BULLETIN NO. 107 12,000 JANUARY, 1910

Department of Chemistry

Oregon Agricultural College
Experiment Station

COMMERCIAL FERTILIZERS AND INSECTICIDES

By C. E. BRADLEY

THE BULLETINS OF THIS STATION ARE SENT FREE TO ALL RESIDENTS OF OREGON WHO REQUEST THEM

Oregon Agricultural College Press
Corvallis, Oregon
1910

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION.

Hon J. K. Weatherford, *President*.....Albany, Oregon
Hon. E. E. Wilson, *Secretary*.....Corvallis, Oregon
Hon. B. F. Irvine, *Treasurer*.....Corvallis, Oregon
Hon. F. W. Benson, *Governor and Secretary of State*.Salem, Oregon
Hon. J. H. Ackerman, *State Supt. Public Instruction*.Salem, Oregon
Hon. A. T. Buxton, *Master of State Grange*..Forest Grove, Oregon
Mrs. Clara H. Waldo.....Macleay, Oregon
Hon. J. T. Apperson.....Park Place, Oregon
Hon. C. L. Hawley.....McCoy, Oregon
Hon. William W. Cotton.....Portland, Oregon
Hon. Walter M. Pierce.....Pendleton, Oregon
Hon. J. D. Olwell.....Central Point, Oregon

OFFICERS OF THE STATION

STATION STAFF

W. J. Kerr, D. Sc.....President
James Withycombe, M. Agr.....Animal Husbandry, Director
A. B. Cordley, M. S.....Plant Pathology and Entomology
E. R. Lake, M. S.....Botany
C. I. Lewis, M. S. A.....Horticulture
F. L. Kent, B. Agr.....Dairy Husbandry
E. F. Pernot, M. S.....Bacteriology
James Dryden.....Poultry Husbandry
H. D. Scudder, B. S.....Agronomy
C. E. Bradley, M. S.....Chemistry
H. V. Tartar, B. S.....Assistant in Chemistry
L. A. Bundy, B. S.....Assistant in Chemistry
B. Pilkington, B. S.....Assistant in Chemistry
J. C. Bridwell, M. S.....Assistant in Entomology
C. A. Cole, M. S.....Assistant in Horticulture
E. L. Potter, B. S.....Assistant in Animal Husbandry
G. R. Hyslop, B. Sc.....Assistant in Agronomy
A. L. Peck, B. S.....Floriculture and Landscape Gardening
A. G. B. Bouquet, B. S.....Olericulture
R. W. Allen, B. S.....Assistant in Horticulture
C. C. Vincent, B. S.....Assistant in Horticulture
E. J. Kraus, B. S.....Assistant in Horticulture
F. L. Griffin, B. S.....Assistant in Entomology
H. S. Jackson, A. B.....Assistant in Plant Pathology
Helen L. Holgate, B. S.....Clerk

COMMERCIAL FERTILIZERS

Summary of Oregon State Fertilizer Law.—The State fertilizer law, in its present form, was passed by the 1907 legislature. The law is very similar to those in force in the various states and its object is to so regulate the sale of fertilizers that the consumer may be directly informed as to the character of the various goods upon the market, and be able to understand the real value of any materials which he may purchase.

It is expected that as the demand for fertilizers increases there will gradually result an increasing demand for high grade materials and the law which requires labeling of all fertilizing materials on the market with the guaranteed analysis naturally raises the standard of fertilizers on sale throughout the State.

Briefly the main provisions of the law are as follows:

1. Every lot. parcel or package of fertilizer offered for sale in the State, the selling price of which is above $5.00 per ton (except land plaster and lime) must bear a label stating the name of the manufacturer or dealer, the source of the fertilizing materials and the analysis showing the plant food content stated according to a certain form.

2. Before any commercial fertilizer, the selling price of which is above $5.00 per ton, shall be sold, offered or exposed for sale, the manufacturer, importer or person who causes the same to be sold, shall file with the Oregon Experiment Station a certified copy of the statements set forth in 1, and such statements shall be filed annually during the month of December.

