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Studies on pre-treatment of seeds with chemicals

I. The effect of presoaking the seed in various chemicals on the growth and yields of paddy

by

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Introduction: A great deal of attention has been devoted in recent years, towards a more efficient utilisation of fertilizers in crop production. Various methods have been tried, starting from broadcasting, to placement of fertilizers right in the feeding zone of the root systems of crop plants, with the object of making available a larger quantity of nutrients to the growing plants. Amongst the various methods tried, coating the seeds with fertilizers was one; thus Gusev (1940) had claimed that by pretreating seeds with phosphates before sowing, either by moistening the seeds with an aqueous solution of phosphate fertilizer or by smearing the seeds with a mixture of starch paste and fertilizer, the plants were able to utilize as much as 70 – 80 percent of the phosphate supplied. This idea was taken a step further by Roach and Roberts (1949) in Great Britain, and subsequently other workers had also found there were practical possibilities in this method of seed pre-treatment with chemicals. In India, the Indian Council of Agricultural Research sponsored a research scheme in 1952 to investigate the scope and possibilities of this method, in improving the growth and yields of important crops. This scheme was worked in the Plant Physiology section of the Agricultural Research Institute at Coimbatore, and a number of crop plants was studied; the results obtained in rice (paddy) plants are presented in this paper.

Review of previous work: The earliest mention in published literature is by Toole and Drummond (1924), who found that presoaking of cotton seeds in water before sowing them was very helpful where the soil moisture was below the optimum required for prompt germination. Soaking the seeds in water and then partially drying them, to 50 percent of the original moisture was found helpful in improving the yield in cucumbers - by Eromolev, (1941). This increase was attributed partly to the earlier emergence of female flowers in the "presoaked" plants; about nine days earlier than in the controls. In Japan, better growth, taller plants, earlier

flowering and higher yields were noted in paddy by Yosiyasu (1942) as a result of presoaking the seed in different concentrations of β-indole-acetic acid and α-naphthalene-acetic acid and for periods ranging from 24 to 72 hours. The possibilities of this method of seed pretreatment were explored in oats and barley by Roach and Roberts (1949) in the United Kingdom. Presoaking in hormone chemicals was found helpful in mitigating the adverse effect of late planting in sugarcane, by Agarwal and Prasad (1954). Similar results have been reported for wheat, by Bharadwaj and Rao (1955). Coconut water, i. e. the liquid endosperm found in unripe coconuts, was also found helpful by Ramaswami and Gowda (1955) as a presoaking medium to hasten germination. In Ceylon, Rhind and his co-workers (1949) observed in rice that yield increases of 19 - 36 per cent were obtainable in the greenhouse trials, but the same response could not be secured in the field; here there was only an evanescent superiority in vegetative vigour in phosphate-presoaked plants. Narayanan and Gopalakrishnan (1949) found that presoaking paddy seeds in a 20 percent solution of tribasic potassium phosphate resulted in an increase in grain yield of nearly 40 percent over the untreated control. Presoaking the seeds in a 10 percent solution of the same salt gave a 21 percent increase over controls, while beneficial effects on grain yield were also noticeable after presoaking in β-indole-acetic acid. Presoaking in mere distilled water had no marked effect on grain yield if done once, but a repetition of the process showed an adverse effect upon paddy grain and straw yields. Ramiah and his co-workers in rice (1952) have also reported yield increases of 15 to 22 percent by pre-soaking treatments. More recently Sivtev (1956) has reported that presoaking maize seeds in potassium sulphate, potassium permanganate, boric acid, ammonium molybdate and zinc sulphate solutions in appropriate concentrations increased the yields; the highest increases being observed in the case of boron and zinc salts.

Materials and Methods: Since indications were obtained from the preliminary studies that for each crop there was a specific concentration of a specific chemical that was most helpful, a large number of salts of both macro and micro-nutrients was first tested to see which of them was most helpful for paddy. The actual method was rather simple; a known weight of paddy seeds was soaked in a known weight of the appropriate salt solution, keeping the ratio of seed to solution at 3:1 in order to ensure that the solution was all fully absorbed by the seeds, and to avoid the risk

of seed constituents being leached out by an excess of the solution. The period for which the seeds should be presoaked was also determined by earlier preliminary tests and 16 hours were found to be the optimum and in accordance with this, the presoaking in paddy was also limited to 16 hours. After presoaking the seeds were spread out and air-dried in the shade and then utilised for sowing in the usual way.

