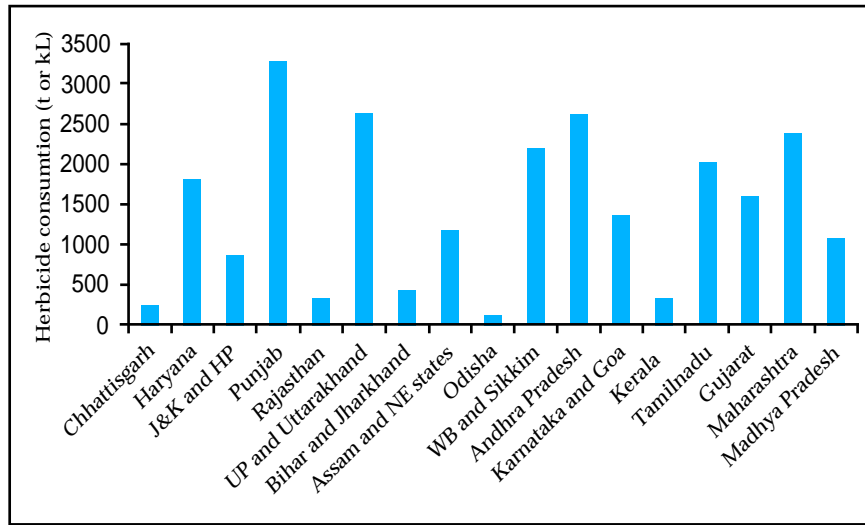


Fig. 5.2 State-wise herbicide consumption in India

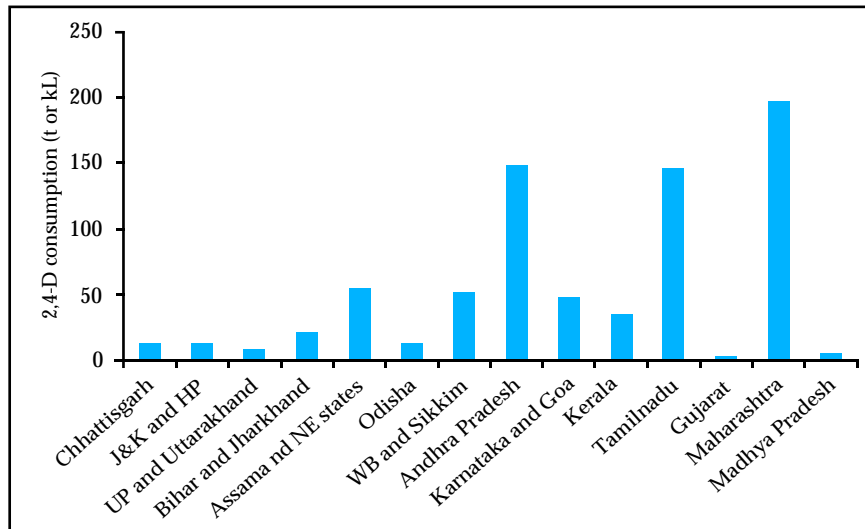


Fig. 5.3 State-wise consumption of 2,4-D in India

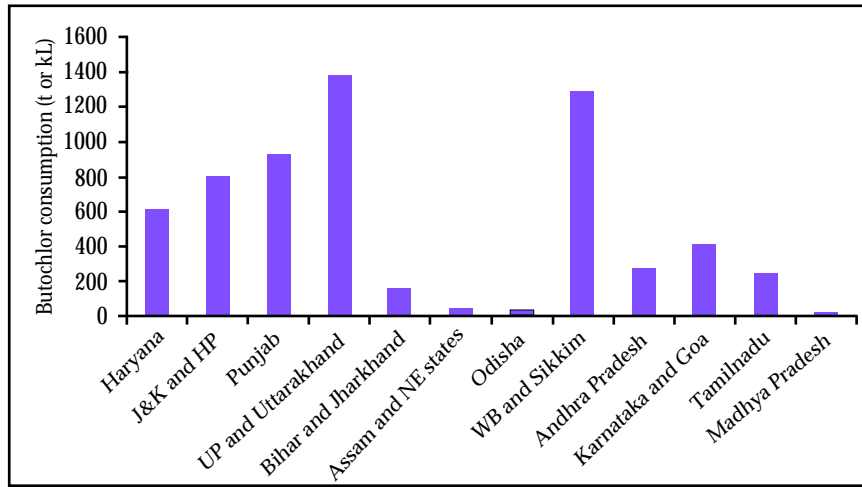


Fig. 5.4 State-wise consumption of butachlor in India

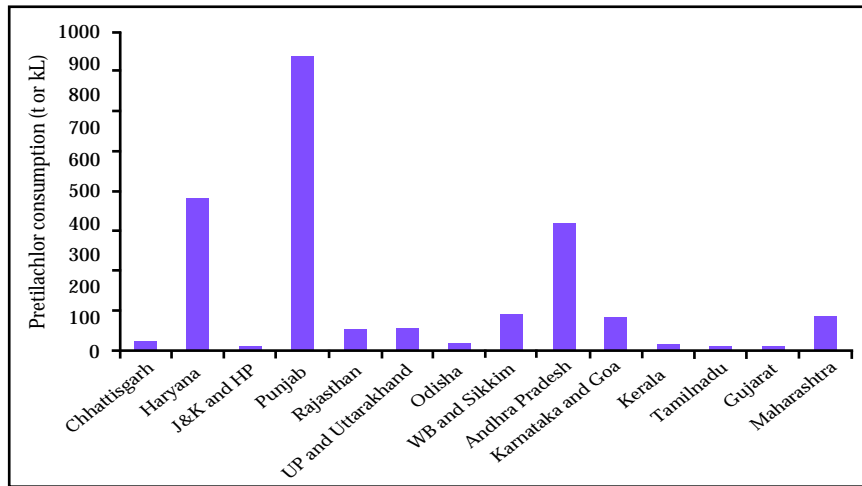


Fig. 5.5 State wise consumption of pretilachlor in India

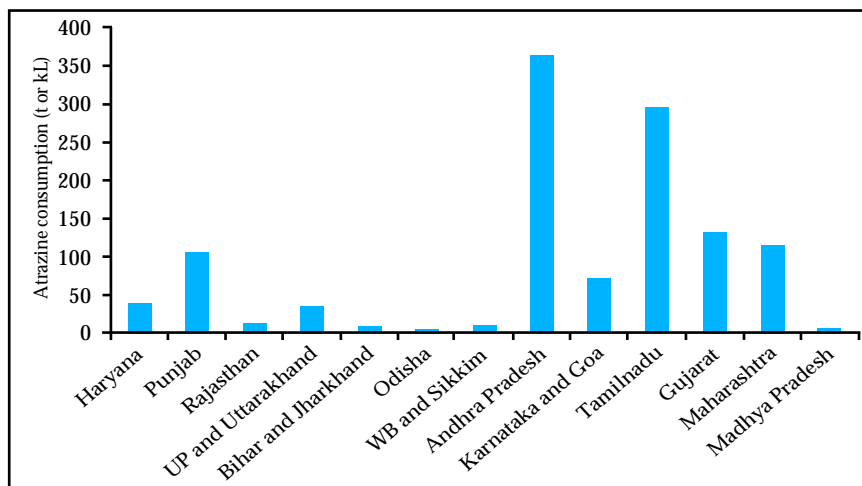


Fig. 5.6 State-wise consumption of atrazine in India

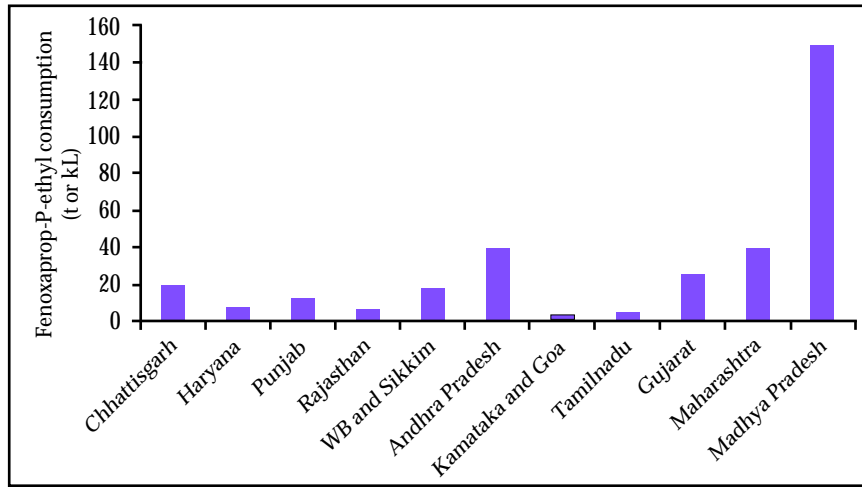


Fig. 5.7 State-wise consumption of fenoxaprop-P-ethyl in India

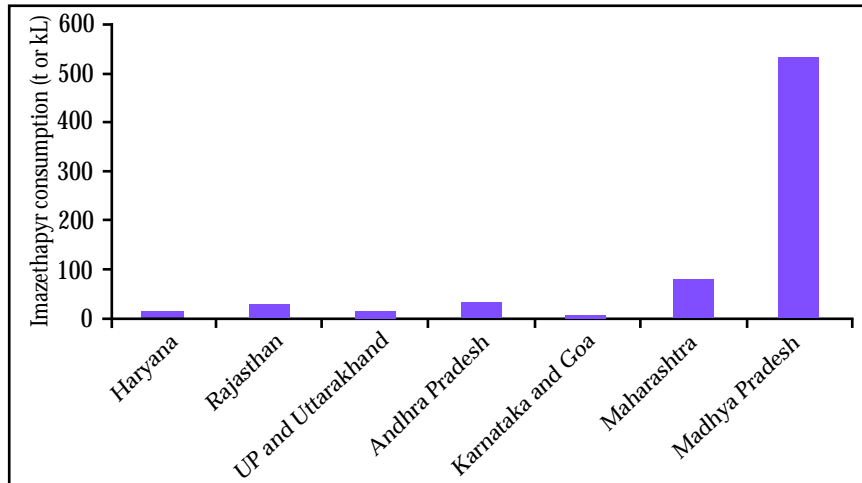


Fig. 5.8 State-wise consumption of imazethapyr in India

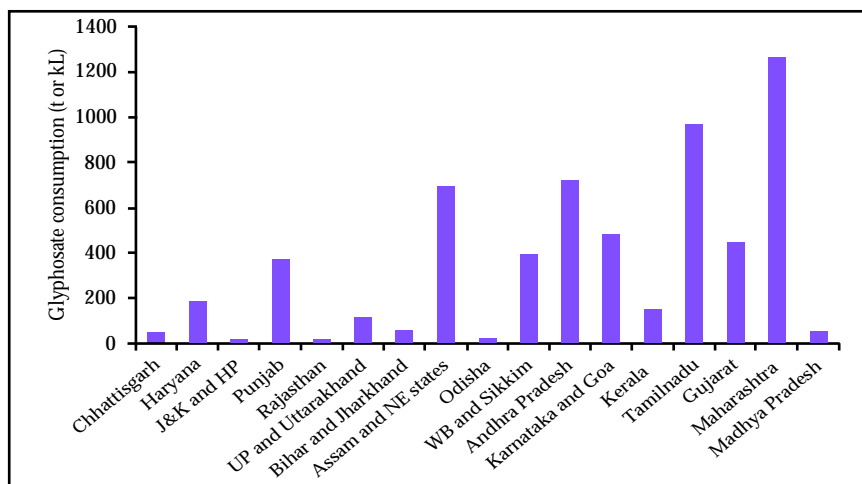


Fig. 5.9 State-wise consumption of glyphosate in India

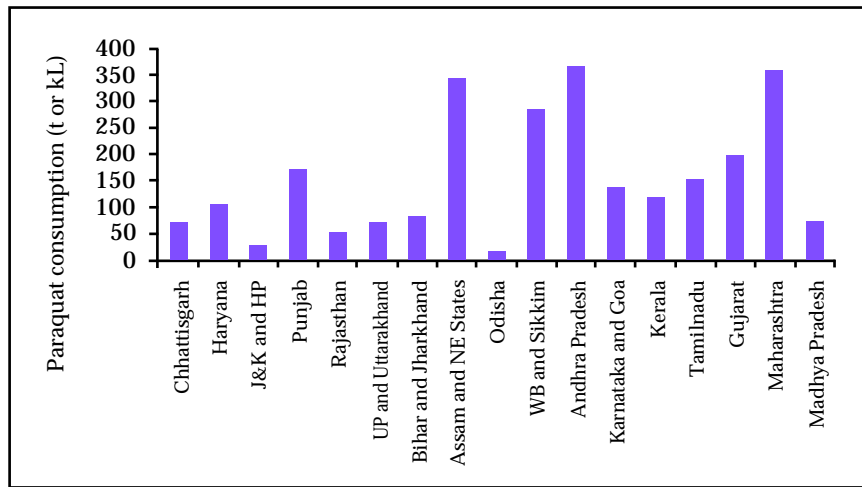


Fig. 5.10 State-wise consumption of paraquat in India

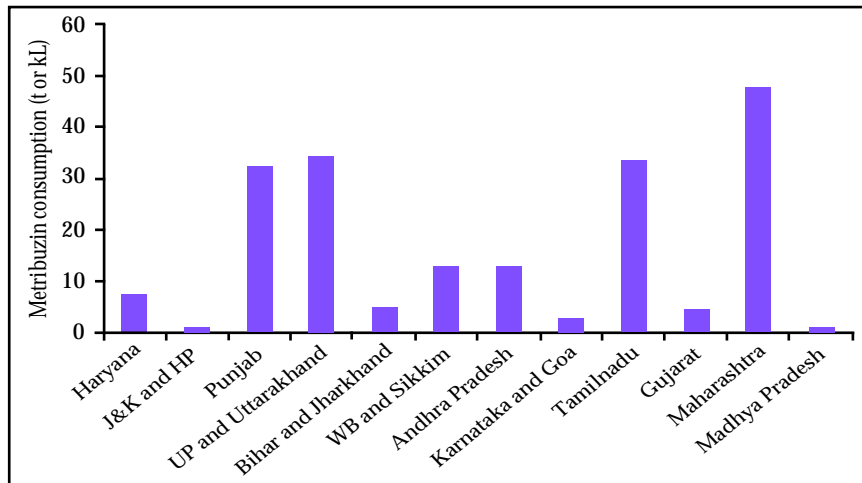


Fig. 5.11 State-wise consumption of metribuzin in India

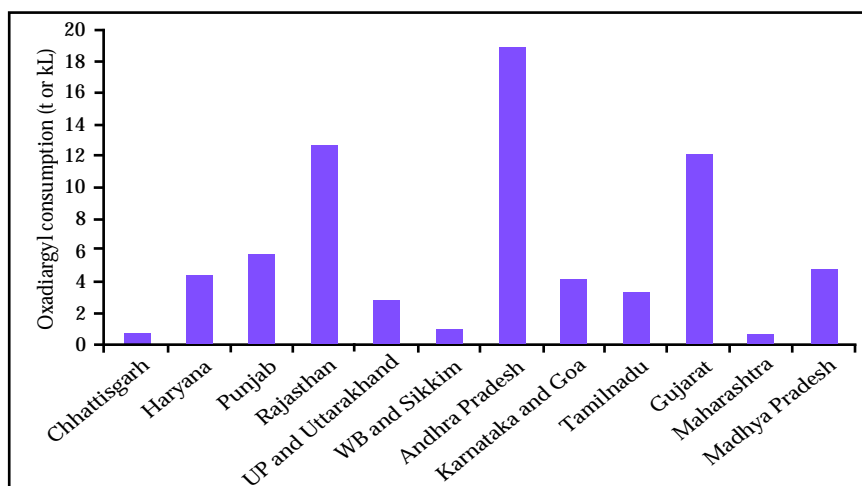


Fig. 5.12 State-wise consumption of oxadiargyl in India

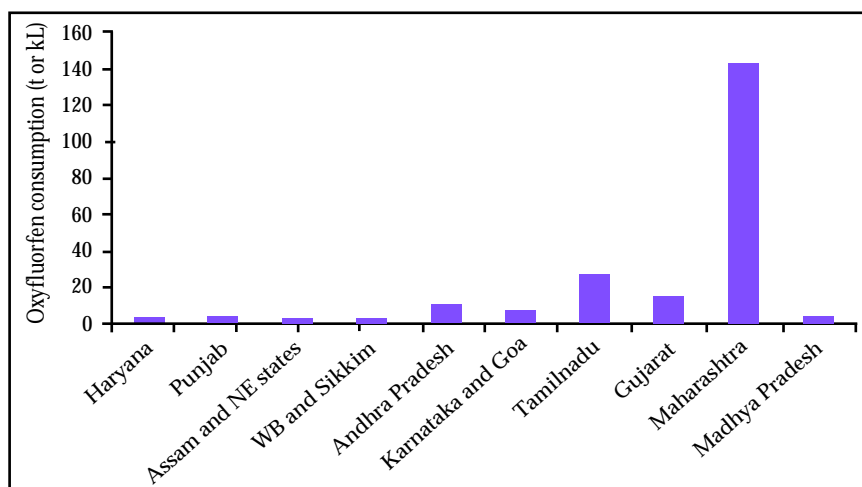


Fig. 5.13 State-wise consumption of oxyfluorfen in India

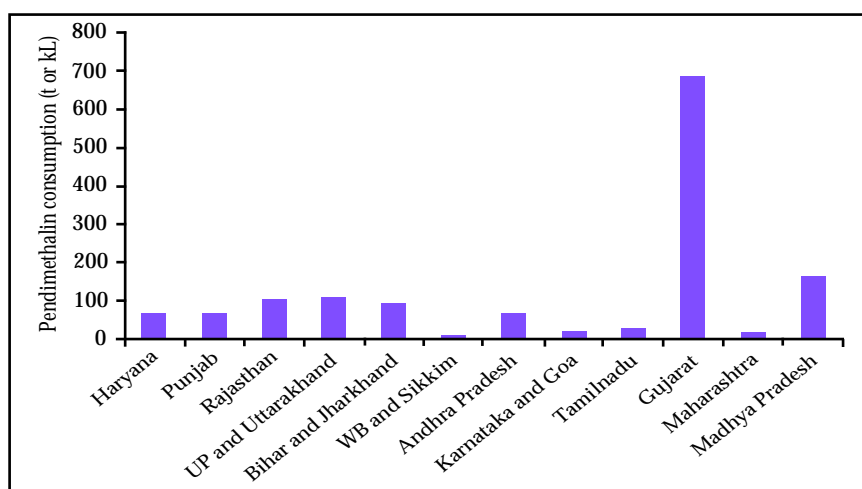


Fig. 5.14 State-wise consumption of pendimethalin in India

Definite recommendations for herbicide use against different weeds in all important crops have been made by the Ministry of Agriculture, Government of India. These recommendations are updated regularly. Recommendations are also available to farmers through the label claim attached to the formulation packages. But our agricultural system is so diversified and fragmented that the use of herbicides takes place beyond the official recommendations. It is due to ignorance of farmers; profit-oriented-wrong-promotion of herbicides by some pesticide retailers and dealers; non-availability of required products; and insufficient extension network at farmers' level. Therefore, the estimation of crop-wise and area-wise (acreage) herbicide consumption on the basis of herbicide production and its location-wise (say block-wise) distribution may not be perfect and accurate. But the data-based information presented here certainly reflects the trend in the use of herbicides.

6. Adjuvants

The technical grades of herbicides are not applied in crop field directly. Most of them are formulated before use, by mixing the active ingredient(s) with inert(s) and/or other auxiliaries/adjuvants, to obtain a product which is effective, easy to handle and apply, possesses satisfactory shelf-life and is devoid of undesirable side effects (Parmar and Tomar, 2004). The auxiliaries or adjuvants present in a formulation are essential for the performance of most herbicides. ASTM (1998) has defined an adjuvant as 'a material added to a tank mix to aid or modify the action of an agrochemical, or the physical characteristics of the mixture' and in WSSA Herbicide Handbook (1994) it is defined as 'a substance in an herbicide formulation or added to the spray tank to modify herbicidal activity or application characteristics'. Thus, adjuvants enhance the performance of an herbicide in different ways, viz. wetting, spreading, deposit building, emulsifying, deflocculating the active ingredients, and many more. It may even enhance the bioefficacy of the active ingredients, thus it reduces the effective herbicide dose as much as 10-fold (Green and Green, 1993).

Table 6.1 Different types of adjuvants used in herbicide formulations

Activator	Acidifying agent	Additive
Antifoam/Defoam	Antifreeze	Attractant
Buffering agent	Binder	Coupler
Chelating agent	Compatibility agent	Colorant/Dye
Detergent	Deposition agent	Drift control agent
Dispersant	Emulsifier	Evaporation reducer
Foam marker	Humectant	Inert
Neutraliser	Modified seed oil	Preservative
Petroleum oil	Penetrator	Rainfast agent
Spreader sticker	Synergist	Safener
Surfactant	Translocation aid	Thickener
UV protectant	Vegetable oil	Wetting agent

Source: Green (2000)

Based on the use there are different types of adjuvants (Table 6.1), among which surfactants are key adjuvants used in most of the formulations. Surfactant is a formulant which reduces the interfacial tension of two boundary surfaces, thereby increasing the emulsifying, spreading, dispersibility and/or wetting properties of liquids or solids. There are four major types of surfactants used in the herbicide formulation. Anionic surfactants are the alkaline metal salts of organic acids, viz. carboxylates, sulphonates, sulphates or phosphates and are most often used with acids or salts. The hydrophilic moieties in cationic surfactants are amino or quaternary nitrogen atoms, which form cations in aqueous phase. Cationic surfactants are useful as wetting agents, emulsifiers, dispersants, foam stabilizers, corrosion inhibitors, etc. Ethoxylated fatty amine, an adjuvant of this class, has been frequently used with the herbicide glyphosate. Non-ionic surfactants are neutral molecules and bear no electrical charge in solution and are generally compatible with most herbicides. The electronegative oxygen atom generates hydrophilicity. Amphoteric surfactant molecules bear both an acidic and a basic hydrophilic heads in the same molecule. Thus, they can produce both the ions, i.e. anions and cations, depending on the chemical nature of the environment. Non-ionic surfactants are neutral molecules and bear no electrical charge in solution and are generally compatible with most herbicides. The electronegative oxygen atom generates hydrophilicity. Uncharged or non-ionic surfactants are compatible with most herbicides. The major

classes of non-ionic surfactants are alcohol ethoxylates, nonyl phenol ethoxylates, alkyl octylphenol ethoxylates, alkyl polysaccharides, urea clathrates, fatty acid ethoxylates, tallow amine ethoxylates, phosphate esters, fatty acids, EO/PO block copolymers (organosilicones), and siloxanes (organosilicones).

Binders and stickers are also important surfactants required for formulating herbicide technical. Binders are cementing materials required to hold the toxicant onto carrier. Some organic binders used in granular formulations are starch and dextrin, natural gum, shellac, resins, lignosulphonates and polyvinyl alcohol, polyethylene glycols, etc. Stickers are added in the formulation to improve its retention on the target surface. Polyethylene polysulphides, polyvinyl acetate, polybutenes, natural gums are some examples of stickers used in herbicide formulations. Spreader-stickers are the combinations of compounds that cause the droplet to spread over the surface and help in retaining the toxicants on the leaf.

