Potassium Nitrate as an Aid to Fertilizer Granulation

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Because of the availability of potassium nitrate as a new raw material, its effect as an aid to granulation was studied. Small batches of an 8–6.98–13.28 (8–16–16) grade mixed fertilizer containing potassium nitrate were granulated at different moisture and temperature levels in a laboratory Roto-Louvre dryer. The optimum moisture in the feed and inlet gas temperature were 9.6% and 450° F., respectively, for a maximum yield of − 6+20-mesh granules. The distribution of the three primary nutrients, nitrogen, phosphorus, and potassium, was determined in the various product size fractions. Similar experiments were made on an 8–6.98–13.28 (8–16–16) grade mixed fertilizer containing only potassium chloride. The optimum moisture in the feed, inlet gas temperature levels, yield, and nutrient distribution were also determined. At least 12.2% moisture was required for maximum yield, and the variation in nutrient distribution was greater.

Potassium nitrate has a high agronomic value as a source of both nitrogen and potassium, but high cost has been a major limitation to its use in fertilizer formulations. The new production facilities of the Southwest Potash Corp. in Vicksburg, Miss., for a fertilizer grade potassium nitrate may make this material economically attractive. This has stimulated considerable interest in the granulation characteristics of mixed fertilizer formulations containing potassium nitrate and also in the physical properties of the resulting products. Studies (*1–5*) have shown that potassium nitrate is an aid to granulation. This paper presents results of laboratory studies using potassium nitrate in a vegetable grade fertilizer.

Granulation experiments in a laboratory Roto-Louvre dryer were made on an 8–6.98–13.28 (8–16–16) grade vegetable fertilizer to study the effects of moisture in the feed and of inlet gas temperature on the yield and distribution of plant nutrients in the various sized fractions. Two formulations were prepared (Table I): Formulation I contained potassium nitrate which contributed 27% of the total potassium and 16% of the total nitrogen, and Formulation II contained potassium chloride as the only source of potassium. The solid raw materials (sieved through a 20-mesh Tyler screen) were mixed in a batch reactor and made to react with phosphoric acid and anhydrous ammonia. The moisture content was varied by adding predetermined amounts of water to fertilizer mixture.

The experimental equipment is shown in Figures 1 and 2. Details of the reactor-mixer have been reported (*1*). The batch reactor, in the center of Figure 1, was constructed from a section of 5-inch O.D. Type 304 stainless steel tube with a $^{3}/_{32}$-inch wall thickness. A stainless steel stirrer, consisting of a hollow shaft and four paddles, was used to mix the ingredients and to distribute the ammonia.

The bench scale Roto-Louvre dryer on the right in Figure 2 was 13 inches in diameter and $3^{1}/_{8}$ inches long, and operated at 7.4 r. p. m. The product was dried, screened, and analyzed for nitrogen, phosphorus, and potassium.

The time in the Roto-Louvre dryer was 30 and 45 minutes, respectively, for Formulations I and II. Final product temperature ranged from 196° to 280° F. To keep the number of variables at a minimum, inlet gas temperature was varied while residence time in the dryer

Table I. Formulations for 8–16–16 Grade Fertilizer

Material	Analysis Basis, % $N\text{-}P_2O_5\text{-}K_2O$	Formulation No. I (Pounds per ton)	Formulation No. II (Pounds per ton)
Triple superphosphate	0–41.0–0	248	330
Normal superphosphate	0–20.6–0	492	339
Phosphoric acid	0–62.9–0	200	200
Anhydrous ammonia	82.2–0–0	90	90
Ammonium sulfate	20.5–0–0	313	438
Potassium nitrate	13.4–0–44.6	200	—
Potassium chloride	0–0–58.4	397	543
Magnesium limestone	— — —	100	100
Borax	— — —	10	10
(Evaporation loss 50 pounds)	Total	2050	2050