3. All brands of fertilizer must be licensed annually at the rate of $20 each. The interpretation of brand is made very liberal in order to encourage the fertilizer industry. A brand is held to be any substance sold for fertilizing purposes which bears a distinct name improvised by the manufacturer or dealer in said materials. All fertilizing materials containing two or more raw products are held to be brands. Raw materials are not considered as brands, unless sold under a distinct name. All raw materials whatsoever, the selling price of which is above $5 00 per ton, except land plaster and lime, must, however, be sold under guaranteed analysis.

4. Penalties of $100 each are prescribed for incorrect labeling and failure to properly register fertilizers.

5. The Director of the State Experiment Station and his deputies are empowered with the enforcement of the law.

In accordance with Section 6 of the law the following information is given, relating to the inspection and analyses of all fertilizers examined by the Station since the law went into effect.

Use of Fertilizers.—It is the aim of the Experiment Station to encourage the proper use of appropriate fertilizers on the part of the farmers of the State. Oregon soils are in the main well stocked with plant food but where large and high-priced products are grown the intelligent use of fertilizers is advisable. The most exacting analysis will not give a complete knowledge of the fertilizer needs of any particular soil for any particular crop, since a variety of conditions aside from plant food content determine a soil's productiveness. Plat tests can readily be made by the farmer, however, and very reliable information obtained as to the value of the various fertilizers on any particular field.

Composition of Fertilizers. *Nitrogen.*—Nitrogen, potassium and phosphorus are the chemical elements which are the basis of all fertilizers. One or more of these plant food elements are present in some form in all fertilizing materials. The most important of these plant food elements is nitrogen, which rests largely in the humus of the soil. Constant removal by crops, oxidation or burning out of organic matter in clean cultivation as well as waste by leaching, all assist in depriving the soil of this expensive element. Experience has shown that under exhaustive systems of farming the soil's nitrogen supply is the easiest impaired. Nitrogen may be supplied to a soil by applications of nitrate of soda, which contains about 15 per cent nitrogen, sulphate of ammonia, containing about 20 per cent nitrogen, and slaughter-house products, such as tankage, containing 5-10 per cent and dried blood about 12 per cent of nitrogen. Barnyard manure is particularly a nitrogenous fertilizer, containing approximately .50 per cent of nitrogen. In intensive forms of farming, like truck gardening, nitrogenous fertilizers are essential and economic. In these commercial forms of nitrogen fertilizers, however, nitrogen costs from 18 to 20 cents per pound and is too expensive for use on a general farming scale. Rotation with a legume has been shown to be an inexpensive and efficient means of supplying this element to a soil and one that is applicable therefore to general farming.

Potassium.—The fact that wood ashes are so rich in potassium as to be a valuable potash fertilizer indicates that certain plants remove large quantities of this element from the soil. Three tons of well-cured vetch hay will contain about 150 pounds of potash and an acre of kale about 225 pounds. Potassium may be supplied to a soil by application of either muriate of potash, coutaining about 42 per cent of potassium, sulphate of potash, containing about 40 per cent of potassium, or kainite, a salt which contains about 8-10 per cent of potassium. Potash is a term used by chemists in reporting potassium. It is a compound of potassium and oxygen, containing about 83 per cent of potassium. Applications of land plaster serve indirectly as a potash fertilizer by rendering soil potash more available.

Phosphorus.—Phosphorus is a chief component of the seed and fruit of the plant and can be supplied when desired by applying bone meal or phosphate rock. Dissolved bone and acid phosphate are readily soluble forms of phosphorus obtained by treating bones and rock phosphate with sulfuric acid and are used when quick-acting phosphate is desired. Phosphoric acid is a compound of phosphorus and oxygen, containing 44 per cent of phosphorus. The acids which develop in the fermentation of a cover crop which has been plowed under have a solvent action upon soil potash and phosphates and render them more readily available to the plant.