There are some special purpose adjuvants or utility adjuvants, which on addition in the formulation may widen the range of conditions under which a given herbicide is useful. They may alter the physical characteristics of the spray solution. This group includes compatibility agents, buffering agents, antifoam agents, and drift control agents. Compatibility agents allow simultaneous application of two or more ingredients. They are most often used when herbicides are applied in liquid fertilizer solutions. The addition of compatibility agents in the formulation may increase stability when mixing fertilizers and pesticides, emulsify spray solution and moderately adjust pH for better tank mix component compatibility. Buffering agents usually contain a phosphate salt or more recently citric acid, which maintains a slightly acid pH when added to alkaline waters. These are added to higher pH solutions to prevent alkaline hydrolysis of some organophosphate (OP) and carbamate herbicides. Some buffering agents act as “water softening” agents that are used to reduce problems with hard water. In particular, calcium and magnesium salts may interfere with the performance of certain herbicides. Ammonium sulfate is sometimes added to reduce hard water problems.

Selection of spray adjuvants: Adjuvant selection should be based on several factors including what the pesticide calls for, what the adjuvant claims to be, cost of the adjuvant, and what is available in your area. The primary source in deciding whether an adjuvant is necessary and the type of adjuvant used should come from the pesticide label. The following are some general guidelines to consider when given a choice of adjuvants.

- If both oil concentrate (crop or vegetable oil) and non-ionic surfactants are listed, then non-ionic surfactant should be used under normal weather conditions when weeds are small and well within label guidelines. It is advised to use oil concentrate if weeds are stressed due to dry weather or with more mature weeds.
- If labeled, oil concentrate may be included in the formulation for control of grasses.
- Nitrogen fertilizer should only be used if it is recommended on the herbicide label.
- If the potential for crop injury is great, then nonionic surfactant should be included instead of oil concentrate.
- To improve crop safety, oil concentrates should not be used with plant growth regulator-type herbicides (i.e., dicamba, 2,4-D, etc.).

In ready-to-apply formulations, adjuvants are essential components along with toxicant. Nowadays, tank-mix adjuvant market is rapidly growing (Underwood, 2000). In most countries

there is no patent protection or government regulation on the use of adjuvants in pesticide formulation. Manufacturers usually do not disclose the compositions of adjuvants in formulation to avoid others who can copy the composition of the non-proprietary items. Introduction of proprietary adjuvants is needed to have well defined composition for any herbicide formulation.

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Safener

Herbicide safeners are chemical agents that selectively protect crop plants from herbicide damage without affecting the activity in target weed species. The concept to enhance crop tolerance to less selective or nonselective herbicide by using chemical agents was established by Otto Hoffman, when he accidentally observed the safening effect of 2,4-D in 2,4,6-T-treated tomato plants. The concept of using chemical safeners in the herbicide formulation practically started with the introduction of 1,8-naphthalic anhydride (NA) to improve the tolerance of maize to thiocarbamate herbicides. Presently, many herbicides of different chemical classes are commercially used along with herbicide formulation (Table 6.2). Safeners act in crop plants by reducing the uptake and transport of herbicide to reach the target site, or by interacting directly by inhibiting receptor proteins.

Table 6.2 Commercially available herbicide safeners

Safener		Herbicide(s) counteracted	Crop(s) protected	Application method
Chemical class	Name			
Anhydride	1,8-naphthalic anhydride (NA)	Thiocarbamates (EPTC, Butylate, Venolate)	Maize	Seed treatment
Dichloroacetamide	Dichlormid	Thiocarbamates, Chloroacetanilide	Maize	Pre-plant incorporated with herbicide
	Furilazole	Acetochlor, Halosulfuron-methyl	Maize	Spray (Pre-em) as a mixture with herbicide
	AD-67	Acetochlor	Maize	Spray (Pre-em) as a mixture with herbicide
	Benoxacor	Metolachlor	Maize	Spray (Pre-em) as a mixture with herbicide
Oxime ether	Cyometrinil	Chloroacetanilide (Metolachlor)	Sorghum	Seed treatment
	Oxabetrinil	Chloroacetanilide (Metolachlor)	Sorghum	Seed treatment
	Fluxofenim	Chloroacetanilide (Metolachlor)	Sorghum	Seed treatment

Adjuvants

Safener		Herbicide(s) counteracted	Crop(s) protected	Application method
Chemical class	Name			
Thiazole carboxylic acid	Flurazole	Alachlor	Sorghum	Seed treatment
Dichloromethyl ketal	MG-191	Thiocarbamates, Chloroacetanilide	Maize	Spray (Pre -em) as a mixture with herbicide
Phenylpyrimidine	Fenclorim	Pretilachlor	Rice	Spray (Pre-em) as a mixture with herbicide
Urea	Dymron	Pyributicarb, Pretilachlor, Pyrazosulfuron-ethyl	Rice	Spray (Pre-em, Post-em) as a mixture with herbicide
Piperidine-1-carbothioate	Dimepiperate	Sulfonylureas	Rice	Spray (Post-em) as mixture with herbicide
8-Quinolinoxy-carboxylic esters	Cloquintocet-mexyl	Clodinafop-propargyl	Cereals	Spray (Post-em) as mixture with herbicide
1,2,4-Triazole-carboxylate	Fenclorazole-ethyl	Fenoxaprop-ethyl	Cereals	Spray (Post -em) as mixture with herbicide
Dihydropyrazole-dicarboxylate	Mefenpyr-diethyl	ACCase inhibitors (Sulfonyl ureas)	Wheat, Rye, Triticale, Barley	Spray (Post-em) as mixture with herbicide
Dihydroisoxazole-cvarboxylate	Isoxadifen-ethyl	ACCase inhibitors (Sulfonyl ureas)	Maize, Rice	Spray (Post-em) as mixture with herbicide
Arylsulfonyl-benzamide	Cyprosulfamide	Isoxaflutole	Maize	Spray (Pre-em, Post-em) as a mixture with herbicide

Adopted from Stephenson and Yaaocoby (1991); Davies (2001) and Rosinger (2014)

7. Herbicide Application Techniques

Herbicides are applied as pre-planting (before planting the crop); pre-emergence (after planting, but before emergence of the crop); and post-emergence (after crop emergence) depending on the crop and weed situation in the field. Most of the herbicides are applied in liquid form, where formulation is mixed with water. Obviously, different types of sprayer are available for the application of herbicides. But a very few number of granular formulation is also available in Indian market. These are generally applied in the field by hand.