In the experiments carried out on rice, besides the dibasic and tribasic potassium phosphates, solutions of micro-nutrient salts like iron, manganese, copper and zinc were also tried in various combinations both amongst themselves and in conjunction with potassium phosphate solutions.

Five different paddy strains were used in these trials, at four locations. The strains employed were GEB. 24 and Co. 1 at Coimbatore, ADT. 3 at the Agricultural Research Station, Aduthurai, in the deltaic Tanjore district, PTB. 2 at the Agricultural Research Station, Pattambi on the Kerala coast and TKM. 6 at the Rice Research Station, Tirurkuppam in Chingleput district. The experiments at Coimbatore were carried out both in the field and in pot cultures, while those in the other stations were confined to field experiments only. The treatments were replicated and laid out in recognised statistical fashion.

Records were maintained on germination, growth rates as reflected in plant height increases at fortnightly intervals and tillering, flowering earliness and yield of grain and straw. In the case of pot-culture studies, the root-weights were also recorded.

Results: In the nursery, marked differences were noticeable in one strain, GEB. 24, in shoot length, shoot weight and root length and root weight. It was however noticed that presoaking in water alone improved both shoot and root length but not their weights, indicating that the initial stimulation caused by presoaking is sufficient for elongation but not for increased dry weight accumulation, unless the seed was presoaked in chemicals as well (Table I, Appendix). A similar behaviour is reported in the case of seedlings grown after treatment with gibberellic acid. (Sarkar, 1957).

Effect on plant height: Both in the field and in pot-cultures, plants from presoaked seeds were taller than controls during the early stages of growth, but the differences got rather levelled off as

the plants grow older. (Table II). In some of the experiments, especially in pot-cultures, the height differences were statistically significant even at the adult stage, and of the order of 10 to 14 percent over the controls, but in general it may be said that the effects of pre-soaking treatments on plant height are not very marked.

Effect on tillering: The results of seven experiments go to show that there is no appreciable effect on tillering by any of the presoaking treatments or chemicals that were tried. In regard to flowering earliness too, that effect of presoaking was not very appreciable, but in grain yield and straw yields, distinct increases were noticeable as a result of presoaking in a number of instances. Of all the chemicals tried, tribasic potassium phosphate (K_3PO_4) appeared to be the best-suited for presoaking paddy. The strength of this chemical could be as much as molar (equivalent to 21·2 percent) but ordinarily, half-molar concentrations are effective and more convenient. Dipotassium hydrogen phosphate (K_2HPO_4) was also tested in several experiments at molar and half-molar strengths but this chemical was less helpful than the tribasic phosphate of potassium. The table below gives a good idea of the relative utility of the different salts for paddy.

TABLE VII

Effect of different phosphates on paddy.

Chemicals	Concentrations	Grain yield (per cent)	Straw yield (per cent)
K_3PO_4	... 10%	105·9	109·0
,,	... 20%	123·0	103·1
K_2HPO_4	... 10%	102·9	111·7
,,	... 20%	103·1	106·3
KH_2PO_4	... 10%	94·5	84·7
,,	... 20%	93·7	115·7
Control (not presoaked)		100·0	100·0

It would be noticed that K_3PO_4 at the higher concentration has induced the highest increase in grain yield, whereas the other two salts are less helpful in improving grain yield, although the straw yields are increased appreciably.

The responses to presoaking treatments were in general more pronounced in pot cultures than in the field, especially in grain yields. Thus the highest increase in grain yields under field conditions, as a

result of presoaking in potassium phosphate was 17·9 percent, while it was 88·8 percent in pot cultures. In straw, the maximum increase of the order of 28.7 percent in the field and 90·0 percent in pot cultures. (Table III to VI, Appendix)

Between different varieties of paddy, the responses to presoaking treatments show a fairly wide range of variations as would be evident from the table below.

TABLE VIII

Varietal response to presoaking treatments in paddy.