Lime.—In addition to the above fertilizing elements, lime, especially in the carbonate or limestone form, plays a very important part in the food supply of the plant. By keeping the soil sweet it provides proper conditions for healthy bacterial growth. It renders the heavy soil more friable and makes the soil's food supply more available. Applications of air slaked lime or of limestone are especially valuable in preparing western Oregon soils for alfalfa planting.

The Value of a Fertilizer.—It is plain that the real value of a fertilizer depends primarily upon the amount of its plant food content. A ton of bone meal containing 20 per cent phosphoric acid, would be worth one-third more than a ton of meal containing but 15 per cent phosphoric acid.

The form in which plant food exists in the fertilizer is also of importance as regards its value as the available or readily soluble plant foods are generally of more value than those which are insoluble.

It is true of fertilizing materials as of all other commodities that the more concentrated products can be handled the cheapest and hence it should be understood that it is economy to buy high grade products. The following schedule of prices has been adopted by the experiment stations of New England for fertilizers in various forms. These values represent the cost at which the raw materials could be bought in the large city markets. For purposes of comparison the schedule of prices for 1908 and 1909 are given:

COMMERCIAL FERTILIZERS

Trade Value of Fertilizing Ingredients in Raw Materials and Chemicals for 1908 and 1909.

	1908 Cts. per lb.	1909 Cts. per lb.
Nitrogen in nitrates	18½	16½
Nitrogen in ammonia salts	17½	17
Organic nitrogen in dry and fine ground fish, blood and meat and in mixed fertilizers	20½	19
Organic nitrogen in fine ground bone and tankage	20½	19
Organic nitrogen in coarse bone and tankage	15	14
Phosphoric acid soluble in water	5	4
Phosphoric acid soluble in ammonium citrate	4½	3½
Phosphoric acid in fine ground bone and tankage	4	3½
Phosphoric acid in coarse bone and tankage	3	3
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers	2	2
Potash as high grade sulphate and in mixtures free from muriate (chlorid)	5	5
Potash as muriate	4½	4½

These prices are of course no criteria of prices in Oregon as the cost of materials, freight conditions and quantities handled, etc., must be considered in determining the selling price of such products. The prices of fertilizing materials as quoted in the Portland market are as follows:

	Per ton		Per ton
Bone meal	$ 32.50	Nitrate of soda	$ 68.00
Superphosphate	28.00	Sulphate of potash	64.00
Blood meal	52.00	Muriate of potash	60.00

The following example will illustrate the method of calculating the value of a mixed fertilizer on the above basis. Suppose the fertilizer contains potash as muriate 4 per cent, organic nitrogen in form of tankage 3½ per cent, phosphoric acid, water soluble, 3 per cent and phosphoric acid insoluble 5 per cent. The values would then be calculated from values in Table I as follows:

	Per Cent	Lbs. in Ton	Price pr lb.	Value
Nitrogen	3½	70	20	$14.00
Potash	4	80	4½	3.60
Phosphoric acid, water soluble	3	60	5	3.00
Phosphoric acid, insoluble	5	100	2	2.00
			Total	$22.60

Licensed Brands.—During the year 1908 the following licenses were issued:

Portland Seed Company, Portland, Oregon.
No. 1, General purposes.
No. 4, Fruit.
No. 5, Lawn and grass.
F. B. Carlisle Co., Port Angeles, Wn.
Wilgrow.
During 1909 the following licenses were issued:
Portland Seed Company, Portland, Oregon.
No. 1, General purposes.
No. 4, Fruit.
No. 5, Lawn and grass.
No. 10, Hop and onion.
Chas. H. Lilly Co., Portland, Oregon.
Potato.
Fruit.
Lawn.
Vegetable.