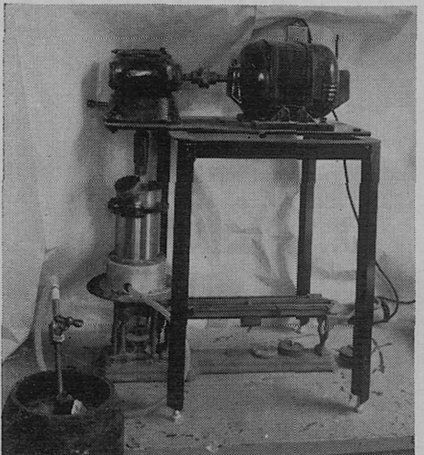

Figure 1. Mixer-reactor assembly

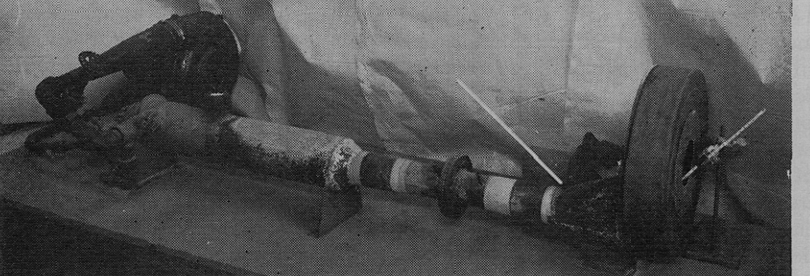

Figure 2. Granulator-dryer assembly

Table II. Relationship between Temperature and Moisture on Yield of —6 +20-Mesh Granules

Run No.	Temp. of Inlet Gas, °F.	Moisture in Feed, %	Yield of −6 +20-Mesh Granules, %
Formulation I Containing Potassium Nitrate			
R-4	425	9.43	79.70
R-5	425	9.08	47.56
R-6	425	10.24	64.13
R-10	425	9.02	64.13
R-11	425	9.48	56.79
R-12	425	10.53	69.80
R-13	425	8.53	51.40
R-14	425	9.37	39.04
R-15	500	9.58	58.85
R-17	350	9.80	69.33
R-18	475	9.47	62.56
R-19	375	9.26	43.65
R-20	475	9.11	72.40
R-21	375	9.50	63.24
Formulation II Containing Only Potassium Chloride			
R-100	475	12.85	60.17
R-101	475	11.78	67.51
R-103	475	12.35	55.47
R-104	475	12.32	48.96
R-105	475	10.94	58.41
R-106	475	12.28	58.88
R-107	550	12.26	72.51
R-108	400	12.69	52.86
R-109	475	13.26	66.36
R-110	475	11.43	56.36
R-111	525	11.39	69.25
R-112	525	12.90	71.41
R-113	425	12.92	54.15
R-114	425	10.94	67.14

was held constant. If product temperature had been the variable, it would have been necessary also to vary residence time.

Discussion

The experimental work followed the central composite rotatable design used by Boylan and Kamat (*1*). The central point was established by averaging four of six runs. The results of granulation experiments using each formulation are shown in Table II. The data in Table II were analyzed by the composite design and plotted in Figures 3 and 4. Runs 5, 14, 103, and 104 were rejected statistically.

Figure 3 shows the relationship between temperature and yield for both formulations. Formulation I, containing potassium nitrate, shows a maximum yield of approximately 70% at an inlet gas temperature of 455° F. Formulation II, without potassium nitrate, shows no maximum within the inlet gas temperature range investigated, although a maximum might be obtained at a higher temperature level.

Figure 4 shows the relationship between moisture and yield for both formulations. Formulation I shows a maximum yield of approximately 68% at 9.6% moisture. Forumulation II shows