	Strain number	Duration (Days) (seed to harvest)	Highest percentage in increase recorded (in field trials) (on control = 100 percent).	
			Grain.	Straw.
Short duration group.	ADT. 3.	95	114·9	147·6
	CO. 13.	110	138·8	110·4 (in pot-cultures only)
	TKM. 6.	110	101·0	112·5
	CO. 10.	120	107·3	104·8
	PTB. 20.	120	114·9	119·0
	PTB. 2.	135	108·3	110·3
Medium duration group.	CO. 1.	155	97·1	123·6
	GEB. 24.	150	107·9	110·6 (field)
	GEB. 24.	150	127·5	124·2 (pots)
Long duration group.	CO. 25.	195 days.	115·6	117·2

It would be noted that in all the varieties, except TKM. 6 and CO. 1 there is a fair response in grain yield ranging from 7 to 27·5 percent under field conditions and upto 38.8 percent in the greenhouse. In straw yields, the range is from 48 to 47·6 percent increase over untreated controls.

Discussion : From the results observed in the various experiments on paddy it is evident that tribasic potassium phosphate is perhaps the most useful chemical for presoaking paddy seeds. The use of growth-hormone chemicals and micro-nutrients such as sulphates of iron, manganese, copper or zinc, was also helpful, but not always, nor was a combination of several salts, in conjunction with potassium phosphate solution, superior to presoaking in the phosphate alone.

The lower degree of response in field trials as compared to pot cultures is in line with what was noted by Rhind and co-workers in 1949. The utility of these presoaking treatments in improving drought resistance was not tested in the course of the studies, although a certain degree of drought-resistance was claimed by some workers (Uttaman, 1944) by repeated soaking and drying of paddy seeds. Presoaking in mere distilled water had no marked effect on grain yield if done once, but a repetition of the process showed an adverse effect upon grain and straw yieds. Ariyanayagam (1952, 1953) has however reported that presoaked seeds showed accelerated growth and better resistance to drought, besides showing higher yields of 20 to 46·5 percent over the controls. It is therefore clear that there is both a need and scope for considerable further work on this question of presoaking effects on crop plants.

With regard to the economics of the results achieved, it is obvious that the method of presoaking is inexpensive as well as convenient. Thus for paddy, taking the grain yield at a very low figure of 1500 lb. per acre and straw at 2000 lb. and the average increases by presoaking treatment at another low figure of 8 percent only for grain and 6 percent for straw, the increased monetary return works out to Rs. 18·75 plus 1·75 i. e. Rs. 20·50 against a cost of Rs. 6·42 per pound of the potassium sulphate that is needed for the presoaking treatment.

This method of supplying plant nutrients by soaking is definitely more efficient than supplying them through the soil and roots. For instance when oats were presoaked in K_3PO_4 solution, it was calculated (Roberts 1948) that 6 lb. of P_2O_5 were added, of which nearly three-fourths was utilised by the seedlings, whereas to get the same increase in yield from soil applications it would have been necessary to add 2 cwts. of superphosphate per acre. Presoaking is thus an economical method for supplying an initial part of the plants' nutrient requirements and has the further advantage that the remainder can be supplied at reduced rates by normal manuring or by foliar sprays.

Summary and conclusions : An account is given of studies carried out on paddy, to assess the possibilities of presoaking the seed in nutrient salt solutions, for improving growth and yields.

Potassium phosphate (tribasic) solution at 10 or 20 percent concentrations induced the most consistent increases in grain yield.

The method is both convenient and inexpensive and seems capable of giving with reasonable certainty a return by way of increased yield that is 4 to 6 times the cost of treatment, but further work is needed to ensure that this increased return is secured under all the varied conditions of soil and other environmental factors.

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REFERENCES

Agarwal, S. B. D. and S. N. Prasad.	1954	Hortomone A and late planting of sugarcane. Curr. Sci. **23** : p. 12.
Ariyanayagam, D. V.	1952	Preliminary studies on the presoaking treatment of paddy ; Trop. Agriculturist **108.**
	1953	Growth and development changes caused by presoaking treatment of paddy. Trop. Agriculturist. **109.**
Bharadwaj, S. N. and Rao, T. M.	1955	Studies on the effect of 2, 4–D, NAA, and IAA on the growth and maturity of wheat. Ind. Jour. Bot. Sci ; **34**, 218.
Ermolev, E. J.	1941	The effect of drying seeds on the growth and development of cucumbers. Ref. in Biol. Abstr. **21**, 23331.
Narayanan, T. R. and Gopalakrishnan, S.	1949	A note on presoaking in phosphate solutions, for increasing yields in rice. Madras Agric. Jour. **36.**
Ramaswamy, M. N. and Gowda, D. R.	1955	Pretreatment with coconut water to hasten germination. Indian Forester. **81**, p. 440.
Ramiah, K. et al	1952	Rice Improvement. Emp. Jour. Agri. **20.** p. 161.
Rhind, D. et al.	1949	Seed placement of phosphates in paddy. Trop. Agriculturist. **105**, p. 908.
Roach, W. A.	1949	Good Crops from poor land. Planters' Jour. **41.**
Roberts, W. O.	1948	Prevention of mineral deficiency by soaking seeds in nutrient solutions. J. Agri. Sci. **38** p. 458 – 68.
Sarkar, S.	1957	Gibberellic acid. Sci. & Cult. **23.** p. 233.
Sivtev, N. V.	1950	The influence of minor elements on the yield of corn. Chem. Abst. **50**, 1140 d.
Toole, E. H. and Drummond, P. L.	1924	The germination of cotton seed ; J. Agric. Res. **28.** p. 291.
Uttaman, P.	1944	Some preliminary observations on the effect of drying sprouted seed on viability in paddy. Madras Agric. Jour. **32.** p. 75.
Yosiyasu, D.	1942	Hormone treatment of lowland rice. Proc. Crop Sci. Soc. Japan. **13**, p. 275—8.