Amount of Fertilizers Consumed in the State. — Relatively small amounts of fertilizers are used in this state as yet. Farming on a large scale does not of course encourage the use of fertilizing materials. Quite often even the accumulated yard manures are neglected and allowed to go to waste. In the great wheat belt of eastern Oregon barn-yard manure is often used to fill the chuck-holes of the road. Where a section or two is cultivated by the farmer it is obviously impossible to consider a system of fertilizing but a very limited portion of this. As the small farms increase and more intensified culture is followed, as in truck farming or orcharding, more faithful applications of fertilizing material must be resorted to if good yields are maintained as experience will show.

It is estimated from figures given by dealers that approximately 310 tons of the various fertilizers were consumed in this state during the year ending July 1, 1909. This total consisted of approximately the following:

Bone meal	150 tons	Acid phosphates	10 tons
Potash	75 "	Tankage	25 "
Nitrate of soda	35 "	Blood meal	15 "

31,288 tons of fertilizers were used in the state of California last year or about 100 times that consumed in Oregon.

Analyses of Fertilizers.—According to the fertilizer law all fertilizers placed on sale must be tagged with the guaranteed chemical analy-

sis stated in a definite form and giving the minimum content of plant foods in each respective sample.

Potash Salts.—In the following table are noted samples of potash salts which have been analyzed by the Station chemical department. The chief potash fertilizers are the sulfate and chloride or muriate of potash. They are obtained from Germany where the muriate exists naturally in salt beds. The sulfate is prepared from the muriate and sells a little higher, being preferred on certain crops. The pure sulfate contains 54.08 per cent of potash or potassium oxid; the muriate 63.20 per cent potash.

Kainite is a double chloride of potassium and magnesium, containing 12 per cent to 14 per cent of potash.

POTASH SALTS.

Dealers	Lab. No.	Substance	Potash Per ct.	Chlorine
Portland Seed Co.	3906	Muriate	52.95	48.72
" "	3495	Muriate	50.78	
" "	3584	Muriate	49.29	47.50
" "	3586	Kainite	13.94	36 87
" "	3905	Sulfate	49.19	1.41
" "	3585	Sulfate	50.24	2.41
Chas. H. Lilly Co.	3933	Muriate	53.66	48.05

All the above are good grades of these materials.

Nitrate of Soda.—Pure nitrate of soda contains 16.55 per cent nitrogen. Nitrate is imported from Chili. Good grades of nitrate run from 15 per cent to 16 per cent in nitrogen.

NITRATE OF SODA.

Dealer	Lab. No.	Substance	Total Nitrogen
Portland Seed Co.	3734	Nitrate of Soda	15.47
C. H. Lilly Co.	3735	* " "	7.10
Portland Seed Co.	3494	" "	15.05
" "	3583	" "	15.15
" "	4057	" "	15.87

* Sample received for analysis from Mr. Wadsworth of Cleone and said to have been purchased from the C. H. Lilly Co. Sample contained much insoluble impurities and was strongly alkaline with carbonate of soda.

With the exception of No. 3735 the above samples are good average grades of nitrates.

Bone Meal.—Bone meal is valuable for its nitrogen and phosphoric acid. If previously treated with acid its phosphoric acid is largely available. If untreated it is largely in the insoluble form. 3.5 per cent nitrogen and 20 per cent total phosphoric acid are usual values.

BONE MEAL.

Dealer	Lab. No.	Substance	Total Nitrogen	Total Phos. Acid	Insoluble Phos. Acid
J. J. Butzer	3879	B. M.	3.63	19.33	----------
" "	3663	"	3.76	22.35	16 05
Portland Seed Co.	3862	"	3.70	19.26	----------
" "	3588	"	3.54	19.60	----------
" "	3589	"	3.62	20.40	----------
F. J. Schofield, Eugene	3949	Ground bone	3 33	21.05	14.00
Portland Seed Co.	3907	Bone flour	3.75	22.80	----------

Tankage and Dried Blood.—These are packing house products. Takage is valuable for its nitrogen and phosphoric acid, and blood meal for its nitrogen. Samples were analyzed as follows:

TANKAGE AND DRIED BLOOD.