Herbicide applicator: Some popular types of herbicide application equipment available are: knapsack sprayer, compression knapsack sprayer, motorized knapsack sprayer, tractor mounted sprayer, handheld granule applicator etc. The most ideal for spraying herbicide is the lever operated knapsack sprayer (Fig. 7.1). With this sprayer it is possible to spray 0.5 ha with the single nozzle in 8 hours in a day (Singh and Kandoria, 1999). The nozzle helps to control the rate, consistency, thoroughness and safety of herbicide application. It carries out four basic functions: atomises liquid to droplets; disperses the droplets in a specific pattern; meters liquid at a certain low rate; and provides hydraulic momentum. The nozzle tip, one of the most important parts of spraying system, guides the spraying pattern. Depending on the nature of tip various types of nozzle has been developed and commercialized. In herbicide application, flood jet and flat fan nozzles are useful as the attachment of knapsack sprayer (Fig. 7.2). When it is desired to spray with more than one nozzle with the help of a spray rig or spray boom, care should be taken in mounting to shun any overlapping or gapping.

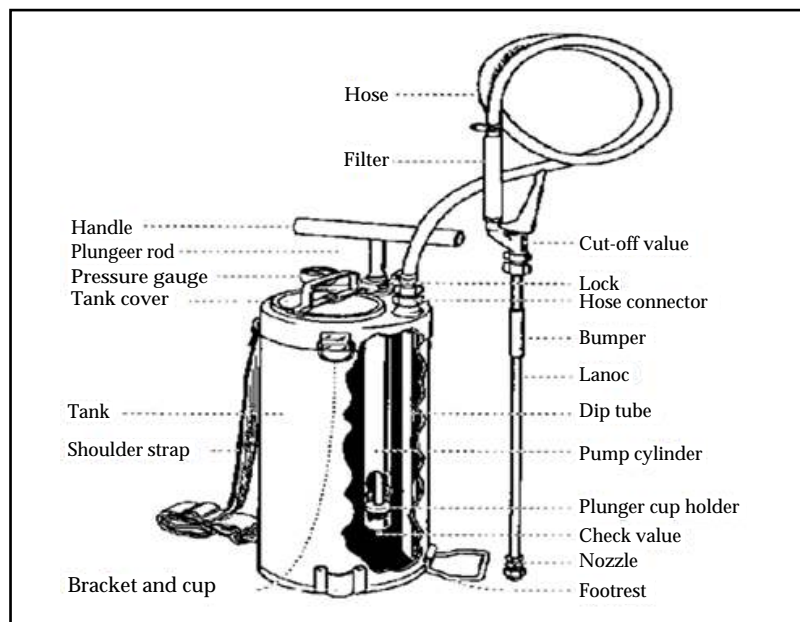


Fig. 7.1 Different parts of knapsack sprayer (Source: WHO, 1997)

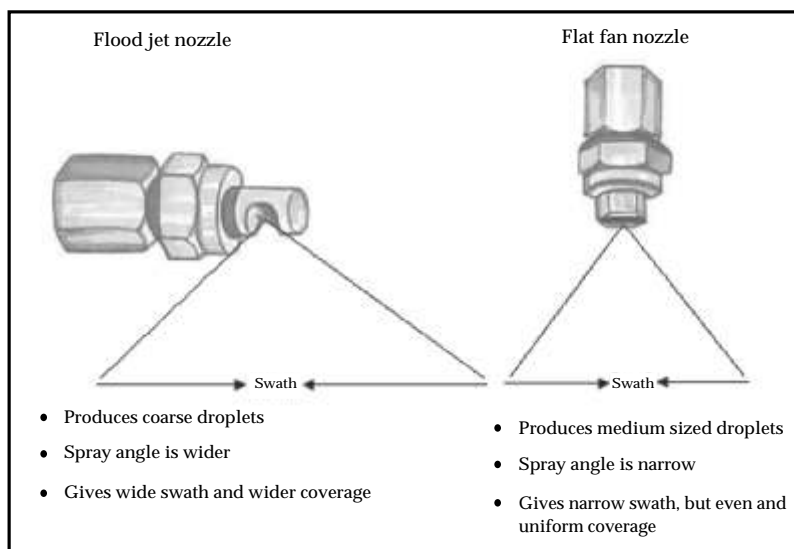


Fig. 7.2 Comparative study of flood jet nozzle and flat fan nozzle

Calibration of the sprayer:

- Mark an area having a width equal to the swath width
- Keep the sprayer on a levelled ground and fill the water to a marked level
- Carry out spraying in the marked area at a normal speed
- Avoid skipping or overlapping
- Refill the sprayer to the original level marked earlier
- The quantity refilled is the quantity required to spray the marked area.
- Work out the volume rate/ha

Example:

Marked area: 20 square meters

Quantity of water used: 1 L

Volume rate = $(1 \times 10,000) / 20 = 500 \text{ L/ha}$

Calculation of herbicide requirement: The amount of commercial formulation of the herbicide required can be calculated by the following formula:

$$\text{Commercial product (kg/ha)} = \frac{\text{Dose in kg a.i./ha} \times 100}{\% \text{ a.i. in the product}}$$

Example:

Isoproturon is available as 75% WP. If the recommended rate of application is 0.75 kg ai/ha then the amount of commercial product required is:

$$75\% \text{ WP product} = \frac{0.75 \times 100}{75} = 1.00 \text{ kg/ha}$$

Maintenance of the equipments:

The sprayer should be well maintained during the spraying season. It is very important to clean both inside and outside of sprayers after each day's work, even if the same chemical is being used the next day. Sprayer should be lubricated thoroughly and regularly before starting the work. All parts should be inspected regularly and damaged parts should be replaced immediately. The nozzle should be checked, and if required, it should be replaced.

Safety related to spraying:

Before spraying

1. Identify the weed and its extent of damage. If it crosses economic injury level, use the recommended herbicide.
2. Check the spraying equipment and accessories.
3. All components should be clean. Replace worn out parts such as 'O'-ring, seal, gasket, nozzle tip, hose clamps and valves. Test the sprayer with water. Check the nozzle spray pattern and discharge rate.
4. Calibrate the sprayer. Set spraying speed and nozzle swath by adjusting the spray height and nozzle spacing.
5. Herbicide should be kept in a dry and locked store.

During spraying

1. Take herbicide sufficient for the day's need, not more.
2. Herbicide formulation should be mixed with water in the correct quantities as mentioned in the instruction.
3. Wear appropriate clothing, such as cap, goggles, face-mask, apron, hand gloves, footwear.
4. Do not spray during high wind and rain.
5. Never eat, drink and smoke during spraying.
6. Spray correctly by operating sprayer at the right speed and pressure.
7. Never try to clean the clogged nozzle by blowing with your mouth.
8. Do not allow children and animals to be nearby during mixing and spraying.

After spraying

1. Unused herbicides in the spray tank should be disposed of in pits dug in the wasteland.
2. Clean the equipment and other accessories with water thoroughly. Do not clean it in a pond or river.
3. After use, oil the sprayer.
4. Crush and bury the empty herbicide containers in a land-filled dump.
5. Remove and wash protective clothing and footwear.

6. Wash yourself well.
7. Keep a proper record of herbicide uses.

Cost of herbicide application

The cost of herbicide application depends on the type and stage of crops and weed status in crop. For the weed management in wheat, a number of herbicides and ready mix combinations of herbicides is available in the market. If the field is infested with only broad leaf weeds, the use of metsulfuron is advisable because it is the cheapest herbicide among all available in our market. If crop is infested with oat and broadleaf weeds the ready mix combination of clodinafop + metsulfuron is yielding better results. The field infested with isoproturon-resistant *Phalaris minor* and some broad leaf weeds can be managed by a ready mix combination of mesosulfuron and iodosulfuron or sulfosulfuron and metsulfuron.

Butachlor was vastly used for managing weeds in rice in the recent past. It is still popular due to its low application cost, only ₹ 500 per hectare excluding the labor cost (Table 7.1). With the introduction of new molecules like bispyribac, cyhalofop, fenoxaprop etc., the options for post-emergence application of herbicide in rice became wide open. The weed management in direct-seeded rice is becoming easy now and it is more economic in comparison to manual weeding, which ranges from ₹ 4900 (Meghalaya) to ₹ 9660 (Gujarat) per ha, calculated on the basis of the minimum wages of labours.

For many years, there were not many option of chemical weed control in pulses as only pre-emergence herbicides, arachlor etc. were available pendimethalin. Now with the introduction of new low-dose high potency chemicals like imazethapyr, quizalofop, clodinafop etc., which can be used safely in black gram, greengram and pigeon pea more economical weed management is possible in pulse crops.

Table 7.1 Cost of herbicide per hectare of crop land

Herbicide	Formulated product	Active ingredient in product (%)	Cost (₹ / pack)	Formulation content in a pack (g or mL)	Herbicide (a.i.) dose (g/ha)	Formulation dose (g/ha)	Cost of herbicide (₹ /ha)
Atrazine	Atrataf	50	181	500	750	1500	543
Alachlor	Lasso	50	490	1000	1500	3000	1470
Anilophos	Aniloguard	30	360	1000	400	1333	480
Azimsulfuron	Segment	50	1184	28	35	70	2960
Bispyribac-sodium	Nominee Gold	10	6640	1000	25	250	1660
Butachlor	Dhanuchlor	50	250	1000	1000	2000	500
Carfentrazone	Affinity	40	155	20	20	50	388
Chlorimuron-ethyl	Kloben	25	254	15	9	36	610
Clodinafop-propargyl	Topik	15	450	160	60	400	1125
Cyhalofop-butyl	Clincher	10	2150	1000	60	600	1290
2,4-D sodium salt	Weedmar	38	305	1000	750	1974	602
2,4-D amine salt	Zura	58	365	1000	750	1293	472
2,4-D ethyl ester	Weedmar	38	311	1000	750	1974	614

Herbicide Use in Indian Agriculture

Herbicide	Formulated product	Active ingredient in product (%)	Cost (₹ / pack)	Formulation content in a pack (g or ml)	Herbicide (a.i.) dose (g/ha)	Formulation dose (g/ha)	Cost of herbicide (₹ /ha)
Diuron	Diurex	83.3	425	500	500	600	510
Ethoxysulfuron	Sunrise	12	285	50	15	125	713
Fenoxaprop-P-ethyl	Whipsuper	9.3	400	250	100	1075	1720
Glyphosate	Round up	42	400	1000	1000	2381	952
Imazethapyr	Pursuit	10	1905	1000	100	1000	1905
Isoproturon	Chemlon	75	350	500	750	1000	700
Metribuzin	Sencor	70	170	100	175	250	425
Metsulfuron-methyl	Algrip	20	147	8	4	20	368
Oxadiargyl	Topstar	80	110	45	70	88	214
Oxyfluorfen	Oxygold	24	515	250	250	1064	2191
Paraquat	Gramoxone	24	400	1000	500	2083	833
Pendimethalin	Stomp xtra	38.7	630	700	750	1973	1744
Pinoxaden	Axial	5	590	400	40	800	1180
Pretilachlor	Rifit	50	570	1000	750	1500	855
Propaquizafop	Society	10	173	100	50	500	865
Pyrazosulfuron-ethyl	Saathi	10	224	80	25	250	700
Pyriithiobac	Hitweed	10	2512	1000	62.5	625	1570
Quizalofop-ethyl	Terga super	5	1521	1000	40	800	1217
Sulfosulfuron	SF_10	75	320	14	25	33	762
Trifluralin	Trifogan	48	440	1000	500	1042	458
Bensulfuron + Pretilachlor	Londex Power	6.6	820	4000	660	10000	2050
Clodinafop + Metsulfuron	Vesta	15+1	525	160	64	400	1313
Pendimethalin + Imazethapyr	Valor	30+2	692	1000	800	2500	1730
Imazethapyr + Imazamox	Odyssey	35+35	765	40	70	100	1913
Metsulfuron -methyl + Chlorimuron-ethyl	Almix	10+10	207	8	4	20	518
Mesosulfuron + Iodosulfuron	Atlantis	3+0.6	570	160	14	389	1385
Sulfosulfuron + Metsulfuron-methyl	Total	80	410	16	32	40	1025

8. Herbicide Residues and Their Mitigation Strategies

A herbicide stays in the treated area long enough to produce the desired effect and then degrades into harmless materials. The duration an herbicide remains active in the environment is called its 'persistence' and the persistence of an herbicide depends on the chemical nature and innate stability of it and on some environmental factors that influence its degradation. The durations of persistence of some herbicides under Indian conditions are given in the table 8.1. The higher the persistence of herbicide, the higher is the chance of transportation to different distant compartments of environment, viz. surface water, ground water, etc., creating non-point source of contamination.