APPENDIX

TABLE I

Presoaking effect on seedling growth in paddy (GEB. 24)

(Mean of 100 seedlings — examined when 45 days old)

Treatments	Seedlings			
	Mean length of shoots (cms.)	Mean length of roots (cms.)	Dry weight shoots (gms.)	Dry weight roots (gms.)
1. Presoaked in water alone (3 times)	42·4	13·0	14·0	5·5
2. Presoaked in K_3PO_4 (M/2) twice	33·2	12·2	15·5	4·0
3. Presoaked in KNO_3 (M/2) twice	31·6	13·8	20·5	7·0
4. Presoaked in (NH4) H_2PO_4 (M/2) twice	40·8	13·8	31·5	9·0
5. Presoaked in Knop's solution (M/2) twice	42·4	11·9	25·0	8·0
6. Presoaked in K_3PO_4 and Fe, 50 p. p. m.	35·8	15·5	24·5	6·0
7. Presoaked in K_3PO_4 and Mn, 20 p. p. m.	30·7	10·8	17·5	5·0
8. Presoaked in K_3PO_4 and Cu, 20 p. p. m.	34·9	12·7	17·5	4·5
9. Presoaked in K_3PO_4 and Cu, and Mn.	34·9	9·4	20·5	6·5
10. Presoaked in K_3PO_4 and all trace elements salts, Cu, Mn, Fe.	37·4	12·4	22·5	7·5
11. Urea spray 15 lb. per acre at preflowering stage	32·5	12·2	17·0	5·5
12. Control (not soaked)	22·9	8·8	9·0	3·5

TABLE II

Effect of Presoaking Treatments on Plant heights on Paddy

Treatments : Six

Replications : Six

Variety. GEB. 24.

	Field – Central Farm Wetlands. Sown on 13—7—54.										Pot cultures. Sown on 11—10—54.									
	3rd Oct. Mean height (cm.)	%	13th Oct. Mean height (cm.)	%	23rd Oct. Mean height (cm.)	%	3rd Nov. Mean height (cm.)	%	13th Nov. Mean height (cm.)	%	1st Nov. Mean height (cm.)	%	11th Nov. Mean height (cm.)	%	22nd Nov. Mean height (cm.)	%	8th Dec. Mean height (cm.)	%	23rd Dec. 1954 Mean height (cm.)	%
1. Control (Not soaked)	37·4	100 0	52·5	100·0	64·3	100·0	74·3	100·0	96·8	100·0	14·5	100·0	34·9	100 0	44·3	100·0	60·8	100·0	67·3	100·0
2. Presoaked in K_3PO_4 (M/2) and Mn 10 ppm., twice	40·4	108 0	54·7	104·2	65·2	101·3	75·2	101·3	97 7	101·0	16·7	115·0	37·3	106·9	43·9	99·2	56·0	92·1	62·5	92·9
3. Presoaked in K_3PO_4 (M/2) and Cu & Mn. 10 ppm. each, twice	41·6	111·1	54 6	104 0	64·5	100·2	77·1	103·1	98·7	102·1	22·0	151·9	37·5	107·4	41·9	94·7	51·1	84·1	68 9	102·3
4. Presoaked in K_3PO_4 (M/2) and all trace elements salts, twice	41·3	110·4	52·9	100 9	63·8	99·2	78·1	105·1	98·8	102·1	23·5	162·1	36·3	104·0	40·3	91·0	48·4	79·7	69 0	102·6
5. Urea 0·25%, twice	40 7	108·7	53·2	101·4	63·5	98·6	73·3	98·7	100·4	103·8	27·7	191·2	40·3	115·3	45·3	102·3	59·6	97·2	61·2	90·0
6. Urea 0·25% & trace elements salts, twice	38·0	101·6	53·2	101·4	62·3	96·9	74·4	100·2	96·9	100·1	28·9	199·8	39·3	112·6	42·4	95·8	51·6	84·9	61·9	93·0
Whether differences are significant or not.	Yes. at 5%		No.		No.		No.		Yes at 5%		Yes at 1%		Yes.		No.		No.		Yes	
Critical difference at 5% level	2·6% cm.								5·51 cm.		1·94 cm.		1·94 cm.						2·86	