Dealer	Lab. No.	Substance	Total Nitrogen	Total Phos. Acid
F. J. Schofield	3972	Tankage	8.40	7.20
Portland Seed Co.	3616	Blood meal	10.45	4.90
" "	3591	Tankage	5.49	12.25
" "	3590	Tankage	5.69	11.90

MISCELLANEOUS.

Dealer	Lab. No.	Substance	Total Nitrogen	Total Phos. Acid	Available Phos. Acid
Portland Seed Co.	3594	Acid phosphate	-------	20.25	19.51
" "	3771	Fish guano	7 65	7.55	6.37

Complete Fertilizers.— Complete fertilizers are those which furnish all three plant foods, nitrogen, potassium and phosphorous. The thorough and uniform mixing of large quantities of mixed fertilizers is somewhat difficult and the taking of a true and representative sample of these goods requires great care. The law allows a deficiency of but .25 of one per cent in nitrogen, .50 per cent potash and one per cent phosphoric acid below the guaranteed analysis in order that goods may be considered properly labeled.

The following complete fertilizers have been analyzed since the fertilizer law went into effect:

COMPLETE EERTILIZERS

COMPLETE FERTILIZERS			Lab. No.	Total Nitrogen guar.	Total Nitrogen found	Total Potash guar.	Total Potash found	Total Phos. Ac. guar.	Total Phos. A. found	Avail. Phos. A. guar.	Avail. Phos. A. found	Insoluble Phos. A. guar.	Insoluble Phos. A. found	Chlorine guar.	Chlorine found
Manufacturer	Name of Brand	Made From													
Chas. H. Lilly Co., Portland, Or.	Lilly's best vegetable	Dried blood, bone meal, muriate	3954	4.45	4.42	2.20	3.57	14.25	16.12	4.05	6.42	10.20	9.70	2.20	5.50
" " " " "	Lilly's best fruit & hop	Dried blood, bone meal, muriate potash	3955	4.00	3.83	4.25	6.72	13.20	15.49	4.00	5.22	9.20	10.27	4.25	6.39
" " " " "	Lilly's best lawn dress'g	Dried blood, bone meal, muriate	3956	5.50	5.04	3.00	6.72	13.70	13.79	4.20	5.09	8.50	8.70	3.00	5.85
" " " " "	Lilly's best potato	Dried blood, bone meal, sulfate potash	3957	4.25	4.00	4.00	11.57	12.70	12.35	5.00	4.60	12.70	12.35	0.40	2.10
F. T. Carlisle Co., Port Angeles, Wn.	Wilgrow	Fish scrap, guano, grnd bone, sulfate potash	3958	3.50	5 62	4 00	7.57	------	12.80	2.50	3.25	2 50	9.85	----	0.50
Portland Seed Co., Portland, Or.	Plant food	----------	3595	----	4.75	------	10.56	------	9.63	----	9.57	------	------	----	----
" " "	No. 1 General purposes	Blood, tankage, bone, A. phos., sulfate potash	3629	2.50	3.39	8.00	6.07	7.00	9.65	5.60	3.83	------	5.82	----	0.67
" " "	No. 4 Fruit	Blood, bone, tankage, A. phos., sulfate potash	3630	2.50	2 88	10.00	10.35	8.00	8.90	6 30	5.33	1.70	3.57	----	1.59
" " "	No. 5 Lawn and grass, roses and flowers	Blood, tankage, bone, A. phos., sulfate potassium	3631	4.00	4.56	4.00	4 15	10.00	10.00	7.00	4.53	3.00	5.47	----	0.15
" " "	No. 10 Hop and onion	Nitrate soda, blood bone A. phos., sulfate potash	3916	3.10	3.31	12.00	10.51	8.15	7.43	----	5.46	------	1.97	----	0.71

Much variation between the guaranteed analysis and that found by the Station analyses is noted in the above. In most cases, however, the guaranteed analysis is below that found by the Station, especially is this so with reference to potash. Incomplete mixing is no doubt the cause of the above wide variation in analyses. In No. 3956 the nitrogen guarantee exceeds that found by a greater margin than is allowed by the law.