Table 8.1 Relative persistence of some herbicides in soil

< 1 months	1- 3 months	3 - 6 months	> 6 months
2,4-D, Glyphosate, MCPA	Alachlor, Acetochlor, Ametryn, Anilofos, Bispyribac-sodium, Butachlor, Carfentrazone-ethyl, Dalapon, Fluazifop-butyl, Halosulfuron, Metribuzin, Metamifop, Metsulfuron-methyl, Metolachlor, Oxyfluorfen, Propachlor, Pyrazosulfuron-ethyl, Thiobencarb	Clomazone, Chlorimuron-ethyl, Diallate, Dithiopyr, Ethofumesate, Fluchloralin, Imazethapyr, Isoproturon, Metamitron, Oxadiazon, Linuron, Pendimethalin, Pyrazon	Atrazine, Bromacil, Chlorsulfuron, Diuron, Diquat, Imazapyr, Picloram, Sulfentrazone, Sulfometuron, Simazine, Trifluralin, Paraquat

Source: Janaki et al. (2015)

Herbicides undergo biotic degradation by microbes or by plant enzymes and abiotic degradation including chemical degradation and degradation caused by the sunlight. The rest unaltered herbicide finally may come in our drinking water and in food chain. The presence of herbicide, if any, in drinking water, food, feeds, and aqueous body may pose toxicity towards human being, domestic and wild life, and microbial world. Not only the indiscriminate use of herbicides affects the environment, but also it influences the weed biology adversely. It definitely changes the shape of plant kingdom in terms of development of resistance, shifting of weeds and effect on non-target plant flora. The continuous long-term use of herbicides of same mode of action can induce the weed physiology to detoxify the herbicide, and thus, resistance against herbicide is developed within the weed. A weed shift is the change in the composition or relative frequencies of weeds in a population in response to natural or man-made environmental changes in an agricultural system. Weed shift occurs when the application of herbicide does not control an entire weed community or population. Some species or biotypes are killed by the herbicide, others are not affected. Those unaffected species can grow, reproduce and increase in the community, resulting in a weed shift.

The escalating problems of weed infestation must be mitigated and that too by the application of herbicides as we do not have any other feasible option in our hand. Only thing, we have to shift ourselves from the conventional approach to the safer alternatives.

Use of low dose herbicides: In our early days of chemical weed control, herbicides employed for are of high doses, more than 1 kg per ha. Some herbicides of them are still in use. But their consumption is in decreasing trend. New generation herbicides of low dose are curbing the use of conventional herbicides, thus, reducing the environmental load. The dose of sulfonyl ureas and imidazolinones is within 10 to 40 g/ha. It is even possible to enhance the bioefficacy of conventional herbicide by manipulating the formulation, so that the dose can be reduced. For example, atrazine

was recommended to control annual weeds in maize at the rate of 2 to 4 kg/ha. Now, the same herbicide is recommended to use only at the rate of 1 to 2 kg/ha.

Use of low toxic herbicides: We need more number of safer herbicides that will pose minimum risk towards non-targets. Today, modern herbicides, such as the sulfonyl ureas and imidazolinones are low in toxicity. They also don't persist for a long time in the environment, particularly in the environment of tropical countries.

Use of herbicides with new modes of action to combat resistance problem: Resistance towards herbicides has developed more slowly than towards insecticides or fungicides, but it is now present and represents an increasing threat to herbicide efficacy. The resistant weeds are able to metabolize the herbicide, thereby reducing its concentration within its physiology to an ineffective level. To avoid this problem, farmers need to change herbicides with different modes of action. Now, we have herbicides with varieties of modes of action in our hand. It is possible now to target different sites of weed. We have enough weapons to target either photosynthesis at photosystem-I or at photosystem-II, or branched chain amino acid synthesis, or so others. For an instance, we have solved the problem of resistant development by *Phalaris* to isoproturon by utilizing the different modes of action of clodinafop, fenoxaprop and sulfosulfuron.

Use of bioherbicides: Hardly a few bioherbicide formulations based on microbial agents were developed since the introduction of the product DeVine® based on *Phytophthora palmivora* in USA. The products based on different species of *Colletrotichum*, *Alternaria*, *Xanthomonas campestris*, *Chondrostereum purpureum*, etc. are available in global market. In our country, three rust fungi, *Puccinia romagnoliana*, *Melampsora euphorbiae* and *Puccinia* sp. (Isolate NRCWSR-3) were isolated and formulated to control *Cyperus rotundus*, *Euphorbia geniculata* and *Lagascea mollis*, respectively. Albeit some limitations are there in the production of microbial herbicides, further collaborative research will certainly enhance the scope of them in future.

Best management practices: With the help of good knowledge on soil-herbicide interactions and their major controlling factors it is possible to limit or eliminate environmental risk from herbicides by manipulating agricultural management systems. The following set of best management practices can be proposed for our farmers to reduce herbicide contamination of water and food chain.






- Never add chemicals or clean tanks near the water bodies. It may contaminate surface water.
- Soil applied herbicides can be incorporated shallowly (from 1 to 5 cm) without reducing efficacy. Incorporation takes the herbicide off the surface soil where it can be moved by runoff water or wind erosion. Surface reductions in herbicide with shallow incorporation can lower the offsite movement by about 70%.
- Apply herbicides when there is a low probability for runoff and leaching events to occur.
- Apply post-emergence herbicides. Post-emergence applications allow farmers to choose herbicides best on known weed infestations and soil-herbicide interaction.
- Use the lowest rate that will give adequate control and/or apply split herbicide applications. Sprayer should be calibrated regularly.
- Conservation tillage must be considered for the reduction of sediments.

In the present situation, chemical method of weed management has become inevitable in the industrialized countries and is becoming so in developing countries like ours. The labor cost involved in mechanical and manual weed control is soaring high due to urbanisation. But we cannot ignore the crop loss due to weed. In these circumstances, our farmers have no other alternative than the application of herbicides. Presently, we have many low-toxic and low-dose herbicides in our hands. It is possible now to manage diverse weeds in different crops by herbicides available in our market. But we have to learn how to deal with the safer herbicides and how to integrate it with other methods of weed management in order to mitigate the herbicide residue problems.

9. Safety Standards

Toxicity refers to the ability of a poison to produce harmful effects. These harmful effects may range from slight symptoms such as headaches to severe symptoms like coma, convulsions, or death. Poisons act by altering normal body functions. Most toxic effects are reversible in nature and do not cause permanent damage if prompt medical treatment is sought. Some poisons, however, cause irreversible (permanent) damage. Herbicides are designed to control weeds, but they can also be poisonous to desirable plants and animals, including humans. In general, herbicides are less toxic than insecticides. But some of them and their transformed products in the environment are potentially toxic to living organisms. Depending on the intrinsic toxicity of each pesticide, World Health Organisation (WHO) and Environmental Protection Agency (EPA) of US present toxicity classification of pesticides. In our country classification made by the WHO is followed to label the toxicity of a pesticide formulation by a color code (Table 9.1).

Table 9.1 WHO hazard classification based on acute LD_{50, (rat)} of formulated product (mg/kg)

WHO Hazard Class	Information to appear in label				Acute LD ₅₀ (rat) of formulation (mg/kg)			
	Hazard statement	Band colour	Hazard symbol	Symbols and words	Oral		Dermal	
					Solid	Liquid	Solid	Liquid
Ia Extremely hazardous	VERY TOXIC	RED		 VERY TOXIC	5 or less	20 or less	10 or less	40 or less
Ib Highly hazardous	TOXIC	RED		TOXIC	5-50	20-200	10-100	40-400
II Moderately hazardous	HARMFUL	YELLOW		 HARMFUL	50-500	200-2000	100-1000	400-4000
III Slightly hazardous	CAUTION	BLUE		CAUTION	>500	>2000	>1000	>4000
Products unlikely to present a hazard in normal use		GREEN			>2000	>3000		

Source: The WHO recommended classification of pesticides by hazard and guidelines to classification 1994-1995. International Programme on Chemical Safety (WHO/PCS/94.2), Geneva

All new pesticides are tested for the determination of the type of toxicity and the dose necessary to produce a measurable toxic reaction. Strict testing procedures are maintained to compare the results of toxicity tests done in different laboratories. Toxicity testing is extensive as it involves several steps and, therefore, expensive. Humans, obviously, cannot be used as test subjects, so toxicity testing is done with animals and plants. Since different species of animals respond differently to chemicals, a new chemical is generally tested in mice, rats, rabbits, and dogs. The results of these toxicity tests are used to predict the safety of the new chemical to humans. The WHO recommended pesticide classification by hazard was approved by the 28th World Health Assembly in 1975. In December 2002 the United Nations Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonised System of Classification and Labelling of Chemicals (UNCETDG/GHS) approved a document called 'The Globally Harmonised System of Classification and Labelling of Chemicals' with the intent to provide a globally-harmonised system (GHS). This classification is based on toxicological parameters, viz. LD_{50 acute, oral, rat} and LD_{50 acute, dermal, rat}. According to this classification, a very few of the herbicides registered in India is dangerous or highly hazardous

(Table 9.2). Recently introduced low-dose and high-potency herbicides are toxicologically more acceptable.

Table 9.2 Toxicity rating of herbicides

Name	Formulation	LD ₅₀ , acute, oral, rat (mg/kg)	LD ₅₀ , acute, dermal, rat (mg/kg)
2,4-Dichlorophenoxy acetic acid	sodium salt: 80% WP, amine salt: 22.5% SL, 58% SL, ethyl ester: 38% EC, 20% WP, 4% Gr	375 (amine salt) 700 (ethyl ester) 500-805 (sodium salt)	>2000
Acetochlor	90% EC	1929	>2000
Alachlor	50% EC, 25% EC, 10% Gr	930-1350	>13300
Anilophos	30% EC, 18% EC, 2% Gr 60% LC	470-830	>2000
Atrazine	50% WP	1870-3100	>3100
Benthiocarb/Thiobencarb	50% EC, 10% Gr	920-1300	>2000
Bensulfuron-methyl	80% DF	>5000	>2000
Bispyribac-sodium	10% SC	4111	>2250
Butachlor	50% EC, 5% Gr, 50% EW	2000	>13000
Carfentazone-ethyl	40% DF	5000	>4000
Chlorimuron-ethyl	25% WP	>4102	>2000
Cinmethylen	10% EC	4553	>2000
Clodinafop-propargyl	15% WP	1829	>2000
Clomazone	50% EC	2077	>2000
Cyhalofop-butyl	10% SC	>5000	>2000
Diclofop-methyl	28% EC	563-693	>2000
Diclosulum	84% WDG	>5000	>2000
Dithiopyr	12% EC	>5000	>5000
Diuron	80% WP	3400	>2000
Ethoxysulfuron	15% WDG	3270	>5000
Fenoxaprop-P-ethyl	10% SC, 9.39% SC	304	>2000
Fluazifop-P-butyl	9% EC	3680	>2110
Fluchloralin	45% EC	>6400	>10000
Flufenacet	60% WP	589	>2000
Glufosinate-ammonium	15% SL	1620-2000	>4000
Glyphosate	41% SL	3680	>5000
Halosulfuron	75% WG	1287	>5000
Hexazinone	75% WDG	1690	>5278
Imazethapyr	10% EC/SL	>5000	>2000
Imazamox	12% SL	>5000	>4000
Isoproturon	75% WP, 50% WP	1826-3600	>2000
Linuron	50% WP	4000	>2000
Mesosulfuron-methyl + Methabenzthiazuron	0.6% WDG 70% WP	>5000 5000	>2000 >5000
Methyl chlorophenoxy acetic acid (MCPA)	40% SL	1160	>4000
Metolachlor	50% EC	2780	>2000
Metribuzin	70% WP	>2000	>20000
Metsulfuron-methyl	20% WP	>5000	>2000
Orthosulfamuron	50% WG	>5000	>5000
Oxadiargyl	80% WP, 6% EC	>5000	>2000
Oxadiazon	25% EC	>8000	>2000
Oxyfluorfen	23.5% EC, 0.33% Gr	>5000	>5000
Paraquat dichloride	24% SL	150	235-500
Pendimethalin	30% EC, 20% EC, 5% Gr	1050-1250	>5000
Pretilachlor	50% EC, 30% EC	6099	>3964
Pinoxaden	5% EC	>5000	>2000
Propanil	35% EC	>2500	>2000
Propaquizafop	10% EC	5000	>2000

Safety Standards

Name	Formulation	LD ₅₀ , acute, oral, rat (mg/kg)	LD ₅₀ , acute, dermal, rat (mg/kg)
Pyrazosulfuron-ethyl	10% WP	>5000	>2000
Pyrithiobac-sodium	10% EC	4000	>2000
Quizalofop-ethyl	5% EC	1670	>5000
Quizalofop-P-tefuryl	4.41% EC	1012	>5000
Sulfosulfuron	75% WDG	>5000	>5000
Tembotrione	34.4% SC	>2000	>2000
Topramezone	33.6% SC	>2000	>4000
Triallate	50% EC	1100	>8200
Tribenuron	10% EC	>5000	>5000
Trifluralin	48% EC	>10000	>2000
Chlorimuron-ethyl + Metsulfuron-methyl	10+10% WP	>4000	>2000
Anilophos + 2,4-D ethyl ester	56% EC	>500	not available
Bensulfuron + Pretilachlor	6.0 + 0.6 % Gr	>5000	>2000
Sulfosulfuron +Metsulfuron-methyl	75 + 5% WG	not available	not available
Pendimethalin + Imazethapyr	30 + 2% EC	>5000	not available
Diuron + Hexazinone	46.8 + 13.2% WP	2073	>5000
Anilophos + Ethoxysulfuron	25 + 1% WP	>500	not available
Clomazone + 2,4-D	20 + 30% EC	>500	not available
Clodinafop-propargyl + Metsulfuron-methyl	15 + 11% WP	>5000	not available
Imazamox + Imazethapyr	35 + 35% WG	not available	not available

Pesticides invariably leave varying amounts of residues in the treated crop. The time for which the residues of pesticide are retained in the treated substrate, is referred to as its persistence. The persistence of these residues is required to give protection to the crop up to a certain period of time. Pesticide residues responsible for keeping the pests away can be hazardous too. High residue may result from either higher dosages or application of the pesticide at the wrong time or both. The term 'pesticide residues' usually means the remnant of the applied pesticide together with its toxic metabolic product(s) and impurities, if any, in a given substrate at a given time after its use. Pesticide residues may be harmful for us depending on their toxicological properties and the degree of exposure to these residues. Therefore, to avoid the harmful effect, there should be a well defined limit or level of pesticide residues present in food commodity. That level of residues is called 'Maximum Residue Limit (MRL)'. The Codex Alimentarius defines MRL as 'the maximum concentration of a pesticide residue that is recommended by the Codex Alimentarius to be legally permitted in or on food commodity'. These limits are proposed by the FAO/WHO Joint Meetings on Pesticide Residues (JMPR) in a series of reports and are based on an estimate of the maximum residue levels expected following Good Agricultural Practices (GAP) and consideration of the Acceptable Daily Intake (ADI) for the pesticide in question. The MRL at harvest for a particular crop/pesticide combination is determined from a series of carefully designed, supervised field trials that represent a wide variety of good agricultural practices. Recently, Food Safety and Standards (contaminants, toxins and residues) Regulations, Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, GOI has developed MRL values of some herbicides in different crop commodities (Table 9.3).