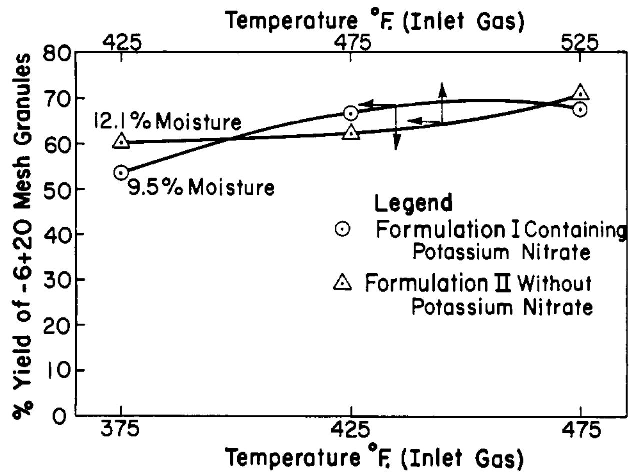

Figure 3. Effect of temperature on product yield

Table III. Nutrient Distribution in Various Sized Fractions

Run No.	+6-Mesh Granules N, %	P_2O_5,[a] %	K_2O, %	−6 +14-Mesh Granules N, %	P_2O_5,[a] %	K_2O, %	−14 +20-Mesh Granules N, %	P_2O_5,[a] %	K_2O, %	−20-Mesh Granules N, %	P_2O_5,[a] %	K_2O, %
Formulation I Containing Potassium Nitrate												
R-4	9.04	17.72	16.18	8.83	17.62	16.13	7.69	18.63	16.26	7.24	17.76	17.32
R-5	8.52	18.05	16.11	8.64	18.32	15.80	8.23	18.80	15.78	7.70	17.41	17.30
R-6	7.73	17.88	16.48	7.55	18.45	16.70	6.94	18.39	17.71	7.23	18.29	17.21
R-10	8.24	18.16	15.76	8.18	18.29	16.03	7.46	17.68	18.08	7.82	17.77	16.54
R-11	8.56	17.77	16.53	8.56	18.06	16.03	7.80	19.15	16.09	7.49	18.13	17.51
R-12	8.42	17.30	16.62	8.64	17.93	16.06	7.64	19.20	16.52	7.46	18.36	17.50
R-13	8.61	18.13	16.11	8.64	18.12	15.59	8.00	19.00	15.80	7.56	17.50	17.96
R-14	8.02	18.23	16.91	8.28	17.96	15.80	7.34	18.51	17.36	7.56	18.18	17.24
R-15	7.78	18.24	16.94	7.72	18.52	16.77	7.26	19.02	17.56	7.36	18.81	17.05
R-17	8.22	17.95	16.60	8.30	18.52	16.09	7.78	19.24	16.31	7.66	18.47	17.32
R-18	8.28	18.09	16.31	7.89	18.73	16.41	7.21	19.66	16.88	7.36	18.66	16.98
R-19	8.04	18.75	16.65	7.68	18.85	16.80	7.79	19.27	16.13	8.04	18.66	17.58
R-20	8.60	17.84	16.64	8.20	18.38	16.00	7.38	19.62	16.02	7.09	17.72	16.86
R-21	7.94	18.37	16.67	7.87	18.79	16.19	7.48	18.87	17.12	7.38	18.80	17.09
Formulation II Containing Only Potassium Chloride												
R-100	7.78	17.16	16.74	7.98	17.43	16.42	7.28	18.20	17.68	7.44	18.24	16.98
R-101	8.01	18.01	16.74	7.96	18.81	16.53	7.08	19.28	17.42	7.18	19.30	17.15
R-103	8.04	18.63	16.24	8.36	17.91	16.49	7.96	19.42	16.02	7.36	19.26	16.53
R-104	7.70	18.62	16.53	7.55	19.41	16.21	7.06	19.85	16.50	6.91	19.00	17.44
R-105	8.13	18.53	16.45	8.35	18.48	16.09	7.44	18.46	17.82	7.31	18.71	17.00
R-106	8.38	18.37	16.35	7.98	18.66	16.50	7.20	18.62	18.36	7.36	18.80	17.24
R-107	8.18	18.52	16.52	8.12	18.20	16.78	7.36	19.16	17.77	6.98	20.01	16.25
R-108	8.80	18.25	16.00	8.90	16.95	16.27	8.16	18.52	16.10	7.56	18.91	17.13
R-109	8.33	17.85	16.06	8.04	18.16	16.30	7.00	18.74	18.07	6.83	19.66	16.41
R-110	8.55	19.41	15.20	8.60	18.10	15.27	7.52	17.25	18.91	7.38	18.26	18.08
R-111	8.18	18.28	16.60	8.52	16.90	16.21	7.44	18.75	17.45	7.02	19.16	17.51
R-112	8.18	18.23	16.83	8.18	18.41	16.27	7.44	19.50	17.14	6.96	19.17	17.76
R-113	7.96	18.13	16.60	7.92	18.52	16.86	7.14	19.24	17.50	6.82	19.59	17.16
R-114	8.27	18.40	16.10	8.66	18.60	15.78	7.40	17.58	19.08	7.48	18.50	17.79

[a] Total.