Several inquiries have been received concerning the following statement with reference to Wilgrow fertilizer:

"A package of Wilgrow contains as much plant food as does $\frac{3}{4}$ of a ton of barnyard manure." The package referred to was labeled to contain $1\frac{1}{2}$ lbs. of fertilizer but only $1\frac{1}{4}$ lbs. was found on weighing same, no doubt due to evaporation of moisture.

The guaranteed analysis of the fertilizer was given as follows:

Nitrogen	3.5 per cent =	.05 lbs. Nitrogen in package
Potash	4.0 per cent =	.06 lbs. Potash in package
Phosphoric acid	5.0 per cent =	.08 lbs Phos. acid in package
	Total	.19 lbs.

or $\frac{1}{8}$ of its entire weight is plant food.

For purposes of comparison the following data may be given concerning the plant food content of $\frac{3}{4}$ ton of barn-yard manure:

$\frac{3}{4}$ ton = 1500 lbs.

Average manure will run—

.50 per cent nitrogen	1500 × .0050 =	7.50 lbs.
.50 per cent potash	1500 × .0050 =	7.50 lbs.
.25 per cent phosphoric acid	1500 × .0025 =	3.75 lbs.
	Total plant food	18.75 lbs.

This is more than 12 times the weight of the entire Wilgrow package or 100 times as much plant food as is contained therein.

The above statement is thus grossly misleading and unjustifiable.

INSECTICIDES.

Analyses of various spraying materials have been carried out in the Station chemical department during the past year. The larger proportion of the samples examined have been arsenate of lead paste and lime-sulfur solutions. As a very complete report on our study of the lime-sulfur spray is to be issued as a separate bulletin, this report will deal only with the lead arsenates and miscellaneous samples which we have analyzed.

Paris Green.—Only two samples of Paris green have been received for analysis, since the commercial product as it is now found on the markets usually conforms to all requirements. The usual requirements for a standard Paris green are that it shall not contain less than 50 per cent of arsenious oxide combined with copper and shall not contain above 3½ per cent arsenious oxide in water soluble forms. Paris green is a compound known to chemists as Aceto-Arsenite of Copper and containing when pure—

Arsenious oxide	58.65 per cent
Copper oxide	31.29 per cent
Acetic acid	10.06 per cent
	100.00

One of the samples tested by us gave 56.40 per cent total arsenious oxide, with 1.28 per cent water soluble arsenious oxide. The other sample analyzed 56.20 per cent total arsenious oxide and a microscopic examination showed only a very small amout of free arsenic crystals present. These results indicate the samples were of good grade.

MISCELLANEOUS.

White Arsenic.—A sample of white arsenic, arsenious oxide, purchased on the market, was sent in by a fruit grower for analysis. It was found to be 98.70 per cent pure. The U. S. Pharmacopœia standards require arsenious oxide to be 99.80 per ct. pure, hence the sample in question was sufficiently pure for the practical purposes to which it was to be applied.

Pear Blight Remedy.—A sample purporting to be a remedy for pear blight was received from an Eastern Oregon fruit grower. The material bore the label of a St. Louis firm. Examination of it revealed the following ingredients: Black gunpowder, asafœtida and a small amount of white arsenic mixed with sulphur. The main portion of the material consisted of the latter named substance. The directions stated that a hole should be bored in the trunk of the tree

and the "remedy" poured in and tightly plugged with a wooden stopper. Since the insolubility of the above ingredients in the tree sap would no doubt prevent their transportation to the affected portion of the tree the treatment would undoubtedly prove useless.

Copper Sulfate.—A sample of copper sulfate was tested by us to determine whether it contained injurious quantities of sulphate of iron or copperas. .99 per cent of iron sulphate was found, a quantity not sufficient to cause any injury in spraying.

LEAD ARSENATES.

Arsenate of lead was first used as an insecticide by the Massachusetts Gypsy Moth Commission in 1893, and is now applied very widely as a standard spray for the control of the codling moth. It has great killing powers, does not injure foliage and has an advantage over Paris green in having greater adhesiveness.