Table 9.3 FSSAI-defined MRL values of some herbicides

Herbicide	Commodity	MRL (mg/kg)	Herbicide	Commodity	MRL (mg/kg)
2,4-D	Foodgrains	0.01	Sulfosulfuron	Wheat	0.02
	Milled foodgrains	0.003	Trifluralin	Wheat	0.05
	Potatoes	0.2	Ethoxysulfuron	Rice	0.01
	Milk and milk products	0.05	Metolachlor	Soybean Oil	0.05
	Meat and poultry	0.05	Glyphosphate	Tea	1.0
	Eggs (shell freebasis)	0.05	Linuron	Pea	0.05
	Fruits	2.0	Oxyfluorfen	Rice Groundnut Oil	0.05 0.05
Paraquat dichloride (determined as paraquat cations)	Food grains	0.1	Butachlor	Rice	0.05
	Milled food grains	0.025	Chlorimuron-ethyl	Wheat	0.05
	Potato	0.2	Diclofop -methyl	Wheat	0.1
	Other vegetables	0.05	Metribuzin	Soybean Oil	0.1
	Cotton seed	0.2	Pendimethalin	Wheat Rice Soybean Oil Cotton seed Oil	0.05 0.05 0.05 0.05
	Cottonseed oil (edible refined)	0.05	Pretilachlor	Rice	0.05
	Milk (whole)	0.01	Metasulfuron-methyl	Wheat	0.1
Fruits	0.05	Methabenz-thiazuron	Wheat	0.5	
Atrazine	Maize	Nil	Imazethapyr	Soybean oil Groundnut oil	0.1 0.1
	Sugarcane	0.25	Triallate	Wheat	0.05
Simazine	Maize	Nil	Isoproturon	Wheat	0.1
	Sugarcane	0.25	Glufosinate-ammonium	Tea	0.01
Alachlor	Cotton Seed	0.05			
	Groundnut	0.05			
	Maize	0.10			
	Soybeans	0.10			
Diuron	Cotton Seed	1.00			
	Banana	0.10			
	Maize	0.50			
	Citrus (Sweet Orange)	1.00			
	Grapes	1.00			
Fluchloralin	Cotton Seed	0.05			
	Soybeans	0.05			
Cyhalofop-butyl	Rice	0.5			
Anilophos	Rice	0.1			
Fenoxypop-P-ethyl	Wheat	0.02			
	Soybean seed	0.02			
Methyl chlorophenoxyacetic acid (MCPA)	Rice	0.05			
	Wheat	0.05			

Safety Standards

Herbicide	Commodity	MRL (mg/kg)	Herbicide	Commodity	MRL (mg/kg)
Clodinafop-propanil	Wheat	0.1	Quizalofop-ethyl	Soybean seed	0.05
Cymoxanil	Grapes	0.1	Oxadiargyl	Rice	0.1
Clomazone	Rice	0.01	Pyrazosulfuron-ethyl	Rice	0.01
	Soybean seed	0.01			
	Soybean seed oil	0.01			

Source: Food Safety and Standards (contaminants, toxins and residues) regulations, 2011, Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, Government of India

10. Herbicide Poisoning and First Aid

Many modern herbicides kill weeds selectively by impairing metabolic processes that are unique to plant life. For this reason, their systemic toxicities in mammals are generally low. However, some herbicides pose a significant risk of poisoning if handled carelessly, and many are irritating to eyes, skin, and mucous membranes (Table 10.1).

Table 10.1 Herbicides and their poisoning symptoms

Chemical class	Generic name	Known or suspected adverse effects
Acetamides	Metolachlor	Irritant to eyes and skin
Aliphatic acids	Trichloroacetic acid (TCA), Dichloropropionic acid (Dalapon)	Irritant to skin, eyes, and respiratory tract
Chlorophenoxy aliphatic acid	2,4-Dichlorophenoxyacetic acid	Irritant to lung, stomach and intestinal linings Injure liver, kidney, and nervous system
Anilides	Alachlor Propachlor Propanil	Mild irritant Dermal irritant and sensitizer Irritating to skin, eyes, and respiratory tract
Benzoic, anisic acid. derivatives	Trichlorobenzoic acid, Dicamba	Moderately irritating to skin and respiratory tract
Benzonitriles	Dichlobenil	Minimal toxic, irritant effects
Benzothiadiazinone dioxide	Asulam, Terbutcarb, Butylate, Cycloate, Pebulate, Vernolate, EPTC, Diallate, Triallate, Thiobencarb	Some are irritating to eyes, skin, and respiratory tract, particularly in concentrated form. Some may be weak inhibitors of cholinesterase
Cyclohexenone derivative	Sethoxydim	Irritant to skin and eyes
Dinitroaminobenzene derivative	Butralin, Pendimethalin, Oryzalin	May be moderately irritating. These herbicides do not uncouple oxidative phosphorylation or generate methemoglobin.
Fluorodinitrotoluidine compounds	Benfluralin, Dinitromine, Ethalfuralin, Fluchloralin, Profluralin, Trifluralin	May be mildly irritating. These herbicides do not uncouple oxidative phosphorylation or generate methemoglobin
Isoxazolidinone	Clomazone	May be moderately irritating
Nicotinic acid isopropylamine derivative	Imazapyr	Irritant to eyes and skin
Phosphonates	Glyphosate	Irritating to eyes, skin, and respiratory tract
Triazines	Ametryn, Atrazine, Cyanazine, Desmetryn, Metribuzin, Prometryn, Propazine, Simazine, Terbutylazine, Tertutryn Prometon	Systemic toxicity is unlikely unless large amounts have been ingested. Some triazines are moderately irritant to the eyes, skin, and respiratory tract Prometon is strongly irritating to eyes, skin, and respiratory tract
Triazole	Amitrole, Aminotriazole	Minimal systemic toxicity. Slight irritant effect
Sulfonyl urea	Chlorimuron-ethyl, Sulfosulfuron, Halosulfuron, Triasulfuron, Metsulfuron-methyl, Ethoxysulfuron, Sulfometuron-methyl	Systemic toxicity is unlikely unless large amounts have been ingested
Urea derivatives	Chlorotoluron, Diuron, Flumeturon, Isoproturon, Linuron, Methabenzthiazuron	Many substituted ureas are irritating to eyes, skin, and mucous membranes
Bipyridylium	Paraquat, Diquat	Strongly irritant to eyes, skin, and respiratory tract

Adopted from Pesticide Safety Education Program (PSEP), Cornell University; Reigart and Roberts (1999)

Treatment

Pesticide poisoning can affect the body in two ways: it can cause a local reaction when a pesticide comes into contact with exposed parts of the skin or eye, or it can be absorbed into the body and cause a systemic reaction.

Skin decontamination:

Skin contamination should be treated promptly by washing with soap and water. Contamination of the eyes should be treated immediately by prolonged flushing of the eyes with large amounts of clean water. If dermal or ocular irritation persists, medical attention should be obtained without delay.

Gastrointestinal decontamination:

Ingestions of these herbicides are likely to be followed by vomiting and diarrhea due to their irritant properties. Management depends on: (1) the best estimate of the quantity ingested, (2) time elapsed since ingestion, and (3) the clinical status of the subject. Some general measures should be adopted to prevent absorption of the poison. Activated charcoal at the rate of 50 g in 400 mL water may be useful when administered as an absorbant for pesticide remaining in intestinal tract in a dose of 5 mL/kg body weight orally or by gastric lavage. According to the need, this gastric lavage may be repeated. For elimination of toxic substances from the bowel a cathartic such as sodium sulfate or magnesium sulfate at a dose of 30 g in 250 mL of water may be administered by mouth. The quantity of the liquid given should not exceed 50 mL/10 kg body weight. Dehydration and electrolyte disturbances may be severe enough to require oral or intravenous fluids.

There are no specific antidotes for poisoning by these herbicides. In the case of suicidal ingestions, particularly, the possibility must always be kept in mind that multiple toxic substances may have been swallowed. If large amounts of herbicide have been ingested and the patient is seen within an hour of the ingestion, gastrointestinal decontamination should be considered. If the amount of ingested herbicides was small, if effective emesis has already occurred, or if treatment is delayed, administer activated charcoal and sorbitol by mouth.

Intravenous fluids:

Excessive vomiting and diarrhea may cause serious dehydration and electrolyte depletion. In that case, blood electrolytes and fluid balance should be monitored and intravenous infusions of glucose, normal saline, Ringer's solution, or Ringer's lactate should be administered to restore extracellular fluid volume and electrolytes. Oral nutrients may be given as soon as fluids can be retained.

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Manufacturing and Marketing Units of Herbicides in India

Company and address	Product
Agrichem (India) Pvt. Ltd. Sagar Plaza-2, UG-14, Saint Nagar Delhi, Rani Bagh, Pitampura, New Delhi, 110034 Ph: 011- 2701 6889 E-mail: agrichem_india@yahoo.com	2,4-D sodium salt 80% WP, 2,4-D amine salt 58% SL, Anilophos 30% EC, Butachlor 50% EW, Glyphosate 41% SL, Imazethapyr 10% SL, Metsulfuron-methyl 20% WP, Pendimethalin 30% EC, Pretilachlor 50% EC, Sulfosulfuron 75% WG
Akruti Trexim Pvt. Ltd. 18, Samta Colony, Raipur - 492 001, Chhattisgarh Ph: 0771-2255667, 4009996, 4009997 Fax: 0771-2255997	Weed Killer (2,4-D sodium salt 80% WP)
AIMCO Pesticides Ltd. Akhand Jyoti, 8 th Road, Santacruz (East), Mumbai-400055 Ph: 022-6760 4000 Fax: 022-6760 4060/ 6760 4070 E-mail: aimco@aimcopesticides.com	Aimchlor (Butachlor 50% EC)
Andu Mineral Industries Pvt. Ltd. Jessore Road, Madhyamgram, North 24 Parganas	Gamachlor (Butachlor 50% EC)
Anu Products Limited 23/23B EMCA House Ansari Road, Darya Ganj, New Delhi-110002 Ph : 011-23261603,23260995,23284900 Fax :011-23284800 E-mail :anu.apl@vsnl.com Web :www.anuproducts.in	Mahan 580 (2,4-D amine salt 58% SL), Anuweed (2,4-D ethyl ester 38% EC), Anugaurd (Anilophos 30% EC), Anutaf (Atrazine), Anuchlor (Butachlor 50% EC), Anuchlor (Butachlor 5% Gr), Fastest (Butachlor 50% EW), Anulin (Fluchloralin), Clear out (Glyphosate 41% SL), Anulon (Isoproturon 75% WP), Mohra (Metribuzin), Anustorm (Pendimethalin 30% EC), Ginny (Paraquat dichloride 24% SL) dichloride 24% SL Mahan 580 (2,4-D amine salt 58% SL), Preeti (Pretilachlor 50% EC), Anustorm (Pendimethalin 30% EC), Mohra (Metribuzin 70% WP), Nirala (Clodinafop-propargyl 15% WP), Kamaal (Sulfosulfuron 75% WG), Viva (Oxyfluorfen 23.5% EC), Metro (Metsulfuron-methyl 20% WP), Nupyr (Imazethapyr 10% SL), Propy Super (Fenoxaprop-P-ethyl 9.3% EC), Anulin (Fluchloralin), Anulon (Isoproturon)
Aristo Biotech & Life Science Pvt. Ltd. 4, Neel Orchid, Sector-10, Navi Mumbai-410206 Ph: 02667-264841 / 2 / 3 E-mail: aristobaroda@yahoo.in	Butachlor 50% EC, Butachlor 50% EW, Butachlor 5% Gr, Glyphosate 71% SG, Popular (Glyphosate 41% SL), Glyphosate technical 95% and 20.2% SL, Paraquat dichloride 24% SL, Isoproturon 75% WP, Pendimethalin 30% EC, Clodinafop-propargyl (Piroxofop propanyl) 15% WP and technical, Pretilachlor 50% EC, Pretilachlor 37% EW and technical, Sulfosulfuron 75% WG, Metsulfuron- methyl 20% WP, 2,4-D amine salt 58% SL, 2,4-D ethyl ester 38% EC, Metribuzin 70% WP, Fenoxaprop-P-ethyl 9.3% EC, Fluazifop-P-butyl 13.4% EC, Cyhalofop-butyl 10% EC
Atul Ltd. P.O. - Atul, Dist - Valsad, Gujarat - 396020. Ph: 02632-230000,233261 Fax: 02632-233024,233619 E-mail: atul_ho@atul.co.in	2,4-D acid, 2,4-D amine salt 48% SL, 2,4-D amine salt 50% SL, 2,4-D dimethylamine salt, 2,4-D ethyl ester, 2,4-D ethylhexyl ester, 2,4-D isobutyl ester, Chlorimuron-ethyl, Clodinafop-propargyl, Clodinafop- propargyl 8% EC, Coneo (Glyphosate isopropyl ammonium salt 41% SL), Coneo 71 (Glyphosate ammonium salt 71% SG), Covo (Metsulfuron-methyl 20% WP), Cyno (Chlorimuron-ethyl 25% WP), Irio (Butachlor 50% EW), Loxo (Sulfosulfuron 75% WG), MCPA, Melina (Fenoxaprop-P-ethyl 9.3% EC),