TABLE III.

Effect of Presoaking in Nutrient Salts on Paddy Yields.

1953—Grain and Straw Yields

Venue : Coimbatore
Sown : 13th July, 1953
Transplanted : 25th August, 1953
Harvested : 8 & 9th December, 1953

Variety : GEB. 24
Treatments : 12
Replications : 4
Layout : In randomised plots of 0·72 cents gross and 0·70 cents nett area, in field trial.

Treatments	Central Farm, Coimbatore				Pot cultures			
	Grain		Straw		Grain		Straw	
	lb./acre	% on control = 100	Mean yield lb./acre	% on control = 100	Mean yield gm./pot	% on control = 100	Mean yield gm./pot	% on control = 100
1. Presoaked in water alone (3 times and air-dried)	4,054	100·2	9,429	100·0	6·95	95·2	8·23	99·4
2. Presoaked in K_2PO_4 (M/2) - twice	4,197	103·8	10,429	110·6	8·33	114·2	10·02	121·4
3. ,, KNO_3 - (M/2) ,,	4,009	97·4	9,214	97 7	8·80	120·6	9·30	112·3
4. ,, $(NH_4) H_2PO_4$ - (M/2) twice	4,286	105·9	9,786	103·8	8·45	105·5	9·08	109·6
5. ,, Knops solution M/2 twice	4,269	105·5	9,400	99·8	13·75	188·8	15·73	190·0
6. ,, (2) plus $FeSO_4$ Fe - 50 ppm. twice	4,233	104·7	9,757	103·4	9 30	127·5	10·13	122·3
7. ,, (2) plus Mn 20 ppm.	4,313	106·6	9,786	103·8	8·98	123·0	10·28	124·2
8. ,, (2) plus Cu. 20 ppm.	3,866	93·8	9,400	99 8	9·18	125·7	10·75	129·8
9. ,, (2) plus Cu. and Mn.	4,366	107·9	9,216	108·8	8·08	110·7	9·35	112 9
10. ,, (2) plus all trace elements salts	4,187	103·5	11,714	124·3	7·75	106·2	4·98	60·2
11. Spray with Urea 15 lbs. per acre at pre-flowering stage	4,297	106·1	10,500	111·4	7·68	105·2	8·73	150·2
12. Control (not soaked)	4,044	99·9	9,429	100·0	7·30	100·0	8·28	100·0
Whether differences are significant are not	No.		No.		Yes.		Yes.	
Critical difference, at 5% level					3·43 gms.		2·15 gms.	

TABLE IV.

Effect of Presoaking in Nutrient Salts on Paddy yields.

1954 - Grain and Straw.

Venue	Central Farm, Wetlands.	Variety	GEB. 24
Sown	13th July, 1954	Treatments	Six:
Transplanted	3rd September, 1954	Replications	Six.
Harvested	20th December, 1954.	Layout	in randomised plots of 1·2 cents gross and 1·0 nett.

Treatments.	Sheaves (fresh weight)		Grain		Straw	
	lb/acre.	% on control = 100	lb/acre.	% on control = 100	lb/acre.	% on control = 100
1. Control (not soaked).	10,670	100·00	2950	100·0	7340	100·0
2. K_2PO_4 (M/2), plus Mn 10 ppm. presoaked twice 8 hours.	10,450	97·92	2980	101·0	7120	97·0
3. ,, plus Mn plus Cu. 10 ppm. do.	10,740	100·70	3080	104·4	7150	97 4
4. ,, plus trace elements Fe, Cu, Mn, Zn twice.	10,140	95·01	2960	100·3	6830	93·1
5. Urea 0·25% presoaked, twice.	10,930	102·40	3080	104·4	7490	102·3
6. Urea 0·25% plus trace elements, twice.	11,060	103·60	3140	106·4	7530	102·6
Whether differences are significant or not.	Yes. at 5 % level		No.		No.	
Critical difference 5 % level.	20·5 lb.	0·67				
Ranking	6, 5, 3, 1,	2, 4				

TABLE V.