There are two varieties of lead arsenate which may exist, dependent upon the method of their manufacture or preparation. These varieties are distinguished as *neutral* or *ortho* arsenates and *acid* arsenates. If a solution of acetate of lead or sugar of lead is mixed with a solution of arsenate of soda, a white insoluble powder is formed which is known as neutral or ortho lead arsenate. When pure chemicals are used this neutral lead arsenate contains theoretically 74.40 per cent of lead oxide and 25.60 per cent of arsenic oxide, estimated on the dried or water-free material.* If, however, solutions of nitrate of lead and arsenate of soda are mixed an arsenate of lead is formed, the composition of which when dried is 64.26 per cent lead oxide and 33.15 per cent arsenic oxide. This latter compound is termed the acid arsenate of lead. It will be noted that the ratio of the arsenic oxide to the lead oxide is approximately 1 : 3 in the neutral arsenates, and 1 : 2 in the acid arsenates.

Home-Made Lead Arsenates.—The reactions in the preparation of lead arsenate from the above mentioned solutions may be expressed as follows:

Acetate of lead + arsenate of soda = arsenate of lead (neutral arsenate) + acetate of soda + acetic acid, or

Nitrate of lead + arsenate of soda = arsenate of lead (acid arsenate) + nitrate of soda.

One part by weight of arsenate of soda requires 2.6 parts by weight of acetate of lead to completely combine with it to form ar-

*Bull. 105 Bureau Chemistry.

senate of lead, considering the chemicals to contain no water of crystallization. When the crystallized varieties of lead acetate and sodium arsenate are used 1 part of the sodium arsenate requires only 1.8 parts of lead acetate for complete combination. In the home-made preparation 10 ozs. of arsenate of soda may be dissolved in a gallon of water and mixed with a solution containing 24 ozs. of acetate of lead to 1 gallon of water, the solutions having been made in wooden buckets. The mixed solutions are then poured into a tank containing from 60 to 75 gallons of water, when the spray is ready for use.

The above formula allows liberally for an excess of lead which must always be present as very small quantities of arsenic in solution are fatal to foliage. One pound of white arsenic in 1,200 gallons of water was found to act injuriously on foliage by Gillette.* In order to determine whether the prepared spray contains excess of lead the thoroughly mixed solutions may be allowed to settle and a portion of the clear liquid poured into a glass. The addition of a few drops of chromate of potash will give a yellow precipitate of lead chromate in case excess of lead is present. If no precipitate occurs the arsenic is in excess and more lead acetate must be added. The fact that the commercial lead acetates and sodium arsenates vary greatly in composition renders it necessary to make a somewhat liberal allowance for excess of lead. Smith† found commercial lead acetate to yield from 58.81 to 66.80 per cent of lead oxide and sodium arsenate to yield from 36.67 to 47.80 per cent of arsenic oxide.

Regarding the relative merits of neutral and acid arsenate so far as is known by us no experiments are on record showing this. There is a common impression that the acid arsenates have burning qualities and are more injurious to foliage. Some tests made by us, however, on very sensitive bean leaves indicated that neither the acid nor the neutral arsenate exerted any injury even when applied in excess. It may be said in this connection that when home-made arsenate is used the acetic acid and acetate of soda, formed as by-products, as well as the excess of lead acetate are applied in the spray and may exert some influence on the foliage. The home-made arsenates usually remain in suspension better than the commercial preparations but for convenience and safety the latter are

* Iowa Bulletin No. 2.

† Agr. Massachusetts, 1897, 357-369.

to be preferred. Great caution should be used in handling arsenicals as they are powerful poisons and should be carefully kept from stock on the farm.