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Company and address	Product
	Metsulfuron-methyl, Rugo (2,4-D ethyl ester 38% EC), Rymix (Metsulfuron- methyl 10% + Chlorimuron-ethyl 10% WP), Salix (2,4-D sodium salt 80% WP), Sulfosulfuron, Thifensulfuron-methyl, Tribenuron-methyl, Vinia (Pretilachlor 50% EC), Vitis (Clodinafop-propargyl 15% WP), Xyris (Pendimethalin 30% EC), Zura (2,4-D amine salt 58% WSC), Zura 22.5 (2,4-D amine salt 22.5% SL)
BASF India Limited Plot 37, Chandivali Farm Road, Chandivali, Andheri (East), Mumbai - 400 072, Maharashtra Ph: 022 2858 0200 Fax: 022 2858 0398 E-mail: basfcc@vsnl.net	Cinmethylen (Argold), Basalin (Fluchloralin), Imazethapyr (Persuit), Stomp and Stomp Xtra (Pendimethalin 30% EC), Prowl (Pendimethalin 5% Gr), Valor (Imazethapyr + Pendimethalin)
Bayer CropScience Ltd. Central Avenue, Hiranandani Estate, Thane (West) - 400607, Maharashtra Ph: 022- 2531 1234 Web: http://www.bayer.co.in/	Arozone (Anilophos 30% EC), Rico (Anilophos 18% EC), Bulk (Anilophos 60% LC), Arozone (Anilophos 2% Gr), Adora (Bispyribac-sodium), Bilchlor (Butachlor), Eloxan (Diclofop-methyl), Klass (Diuron), Sunrice (Ethoxysulfuron), Puma Power (Fenoxaprop-P-ethyl 10% EC), Weepsuper (Fenoxaprop-P-ethyl 9.3% EC) Ricestar (Fenoxaprop-P-ethyl 6.9% EC), Basta and Liberty (Glufosinate-ammonium), Prepare (Glyphosate 41% SL), Urgent SG (Glyphosate 71% SC), Bilon and Erelon (Isoproturon 75% WP), Tolcan and Erelon (Isoproturon 50% WP), Atlantis (Mesosulfuron-methyl + Iodosulfuron-methyl sodium), Tribunil (Methabenzthiazuron), Sencor (Metribuzin), Topstar (Oxadiargyl 80% WP), Raft (Oxadiargyl 6% EC), Ronster (Oxadiazon), Goal (Oxyfluorfen), Clean (Trifluralin), Arozone D (Anilophos + 2,4-D ethyl ester), Rice guard (Anilophos + Ethoxysulfuron)
Bharat Insecticides (Bharat Group) 1501, Vikram Tower, Rajendra Place, New Delhi-110008 Ph:41538383,43661111; Fax:011-25727781, 43661100 Email: info@bharatgroup.co.in	Penda (Pendimethalin 30% EC)
Bharat Rasayan Limited (Bharat Group) 1501, Vikram Tower, Rajendra Place, New Delhi-110008 Ph:41538383,43661111; Fax:011-25727781, 43661100 E-mail: info@bharatgroup.co.in	Weed out (2,4-D amine salt 58% SL), Anilocide and Quatar (Anilophos), Tofa (Atrazine), Butacid and Guru (Butachlor 50% EC), Superfirst (Butachlor 50% EW), Root Out (Glyphosate 41% SL), Andhi 71% (Glyphosate 71% SC), Shikhor (Imazethapyr), Isolon and Ghashmar (Isoproturon 75% WP), Isolon (Isoproturon 50% WP), Zero weed (Metribuzin), Bilgrip (Metsulfuron-methyl), Errant (Pretilachlor 50% EC), Errant-N (Pretilachlor 30.7% EC), Wazir (Sulfosulfuron),
Biostadt India Ltd. Poonam Chambers, 'A' Wing, 6th Floor, Dr. A. B. Road, Worli, Mumbai - 400 018. Ph: 022-6652 0520 E-mail: corporate@biostadt.com	Brake (Glyphosate 41% SL), Dhwanish (Atrazine 50% WP), Ingold (Oxyfluorfen 23.5% EC), Jodi (Imazethapyr 35% + Imazamox 35% WG), Maachis (Clodinafop-Propargyl-15% WP), Metgrip (Metsulofuron-methyl 20% WDG), Nanchaku (Pyriithiobac-sodium 10% EC), Parq (Paraquat Dichloride 24% SL), Remove (Pretilachlor 50% EC), Security (Imazethapyr 10% SL)

Company and address	Product
Chemtura Chemicals India Pvt. Ltd. C-6, 7 and 8 UPSIDC Industrial Area, Gajraula, UP Ph : 05924-253458,254495, 254595 Fax: 05924-253458	Moolah (Clodinafop-propargyl), Rango (Quizalofop-P- tefuryl)
Coromandel International Limited Coromandel House, Sardar Patel Road, Secunderabad - 500 003, Telangana Ph: 040 27842034 Fax: 040 27844117	Delchlor (Butachlor 50% EC), Delchlor (Butachlor 5% Gr), Skipper (Clodinafop-propargyl), Glycor (Glyphosate 41% SL), Killshot ((Glyphosate 71% SG), Pyramox (Imazamox + Imazethapyr), Cormix (Chlorimuron-ethyl + Metsulfuron-methyl), Fervent (Imazethapyr), Delkron (Isoproturon 75% WP), Grometri (Metribuzin), Weedax (Paraquat Dichloride 24% SL), Eezykill (Pendimethalin 30% EC), Pilot and Lorette (Pretilachlor 50% EC)
Crystal Crop Protection Pvt. Ltd. B-95, Wazirpur Industrial Area, Wazirpur, Delhi-110052, India Tel: 011-49007100, +91-11-27006800 Fax: 011-49007200 E-mail : info@crystalcrop.com	Cut Out (2,4-D sodium salt 80% WP), Cut out and Cut Short (2,4-D ethyl ester 38% EC), Cut Out (2,4-D ethyl ester 4.5% Gr), Anilon and Aniloshree (Anilophos 30% EC), Sreejon and Reed off (Atrazine), Bumper and Topper (Butachlor 50% EC), Bumper (Butachlor 5% Gr), Falone (Chlorimuron-ethyl), Rider (Fenoxaprop-P-ethyl 10% EC), Cleanton (Glyphosate 41% SL), Sreelon and Kripan (Isoproturon 75% WP), Shreecor and Tidemetri (Metribuzin), Rado and Algo (Metsulfuron-methyl), Penadril (Pendimethalin 30% EC), Sift and Growfit (Pretilachlor 50% EC), Razor or Kripon (Sulfosulfuron 75% WDG)
Dara Chemical Industries Ltd. C-123, Basement, Lajpat Nagar-1, New Delhi, 110024 Ph: 011- 2633 2290 E-mail: darachemical@rediffmail.com	Weed burn (2,4-D amine salt 58% SL), Strong (Anilophos 30% EC), Darachlor (Butachlor 50% EC), Butachlor (Butachlor 5% Gr), Dararon (Isoproturon 75% WP)
Devidayal (Sales) Ltd. (Acquired by Arysta LifeScience India Pvt. Ltd.) 123/124,Mittal Chamber, 12 th Floor, Nariman Point , Mumbai-400021 Ph: 022-61843333 E-mail: bombay@devidayalagro.com	Safaya (2,4-D sodium salt 80% WP), Electron (2,4-D ethyl ester 38% EC), Foster (Anilophos 30% EC), Attack (Atrazine), Betaten (Butachlor 50% EC), Devi Slash (Fenoxaprop-P-ethyl 10% EC), Gladiator (Glyphosate 41% SL), Flight (Fluchloralin), Isoproturon (Isoproturon 75% WP), Isoproturon (Isoproturon 50% WP), Encor (Metribuzin), Profit (Pretilachlor 50% EC), Safari (Sulfosulfuron 75% WDG)
Dhanuka Agritech Limited 14th Floor, Building 5A, DLF Cyber Terrace, Cyber City, DLF Phase III, Gurgaon- 122002, Haryana Ph: 0124-3838500 E-mail: headoffice@dhanuka.com	Weedmar-80 (2,4-D sodium salt 80% WP), Amine ester (2,4-D 58% SL), Weedmar (2,4-D 38% EC ethyl ester), Alachlor (Alachlor), Anilodhan (Anilophos 30% EC), Dhanuzine (Atrazine), Dhanuchlor (Butachlor 50% EC), Dhanuchlor (Butachlor 5% G), Don mix (Butachlor 50% EW), Curin (Chlorimuron-ethyl), Dinofop (Clodinafop- propargyl), Wrap up (Cyhalofop-butyl), Phenox (Fenoxaprop-P-ethyl), Dhanulin (Fluchloralin), Noweed (Glyphosate), Dhanulon (Isoproturon 75% WP), Dhanulon (Isoproturon 50% WP), Dhanulin (Methabenzthiazuron), Barrier (Metribuzin), Hook (Metsulfuron-methyl), Oxykill (Oxyfluorfen), Dhanuxone (Paraquat dichloride), Dhanustomp (Pendimethalin), Crase (Pretilachlor 50% EC), Dhanustam (Propanil), Targa Super (Quizalofop), Sultop (Sulfosulfuron 75% WDG)

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Company and address	Product
Dow AgroSciences India Pvt. Ltd. (De-Nocil Crop Protection Pvt. Ltd.) 1st Floor, Block B, Gate 02, Godrej IT Park, Godrej Business District, Pirojshanagar, L.B. S. Marg, Vikhroli (West) Mumbai- 400079 Ph: 02356-272034-40 Fax: 02356-272042, 272310	Ricil (Anilophos 30% EC), Cleancher (Cyhalofop-butyl), Weedoff (Glyphosate 41% SL), Nocilon (Isoproturon 75% WP)
ECI Agro Chem. Pvt. Ltd. Udayrajpur (East), North 24 Parganas, West Bengal	Estachlor (Butachlor 50% EC), Estachlor (Butachlor 5% Gr), Imetar (Metribuzin), Giant (Pretilachlor 50% EC)
E.I.D. Parry (India) Ltd. Dare House, New No.2, Old 234, NSC Bose Road, Chennai - 600 001. Ph: 044-2530 6789 (60 Lines) Fax : 044-2534 0858 Web: http://www.eidparry.com	Surya (Anilophos 30% EC), Atrazine (Atrazine), Isoper (Isoproturon 75% WP), Pilot (Pretilachlor 50% EC)
Excel Crop Care Limited 13/14 Aradhana Industrial Development Corporation, Near Virwani Industrial Estate, Goregaon East, Mumbai - 400063 Ph:022- 42522200 Fax:022- 42522380 Web: http://www.excelcropcare.com	Weedcel Super (2,4-D amine salt 58% SL), Atracel (Atrazine), Cyhalofop-butyl (Cyhalofop-butyl), Glycel (Glyphosate 41% SL), Excel Meera 71 (Glyphosate 71% SC), Take-5 (Glyphosate 5% SL), Gamboy (Glyphosate 20.2% SL), Metex (Metribuzin), Excel Plus (Pendimethalin 30% EC), Excel merit (Pretilachlor 50% EC), Excel-Lolkar (Sulfosulfuron)
FIL Industries Limited H-88, The South Mall, South Extension - I New Delhi - 110049 Ph: 011- 24620505 / 0707 / 0808, 011- 24605600 Fax: 011-24633874 / 24646551 E-mail: admin@filindustrieslimited.com	Agni (2,4-D ethyl ester 38% EC), Anilex (Anilophos 30% EC), SMP (Atrazine), Finish (Butachlor 50% EC), Finish granule (Butachlor 5% Gr), Miracle (Isoproturon 70% WP), Century (Metribuzin), Volt (Metsulfuron-methyl), Alto (Oxyfluorfen), Pretil (Pretilachlor 50% EC)
FMC India Private Ltd. Embassy Star (1st Floor), No. 8, Palace Road, Bangalore - 560052. Ph: 080-40099300 /388 Fax: 080-22385255 / 080-40099360 Web: http://www.fmc.in	Affinity (Carfentrazone-ethyl), Carfentrazone-ethyl + Sulfosulfuron
Gharda Chemicals Ltd. Gharda House, 48 Hill Road, Bandra (W) Mumbai-400050 Ph: 022-3306 5600 (30 lines) Fax: 022-2640 4224 E-mail: ghardaho@gharda.com	Anilougourd (Anilophos 30% EC), Glyder (Glyphosate 41% SL), Isougourd (isoproturon 75% WP), Pendiguard (Pendimethalin 30% EC), Blade (Pretilachlor 50% EC), Safal (Sulfosulfuron 75% WDG), (Trifluralin), Topshort (Anilophos + 2,4-D ethyl ester).
Godrej Agrovet Pirojshanagar, Eastern Express Highway Vikhroli (E), Mumbai - 400079 Ph: 022-25188010 Fax: 022-25188485 Web: http://www.godrej.com	Anilovip (Anilophos 30% EC), Atravip (Atrazine), Butavip (Butachlor 50% EC), Weedout (Clodinafop- propargyl), Glycovip (Glyphosate 41% SL), Isovip (Isoproturon 75% WP), Metribusvip (Metribuzin), Delete (Pretilachlor 50% EC)
Gujarat Insecticides Ltd. No. 8, Darshan Society, Behind Hindu Colony, Near Stadium Circle, Commerce Six Road, Navranapura, Ahmedabad - 380009, Gujarat Ph: 080-49188731 Fax : 91-2646250116. E-mail: info@gilgharda.com	Nidan (Anilophos 30% EC), Jeet (Clodinafop-propargyl 15% WP)