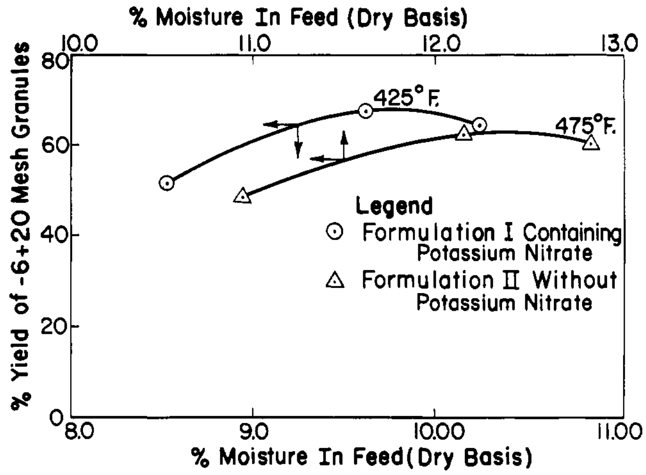

Figure 4. Effect of moisture on product yield

Table IV. Averaged Maximum Variation in Product Nutrient Content

Formulation	N	P_2O_5	K_2O
I	0.962	1.112	1.360
II	1.144	1.396	1.642

a maximum yield of approximately 62% at 12.2% moisture. The more pronounced dependence of yield on moisture in Formulation I is probably due to a higher solubility of the salt phase. Table III shows the nutrient distribution of both formulations in the various sized fractions of the granules. The averaged maximum variation of nutrient content in the product was lower for Formulation I than for Formulation II for all nutrients (Table IV).

The extent of agglomeration could be controlled by the mixing time after the addition of the water. Formulation II formed large agglomerates in the batch reactor, while Formulation I formed more uniformly sized granules. This was primarily due to the lower moisture requirement of the salt solution phase of Formulation I. This lower moisture resulted in a drying time of only 30 minutes at 425° F. for an average product moisture content of less than 1%; Formulation II required 45 minutes drying at 475° F.

Conclusions

Because of the high solubility of potassium nitrate at the elevated temperatures of granulation, Formulation I, containing potassium nitrate, required only 9.6% moisture for a maximum yield of 67.6% in the −6 +20-mesh size fraction. Formulation II, without potassium nitrate, required 12.2% moisture for a maximum yield of 62.3%. This yield was considered good, since no recycle was employed.

For a product with an average moisture content of less than 1%, Formulation I required a drying time of 30 minutes at an inlet gas temperature of 425° F; Formulation II required 45 minutes at 475° F.

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INSECTICIDE MODE OF ACTION

Absorption and Binding of DDT by the Central Nervous System of the American Cockroach

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It is hypothesized that DDT interferes with nervous function by forming a charge-transfer complex with a component of nerve. Studies on the kinetics and equilibria of DDT penetration into and out of nerve cords indicated the formation of complexes of DDT with two components of the cord and having dissociation constants of approximately 6×10^{-6}M and 1.5×10^{-7}M. At 10^{-5}M DDT, about 83% of the DDT in the cord is complexed. Two complexes have been partially purified on Sephadex and DEAE-cellulose columns. One contains protein and is extractable by butanol.

THE CHLORINATED HYDROCARBONS are presumed to owe their toxicity against insects to effects upon the nervous system because tremors and later paralysis are the most prominent symptoms of poisoning, and because profound disturbances can be shown electrophysiologically in nerve preparations from poisoned insects. The basis of these effects has never been experimentally demonstrated. However, Mullins (*7*) has suggested that DDT and related compounds owe their properties to precise fit in a hypothetical intermolecular lattice, and Gunther *et al.* (*3*) have proposed that Van der Waals binding to a protein in nerve is involved. From the effects of DDT upon negative afterpotentials in single axons and the modification of these effects by applied

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