Commercial Lead Arsenates.—The commercial lead arsenates are sold in the form of a paste, containing more or less water; these pastes being obtained by washing and expressing the excess of water from the precipitated lead arsenates. Excess of water of course lowers the proportion of real lead arsenate or active principle in the samples, and a lack of sufficient moisture to form a true paste prevents the material from standing up well in water when mixed for spraying. The standards to which it is required lead arsenate shall conform, according to the bill now before Congress, are as follows: "Not more than 50 per cent of water, not less than 12½ per cent of arsenic oxide and not more than .75 per cent of water-soluble arsenic oxide."

The following table represents the composition of the various commercial lead arsenates which have been examined by this department:

COMMERCIAL LEAD ARSENATES.

Name of Brand	Lab. No.	Moisture	Total Lead Oxide	Total Arsenic Oxide	Soluble Impurities	Soluble Arsenic Oxide	Total
		%	%	%	%	%	%
Swift	3652	43.45	34.47	16.68	1.82	.45	96.42
Star	3693	54.02	32 99	10.72	.31	.10	98.04
Grasselli	3712	38.95	43.11	14.85	.16	.39	97.07
Lion	3718	58.40	26.19	12.26	.61	.12	97.46
Sherwin-Williams	3978	49.55	41.00	5.17	2.85	.15	98.57
Sherwin-Williams	4008	51.84	33.11	12.35	1.58	.11	98.88
Bean	4009	41.68	42.19	13.47	1.60	.10	98.94
Hemingway	6006	32.46	42.64	21.45	.98	.31	97.48

In Nos. 3652, 3718 and 6006 it will be noticed that the 1 : 2 ratio exists between the arsenic oxide and the lead oxide. This indicates that they are acid arsenates and tests of the samples show they have been made from lead nitrate. In the other samples the 1 : 3 ratio exists which is characteristic of the neutral arsenates which are obtained by employing lead acetate. No. 3978 is an unusual material in that it contains only a very low percentage of arsenic. It was received from the manufacturers for purposes of practical testing in the field.

Three samples, 3693, 3718 and 4008 exceed the limit for standard arsenates in moisture and three, 3693, 3718 and 4008 fall under the standard requirements for arsenic oxide. None of the samples contain excessive amounts of soluble arsenic. The amount of soluble

impurities is considerable in some of these samples which indicates incomplete washing of the arsenate in the process of manufacture. These impurities are the biproducts formed in the reactions as given on page 13 and in the home-made arsenate are contained in and applied with the spray. Glucose is sometimes added to the arsenate to give the spray greater adhesiveness.

The summation of the results in the column marked total it will be noticed, is in all cases short of 100 per cent. This is largely due to the undetermined carbon dioxid which exists in small proportions in the arsenate combined with the lead as lead carbonate. In judging the practical value of the above arsenates it may be said that a high arsenic content, which is the active principle, and a paste form which permits ready mixing with water are important points of consideration.

Iron Arsenate.—A 25-lb. keg of ferrous arsenate in the form of a greenish paste was furnished by the Sherwin-Williams Company for experimental purposes. This sample was received too late for trial last season but was analyzed with the following results:

Moisture	84.25 per cent
Arsenic oxide	7.37 "
Iron oxide (ferrous)	5.51 "

Ferrous arsenate has been advocated as a substitute for lead arsenate and is said to possess the following advantages of the latter: First, greater adhesiveness; second, greater percentages of arsenic oxide and therefore greater killing power; third, much less cost. In the dry condition ferrous arsenate contains from 40 to 45 per cent of ferrous oxide and from 50 to 55 per cent of arsenic oxide, while the maximum arsenic oxide in the neutral lead arsenate is approximately 25 per cent and in the acid lead arsenate 33 per cent.

It is evident that a considerable portion of the excess water found in the above sample would have to be removed in order to give a product as high in arsenic as the average lead arsenate. Ferrous arsenate containing equivalent amounts of arsenic can, however, no doubt be made more cheaply than lead arsenate. So far as is known by us no data are yet available which show practical results obtained by use of ferrous arsenate as a substitute for lead arsenate.

Credit is due Mr. L. A. Bundy for the greater part of the analytical work reported in this bulletin.