Company and address	Product
Gujarat Krishi Chem Corpn. 33/3 rd Floor, Maker Chamber VI, 220, Nariman Point, Mumbai - 400021 Ph: 022- 2287 0923 E-mail: info@viavapi.org	Rainbow (Anilophos 30% EC), Vicolin (Fluchloralin), Catlus (Glyphosate 41% SL), Sonaron (Isoproturon 75% WP), Sonaron (Isoproturon 50% WP)
GSP Crop Science Pvt. Ltd. 404, Lalita Complex, Navrangpura, Ahmedabad-380009, Gujarat Ph: 079-26466580, 26449936 Fax : 079-26448872 E-mail: domestic@gspcrop.in	Xtrazine (Atrazine), Run out (Glyphosate 41% SL), Sicle (Pretilachlor 50% EC), Clear (Sulfosulfuron 75% WDG)
Hem-an Noble Biotech Laboratories Pvt. Ltd. S. C. O.-321 Sector 9, Panchkula, Haryana Ph: 0172-2567370 Fax: 0172-2590370	Eliminator (2,4-D ethyl ester 38% EC), Hemilophos (Anilophos 30% EC), Atrazide (Atrazine), Burnchlor (Butachlor 50% EC), Irador (Glyphosate 41% SL), Elemiron (Isoproturon 75% WP), Metshort (Metribuzin), Weep (Pretilachlor 50% EC), Top shot (Sulfosulfuron 75% WDG)
Heranba Industries Ltd. 101/102, Kanchanganga, Factory Lane, Borivali (W), Mumbai - 400092 Ph: 022-2898 7912 / 14, 91-22-2898 2133 / 44, 022-2898 4439 Fax: 022-2899 3948	Atrea (Atrazine), Herachlor (Butachlor 50% EC), Glory (Glyphosate 41% SL), Metro (Metsulfuron-methyl), Zinta (Pretilachlor 50% EC), Image (Sulfosulfuron)
Herbicides (India) Ltd. 13, Prakesh Apartment 5, Ansari Road, Daryaganj, New Delhi - 110002 Ph: 011 2326 0903 /23272560/23275270/27473035 Fax: 011-23267210/23267210	Champion (2,4-D amine salt 58% SL), Champion (2,4-D ethyl ester 38% EC), Avail (Anilophos 30% EC), Punch (Butachlor 50% EC), Punch (Butachlor 5% Gr), Award (Clodinafop-propargyl), True (Diuron), Super Power (Fenoxaprop-P-ethyl 10% EC), Herbilin (Fluchloralin), Wonder (Glyphosate 41% SL), Wonder (Isoproturon 75% WP), Sarpanch (Isoproturon 50% WP), Herbi Metri (Metribuzin), Herbigold (Oxyfluorfen), Don (Sulfosulfuron 75% WDG)
Hindustan Insecticides Ltd. 2 nd Floor, Core-6, SCOPE Complex , 7 Lodi Road, New Delhi-110003 Ph: 011-24361107/24368802,24362100, 24365012, 24364662 Fax: 011-24362116, 24361363 E-mail: hilhq@nde.vsnl.net.in	Hilanil (Anilophos 30% EC), Hiltachlor (Butachlor 50% EC), Hiltachlor (Butachlor 5% Gr), Trinnashi (Glyphosate 41% SL), HIL-proturon (Isoproturon 50% WP), Hilmetri (Metribuzin), HIL-Preti (Pretilachlor 50% EC)
Hindustan Pulverising Mills (Hpm Crop Science Limited) 209-210, Anupam Bhawan, Azadpur Commercial Complex, Azadpur, Delhi-110033 Ph: 011-45071800-899 Fax: 011-27681800 E-mail: info@hpmindia.com	Heera super (2,4-D sodium salt 80% WP), Heera (2,4-D amine salt 58% SL), Heera 44 (2,4-D ethyl ester 38% EC), Anilohit (Anilophos 30% EC), Atrahit (Atrazine), Biochlor and Hunter (Butachlor 50% EC), Rise (Chlorimuron-ethyl), Groundup (Glyphosate 71% SC), Cheetah (Imazethapyr 10% SL), Isohit (Isoproturon 75% WP), Isohit (Isoproturon 50% WP), MCPA amine-salt (Methyl chlorophenoxy acetic acid), Stump (Metribuzin), Freedom and Hygrip (Metsulfuron-methyl), Waada (Oxyfluorfen), Gaadar (Pendimethalin 30% EC), Hifit (Pretilachlor 50% EC), Target (Sulfosulfuron 75% WDG)
Hyderabad Chemical Ltd. A-24/25, AP.I.E., Balanagar, Hyderabad - 500 037 Andhra Pradesh Ph: 040-2377 2502 / 1849 / 2651 Fax: 040-23772595	Matin (Metribuzin 70% WP), Pendistar (Pendimethalin 30% EC), Check (Pretilachlor 50% EC)

Annexure

Company and address	Product
Indofil Industries Ltd. Kalpataru Square, 4 th floor, Kondivita Road, Opposite Andheri Kurla Road, Andheri East, Mumbai-400059 Ph: 022-66637373 Fax: 022-28322272 E-mail: indofil@modi.com	Atrafil (Atrazine), Flat (Chlorimuron-ethyl), Clean up (Glyphosate 41% SL), Chase (Metribuzin), Oxygold (Oxyfluorfen), Speed (Pendimethalin 30% EC), Offset (Pretilachlor 50% EC) Stomp F-34 (Propanil), Society (Propaquizafop), Décor (Sulfosulfuron 75% WDG)
Indogulf Fertilizer & Chem. Corpn. Ltd. 14A/5, Park Road, Lucknow-226001	Shaktiman amine ester (2,4-D amine salt 58% SL), Shaktiman butachlor (Butachlor 50% EC), Shaktiman butachlor (Butachlor 5% Gr), Shaktiman isoproturon (Isoproturon 75% WP)
Insecticides (India) Ltd. 401-402, Lusa Tower, Azadpur Commercial Complex, Delhi-110033 Fax: 011- 27679700-04	Super Hit (2,4-D sodium salt 80% WP), Twister (2,4-D amine salt 58% SL), Hit (2,4-D ethyl ester 38% EC), Anilocide and Army (Anilophos 30% EC), Millchlor (Butachlor 50% EC), Millchlor (Butachlor 5% Gr), Millfast (Butachlor 5% EW), Omega (Clodinafop 15% WP), Trick (Chlorimuron-ethyl 25% WP), Wego Super (Fenoxaprop-P-ethyl 9.3% EC), Hijack (Glyphosate 41% SL), Selector (Imazethapyr 10% SL), Milron and Skylark (Isoproturon 75% WP), Anchlor (Metribuzin), Weed Grip (Metsulfuron-methyl), Pendamil (Pendimethalin 30% EC), Racer (Pretilachlor 50% EC), Hakama (Quizalofop-ethyl 5% EC), Kaizer and Guru (Sulfosulfuron 75% WDG)
Isagro (Asia) Agrochemicals Pvt. Ltd. Unit No.1 Ground, 2 nd & 3 rd Floor, Brady Gladys Plaza, 1/447, Senapati Bapat Marg, Lower Parel, Mumbai-400013 Ph: 022-56955656 Fax: 022-56955666	Trapp (Butachlor 50% EC), Leanch (Glyphosate 41% SL), Grenade (Glyphosate 71% SC), Passport (Isoproturon 75% WP), Life-Gold (Oxyfluorfen), Dismiss (Pretilachlor 50% EC), Metsil-M (Metsulfuron-methyl)
J.U. Pesticides & Chemicals Pvt. Ltd. 14, NSC Road, Kolkata-700001	Angola (Anilophos 30% EC), (Atrazine), Cropchlor (Butachlor 50% EC), Cropchlor (Butachlor 5% Gr), Bonus (Glyphosate 41% SL), Dragon (Isoproturon 75% WP), Dragon (Metribuzin), JU-grip (Metsulfuron-methyl), Toss (Sulfosulfuron 75% WDG)
Krishi Rasayan Exports Pvt. Ltd. Block A-11, 4th Floor, FMC Fortuna, 234/3-A, A.J.C. Bose Road, Kolkata-700 020 (India) Ph: 033-22875730, 22875731, 22839454 / 22839455 Fax: 033-22871436 E-mail: kr@krishirasayan.com	K-D (2,4-D sodium salt 80% WP), K-D (2,4-D ethyl ester 38% EC), Rasayanzin (Atrazine), Rasayanchlor (Butachlor 50% EC), Rasayanchlor (Butachlor 5% Gr), Krup and Kriup (Glyphosate 41% SL), (Glyphosate 71% SC), Keturon and Krilon (Isoproturon 75% WP), Krilon (Isoproturon 50% WP), Krizine (Metribuzin), Crall (Oxyfluorfen), Stop (Pendimethalin 30% EC), Prince (Pretilachlor 50% EC)
Markfed Agro Chemicals Markfed House, Block No.4, Dakhshin Marg, Sector-35-B, Chandigarh - 160035 Ph: 0172-2660095-97, 2660161-65, 2660081, 2609470 Fax: 0172-2609471 E-mail: business@markfedpunjab.com	Markzine (Atrazine), Markchlor (Butachlor 50% EC), Marklon (Isoproturon 75% WP), Markclodina (Clodinafop)
ADAMA India Pvt. Ltd. (Previously known as Makhteshim-Agan India Pvt. Ltd.) Plot No: DS -13, IKP Knowledge Park, Sy. No. 542/2, Genome Valley, Turkapally, Shameerpet, Ranga Reddy District, Hyderabad-500078	2,4-D Agan (2,4-D sodium salt 80% WP), 2,4-D Main (2,4-D amine salt 58% WP), Atranex (Atrazine), Blumen (Chlorimuron-ethyl), Diurex (Diuron), Glyphogun (Glyphosate 41% SL), Metriagan (Metribuzin), Nikanor (Metsulfuron-methyl), Sulfomen (Sulfosulfuron 75% WDG), Pretigan (Pretilachlor 50% EC), Pretigan-S (Pretilachlor 30.7% EC)

Company and address	Product
Meghmani Industries Ltd. Plot No. 27 , Phase-I, GIDC Indl. Estate, Vatva, Ahmedabad-382445 Ph: 079-25897793, 25831050 Fax: 079-25893495, 26463999	Meghachlor (Butachlor 50% EC), Meghalon (Isoproturon 75% WP)
Monsanto India Ltd. Ahura Centre, 5th Floor, 96, Mahakali Caves Road, Andheri (East), Mumbai 400 093 E-mail: information.india@monsanto.com	Slash (2,4-D ethyl ester 38% EC), Lasso (Alachlor 50% EC), Lasso (Alachlor 10% Gr), Machete and Aristo (Butachlor 50% EC), Machete (Butachlor 5% Gr), Fastmix (Butachlor 5% EW), Roundup (Glyphosate 41% SL), Avadex-BW (Triallate)
Multiplex No. 180, 1st Main Road, Mahalakshmi Layout, Bangalore- 560086 Ph: 080 - 23497464 Fax: 080 - 23490647 E-mail: multiplex@multiplexgroup.com	Naagsol (2,4-D sodium salt 80% WP), Naagmin (2,4-D 58% SL), Nagester (2,4-D ethyl ester 38% EC), Nagzine, (Atrazine), Nagchlor (Butachlor 50% EC), Naguron (Diuron), Nagfenop (Fenoxaprop-P-ethyl), Nagflur (Fluchloralin), Nag Glypo (Glyphosate 41% SL), (Pendimethalin 30% EC), Nag Pretichlor (Pretilachlor 50% EC), Nagsuron (Sulfosulfuron 75% WDG)
Nagarjuna Agrichem Ltd. Plot No.12-A, 'C' Block, Lakshmi Towers Nagarjuna Hills, Punjagutta, Hyderabad-500082 Ph: 08942- 231172,73,74 Fax: 08942- 231171 Web: http://www.nagarjunaagrchem.com	Smash (2,4-D ethyl ester 38% EC), Smash (2,4-D ethyl ester 4.5% Gr), Anilophos (Anilophos 30% EC), Point (Clodinafop-propargyl), Globus (Glyphosate 41% SL), Norilon (Isoproturon 75% WP), Imax (Metribuzin), Dot (Metsulfuron-methyl), Rhino (Paraquat dichloride), Nagastra (Pendimethalin 30% EC), Erase (Pretilachlor 50% EC), Erase-N (Pretilachlor 30.7% EC), Erase strong (Bensulfuron + Pretilachlor)
Paushak Limited Alembic Road, Vadodara – 390 003, Gujarat Ph: 0265-2280550/2280880 Fax: 0265-2282506/2281508 E-mail: paushak@alembic.co.in	Kanak (Isoproturon 75% WP), Kanak (Isoproturon 50% WP)
PI Industries Ltd. 5 th floor, Vipul Square, B-Block, Sushant Lok, Phase-1, Gurgaon 122002, Haryana Ph.: 0124-6790000 Fax: 0124- 4081247 E-mail: pifinechem@piind.com	Nominee Gold (Bispyribac-sodium), PI Glypho (Glyphosate 41% SL), Inro (Imazethapyr), Taurus (Isoproturon 75% WP), Taurus (Isoproturon 50% WP), Bunker (Pendimethalin 30% EC), Melsa (Propanil), Sattern (Thiobencarb/Benthiocarb), Pimix (Chlorimuron-ethyl + Metsulfuron-methyl), Bingo (Imazamox+Imazethapyr)
Plant Remedies Pvt. Ltd. 15, India Exchange Place, Kolkata-700 001	Kaal (2,4-D sodium salt 80% WP), Plant 2,4-D (2,4-D ethyl ester 38% EC), Ratcheat (Butachlor 50% EC), Ratcheat (Butachlor 5% Gr), Plant Iso (Isoproturon 75% WP), Razor (Pretilachlor 50% EC)
Punjab Chemicals and Crop Protection Ltd. Oberoi Chambers II, 5th Floor, 645/646, New Link Road, Andheri (West), Mumbai-400053 Ph: 91-22-26747900. Fax: 91-22-26736193/78 E-mail: enquiry@punjabchemicals.com	PC 2,4-D (2,4-D ethyl ester 38% EC), Citra (Atrazine), Ohm (Clodinafop-propargyl), Veto (Glyphosate 41% SL), Veto Plus (Glyphosate 71% SC), Siege (Metsulfuron-methyl), Klean up (Pendimethalin 5% Gr), Klean Out (Pretilachlor 50% EC), Blanket (Sulfosulfuron 75% WDG)
Rallis India Ltd. 156/157, Nariman Bhavan, 15 th Floor, 227 Nariman Point, Mumbai-400021 Ph: 022-6665 2700 Fax: 022-6665 2860 Web: http://www.rallis.co.in	Anilotaf (Anilophos 30% EC), Atrataf (Atrazine), Taarak (Bispyribac-sodium), Teer (Butachlor 50% EC), Sartaj (Clodinafop-propargyl), Command (Clomazone), Tata Cylo (Cyhalofop-butyl), Ficol (Fenoxaprop-P-ethyl), Glytaf (Glyphosate 41% SL), Tata Vaar (Imazethapyr), Lorox (Linuron), Tata Metri (Metribuzin), Teg (Metsulfuron-methyl), Honcho (Oxyfluorfen), Paralac (Paraquat dichloride), Tata Ponida (Pendimethalin 30% EC), Tatapreet (Pretilachlor 50% EC), Fateh (Sulfosulfuron 75% WDG)

Annexure

Company and address	Product
RPC Agro Industries 3, Portuguese Church St., Kolkata-700 001	Rajchlor (Butachlor 5% Gr)
Sabero Organics Gujarat Ltd. 2102, GIDC, Sarigam-396 155, Valsad, Gujarat Ph: 0260 3918500, 0260-3918513 Fax: 0260-2780853 E-mail: sabero@quest4india.com, sabero@bom3.vsnl.net.in	Gly-weed (Glyphosate 41% SL)
Somanil Chemicals 19A, New Mandi, Muzaffarpur, - 251001, UP	Currant (Butachlor 50% EC), Somilon (Isoproturon 75% WP), Somilon (Isoproturon 50% WP)
Sulphur Mills Ltd. 404/405 604/605, 349 – Business Point Western Express Highway, Andheri(E), Mumbai – 400 069. India Ph: 022- 43452222 Fax : 022_ 43452245 E-mail: sml@sulphurmills.com	Anilon (Anilophos 30% EC), Atrasul (Atrazine), Weed out (Butachlor 50% EC), Weed out (Butachlor 5% Gr), Vinash (Glyphosate 41% SL), Proton-75 (Isoproturon 75% WP), Proton-50 (Isoproturon 50% WP), Macro (Metribuzin), Sureshot (Pretilachlor 50% EC), Arrow (Sulfosulfuron 75% WDG)
Shri Ram Agro Chemicals Near Tehsil, Chaupla, Garhroad Hapur- 245101, Uttar Pradesh Ph: 0122-2312627	Glyphos (Glyphosate 41% SL), Genious (Metribuzin), Tusker (2,4-D ethyl ester 38% EC)
Shriram Fertilizers & Chemicals 19, Kirti Mahal, Rajendra Place, New Delhi-110008 Ph: 011-25713442 Fax: 011- 25781575	Shriram Buta 50 (Butachlor 50% EC), Shriram iso 75 (Isoproturon 75% WP), Shriram atrazine (Atrazine), Shriram pretilachlor (Pretilachlor 50% EC), Shriram metribuzin (Metribuzin)
Solas Cropstech Pvt. Ltd. 36, Strand Road, 4 th Floor, Room-1, Kolkata - 700001, West Bengal	Aminosol (2,4-D amine salt 58% SL)
Sudarshan Chemical Industries Ltd. 162, Wallesley Road, Pune-411001 Ph: 020- 26058888 Fax: 020-2026058222 Web: http://www.sudarshan.com	Weedkill (Butachlor 50% EC), Josh (Isoproturon 75% WP), Jet Strike (Metribuzin), Phenom (Pretilachlor 50% EC)
Sumitomo Chemical India Pvt. Ltd. 7 th Floor, Moti Mahal, 195, J. Tata Road, Churchgate, Mumbai - 400 020 Ph: 022-22892610 Fax: 022-22892600 E-mail: newchemi@vsnl.com	Leader (Sulfosulfuron 75% WDG)
SWAL Corporation Ltd. (Formerly known as Shaw Wallace) V – Fortune Building, 4th Floor, S V Road, Near Vijay Sales, Santacruz (W), Mumbai-400054. Ph: 022-66072300 Web: http://www.swal.in	Chem-D (2,4-D sodium salt 80% WP), Chem-amine (2,4-D amine salt 58% SL), Chem-est (2,4-D ethyl ester 38% EC), Anilostar (Anilophos 30% EC), Attrastar (Atrazine), Starchlor (Butachlor 50% EC), Topple (Clodinafop-propargyl), Dryphosate (Glyphosate 41% SL), Star71 (Glyphosate 71% SC), Spur (Imazethapyr), Metstar (Metsulfuron-methyl), Swat (Paraquat dichloride), Swalpendi (Pendimethalin 30% EC), Pitla (Pretilachlor 50% EC), Unik (Sulfosulfuron 75% WDG), Sandesh (Clodinafop + Metsulfuron-methyl), SataSat (Sulfosulfuron + Metsulfuron-methyl)

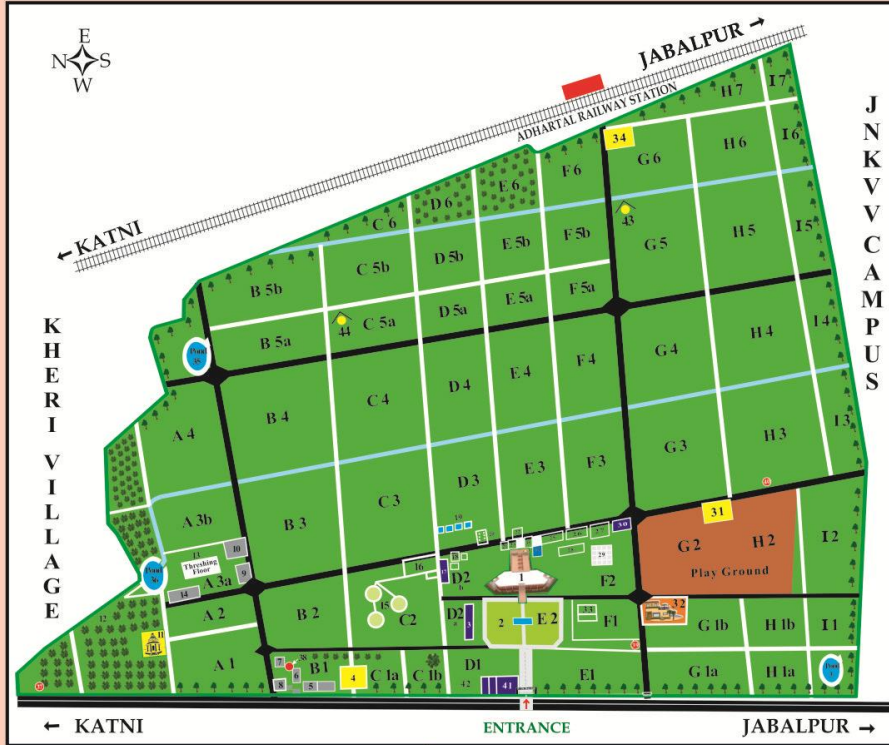
Herbicide Use in Indian Agriculture

Company and address	Product
Super Agro India Pvt. Ltd. 168/2, Lenin Sarani, Kolkata-700 013 Ph: 033-2212-6809/2212-7867 Fax: 033-2212-6809 E-mail: superai@vsnl.ne	Weedclean (Metribuzin), Wranglar (Pretilachlor 30.7% EC), Rizal (Bensulfuron + Pretilachlor)
Swaraj Pesticides Pvt. Ltd. A-61/3, Industrial Area, Sikandrabad-203205, UP	Goldiseed (2,4-D ethyl ester 38% EC), Goldchlor (Butachlor 50% EC), Goldron (Isoproturon 75% WP)
Syngenta India Ltd. Amar paragigam, Sr. no. 110/11/3, Banner Road, Banner, Pune-411045, Maharashtra Ph: 020-30699200 Fax: 020-30699480 Web: http://www3.syngenta.com/country/in	Fernoxone (2,4-D sodium salt 80% WP), Gesaprim (Atrazine), Topic (Clodinafop-propargyl), Fusilade Super (Fluazifop-P-butyl), Touch down (Glyphosate 41% SL), Graminon (Isoproturon), Dual (Metolachlor), Gramoxone (Paraquat dichloride), Pendigold (Pendimethalin 30% EC), Rifit (Pretilachlor 50% EC), Sofit (Pretilachlor 30.7% EC), Erasan (Pretilachlor 34% EW), Axial (Pinoxaden)
Tarama Industries Habul Nagar, Madhyamgram, North 24 Parganas, West Bengal	Tarachlor (Butachlor 50% EC) Tarachlor (Butachlor 5% Gr)
Tata Chemicals Ltd. Bombay House, 24 Homi Mody Street, Fort, Mumbai 400 001 Tel: 022- 6665 8282 Fax: 022- 6665 8143 / 44 E-mail: chemconnect@tatachemicals.com	TKS-Pyri (Bispyribac-sodium), TKS Buta (Butachlor 50% EC), Phosgly (Glyphosate 41% SL), TKS Pretila (Pretilachlor 50% EC)
TCM Ltd. (formerly Travancore Chemical and Mfg. Co. Ltd.) 32/1111, Snigdha, Chathangat Cross Road, Palarivattom, Cochin - 682025 Ph: 0484-540742, 540182, 541985, 541488 Fax: 0484-855202 E-mail: investorcare@tcmlimited.in	TCM 2,4-D sodium salt (2,4-D sodium salt 80% WP)
Tropical Agro System (I) Ltd. 14, N.S. Road, Kolkata-1	Kill Herb (2,4-D ethyl ester 38% EC), Kill Herb (2,4-D ethyl ester 20% WP), Allert (Alachlor), Tag guard (Anilophos 30% EC), Tagtaf (Atrazine), Thunder (Butachlor 50% EC), Thunder (Butachlor 5% Gr), Safal (Glyphosate 41% SL) Wonder (Isoproturon 75% WP), Wonder (Isoproturon 50% WP), Desire (Metribuzin)
UPL Ltd. (formerly known as United Phosphorus Limited) 11 th Road, Madhu Park, CD Marg, Khar (W), Mumbai-12 Ph: 022-604909/0226041010 Fax: 022-6049117 E-mail: info@uniphos.com	Volvo (2,4-D sodium salt 80% WP), Pearl (Atrazine), Check-out (Butachlor 50% EC), Jhatka, Cloudy (Clodinafop-propargyl), Sweep (Glyphosate 41% SL), Laskar (Metribuzine), Metsy (Metsulfuron-methyl), Uniquat (Paraquat dichloride), Saathi (Pyrazosulfuron), Sulfo and SF 10 (Sulfosulfuron 75% WDG), Irish (Sodium acefluorfen + Clodinafop-propargyl), Trident (Pretilachlor + Pyrazosulfuron-ethyl), Total (Sulfosulfuron + Metsulfuron-methyl), Vesta (Clodinafop + Metsulfuron-methyl)
Vantech Chemicals Ltd. 103 Vijaya Enclave, Plot No. 32 Srinagar Colony, Hyderabad- 500073 Ph: 040-3751855/3751877/3751458 Fax: 040 -3751452	Vanchlor (Butachlor 50% EC), Vanchlor (Butachlor 5%Gr)
Vikrant Agro Industries Muratgacha, Jugberia, N. 24 Parganas, West Bengal	Butabic (Butachlor 50% EC)
Vimal Pesticides Pvt. Ltd. Naroda, Gandhinagar, Gujarat	Thiobencarb (Thiobencarb 10% Gr)

Abbreviations

ADI: Acceptable Daily Intake	LD _{50, acute, oral} : Acute oral median lethal dose (LD ₅₀) is the dose of a substance (here herbicide) or mixture of substances, in milligrams per kilogram of test animal body weight, which, when administered orally as a single dose, produces death of 50 percent of test animals (here rats) within 14 days.
a.i.: active ingredient	
ASTM: American Society for Testing and Materials	
CIB: Central Insecticides Board	
CIB RC: Central Insecticides Board and Registration Committee	
CIF: Cost, Insurance and Freight	
CS: Capsule Suspension	
DAS: Days After Sowing	
DAT: Days After Transplanting	
DDT: Dichlorodiphenyl tetrachloroethane	
DF: Dry Flowable	
EC: Emulsifiable Concentrate	
EW: Emulsion, Oil in Water	
EPA: Environmental Protection Agency	
FAO: Food and Agricultural Organisation	
FSSAI: Food Safety and Standards Authority of India	
g: gram	
GAP: Good Agricultural Practices	
GOI: Government of India	
Gr: Granule	
ha: hectare	
HN: Hot fogging concentrate	
HRAC: Herbicide Resistance Action Committee	
JMPR: Joint FAO/WHO Meetings on Pesticide Residues	
kg: kilo gram	
kL: kilo litre	
L: Litre	
	LD _{50, acute, dermal} : Acute dermal median lethal dose (LD ₅₀) is the dose of a substance (here herbicide) or mixture of substances, in milligrams per kilogram of test animal body weight, which, when administered through skin as a single dose, produces death of 50 percent of test animals (here rats) within 14 days.
	mL: milli litre
	MRL: Maximum Residue Limit
	Post-em: Post-emergence
	Pre-em: Pre-emergence
	SAU: State Agricultural University
	SC: Suspension Concentrate
	SG: Water Soluble Granule
	SL: Soluble Concentrate
	t: tonne
	UTs: Union Territories
	UNCETDG/GHS: United Nations Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonised System
	w/v: weight by volume
	w/w: weight by weight
	WG/WDG: Water Dispersible Granules
	WHO: World Health Organisation
	WP: Wettable Powder
	WSC: Water Soluble Concentrate
	WSSA: Weed Science Society of America

निदेशालय परिसर मानचित्र DWR CAMPUS MAP



प्रशासनिक भवन	1	Administrative Building
फव्वारा एवं उद्यान	2	Fountain & Lawn
कार पार्किंग	3	Car Parking
प्रक्षेत्र भण्डार - 1	4	Farm Store-1
कार्यशाला	5	Workshop
ट्रेक्टर शेड	6	Tractor Shed
प्रक्षेत्र अनुभाग	7	Farm Section
मनोरंजन सदन	8	Recreation Club
प्रक्षेत्र भण्डार - 2	9	Farm Store-2
वर्मिकम्पोस्ट इकाई	10	Vermicompost Unit
बागदाना बाबा मंदिर	11	Bagdana Baba Temple
बागान	12	Orchard
खलिहान	13	Threshing Floor
उपकरण शेड	14	Implement Shed
फेस सुविधा	15	FACE Facility
कंटेनमेंट सुविधा	16	Containment Facility
फील्ड प्रयोगशालाएँ	17	Field Laboratories
इनसेक्टरी	18	Insectory
मत्स्य संवर्धन कुण्ड	19	Fish Culture Pond
लाईसीमीटर	20	Lysimeter
रिप्रोग्राफिक यूनिट	21	Reprographic Unit
ओ.टी.सी. यूनिट	22	OTC Unit
कार्बन डाय ऑक्साइड चेंबर	23	CO ₂ Chamber

केन्द्रीय भण्डार	24	Central Store
पॉली हाउस	25	Poly House
नेट हाउस - 1	26	Net House-1
जलीय प्लेटफार्म	27	Aquatic Platform
नेट हाउस - 2	28	Net House-2
खरपतवार केफेटेरिया	29	Weed Cafeteria
विद्युत उपकेंद्र	30	Electric Substation
क्रीडांगन	31	Play Ground
निदेशक आवास	32	Director's Residence
जलीय खरपतवार होज़	33	Aquatic Weed Tank
फायटोरेमेडिएशन इकाई	34	Phytoremediation Unit
तालाब - 1	35	Pond-1
तालाब - 2	36	Pond-2
ट्यूब वेल नं. 3	37	Tube Well No. 3
ट्यूब वेल नं. 2	38	Tube Well No. 2
ट्यूब वेल नं. 1	39	Tube Well No. 1
ट्यूब वेल नं. 4	40	Tube Well No. 4
सुरक्षा चौकी	41	Security Office
विक्रय केंद्र एवं एस बी आई एटीएम	42	Sale Counter & SBI ATM
पर्यवेक्षण टॉवर - 1	43	Watch Tower-1
पर्यवेक्षण टॉवर - 2	44	Watch Tower-2
दुपहिया स्टैंड	45	Two Wheeler Stand
तालाब - 3	46	Pond-3

**भा कृ अनु प - खरपतवार अनुसंधान निदेशालय
ICAR - Directorate of Weed Research**