Effect of Presoaking in Nutrient Salts on Paddy Yields

1955 — '56, Summary of results on grain and straw yields from five experiments carried out at four locations, using five paddy strains and involving two levels of fertility. The fertility level differences are not presented in these summary tables.

Treatments.	Central Farm Coimbatore (CO. 1)				Agricultural Research Station, Tirukuppam (TKM. 6)				Agricultural Research Station, Aduthurai (ADT. 3)				Agricultural Research Station, Pattambi (PTB. 2)				Agricultural Research Station, Pattambi (PTB. 20)			
	Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw	
	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%	lb./acre	%
1. Control (not soaked).	1390	100·0	2784	100·0	3055	100·0	5110	100·0	2816	100·0	2326	100·0	2822	100·0	5380	100·0	1150	100·0	5895	100.0
2. Presoaked. K_2HPO_4 (M/2)	1350	97·1	3436	123·4	3027	99·0	5181	101·3	2756	97·9	2624	112·8	2910	103·1	5411	105·8	1181	102·7	5835	98.9
3. (2) plus Mn	1305	93·9	2892	103·9	2977	90·0	5479	107 2	2695	95·8	2472	106·3	2881	102·1	5285	98·2	1281	111·4	5737	97.3
4. (4) plus Mn plus Cu & Fe	1320	94·9	3173	113·9	3040	99·2	5380	105·3	2816	100·0	2996	128·7	2882	102·1	4989	92·7	1179	102·5	5396	91·5
5. (2) plus all trace elements as spray	1350	92·1	2556	91·7	3009	98·4	5522	108·0	2866	101·8	2503	107·6	2404	85·2	4191	77·9	1088	94·9	4884	82.9
6. Presoaked in $ZnSO_4$ 10 ppm.																	1300	113·0	5142	87·2
7. Presoaked in K_3PO_4 & Zn 10 ppm.																	1245	108·2	5606	95·1
8. Presoaked in K_3PO_4 & Cu. 10 ppm.																	1215	105·6	5499	93·3
Whether differences are significant or not	No.		Yes.		No.		Yes.		No.		Yes.		Yes.		Yes.		Yes.		Yes.	
Critical difference at 5% level.			694 lb.				308 lb.				339 lb.		261 lb.		864 lb.		120 lb.		476 lb.	

TABLE VI

Effect of Presoaking in Nutrient Salts - on Paddy yields.

1956—57 Summary of results on grain and straw yields, from three experiments in three locations

Layout — Simple randomised plots

Treatments — Nine

Replications — Four

Treatments	Central Farm, Coimbatore Co. 25				Agricultural Research Station, Pattambi PTB. 2				Agricultural Research Station, Tirurkuppam TKM. 6			
	Grain		Straw		Grain		Straw		Grain		Straw	
	lb./acre	% on Control =100	lb./acre	% on Control =100	lb./acre	% on Control =100	lb./acre	% on Control =100	lb./acre	% on Control =100	lb./acre	% on Control =100
1. Control (not soaked)	4425	100·0	11,137	100·0	3141	100·0	7921	100·0	3608	100·0	5334	100·0
2. Water-soaked (16 hours)	4650		11,590	104·1	3042	97·4	7527	94·9	3348	93·1	4576	85·8
3. Presoaked in K_3PO_4 (M/2)	4575		13,015	116·6	3173	101·0	8286	104·6	3576	99·4	5169	66·9
4. Presoked in β indolyl-acetic acid	4475		13,030	116·9	3053	97·2	7849	99·1	3618	100·2	4329	81·2
5. Presoaked in naphthalene-acetic acid 50 ppm.	4400		10,517	94·4	3274	104·2	8213	103·7	3439	95·3	3807	71·4
6. (3) plus (4)	4525		10,062	90·3	3168	100·9	7703	97·2	3563	98·8	5727	107·9
7. (3) plus (5)	4325		10,525	94·5	3289	104·7	8548	107·9	3511	97·3	5232	98·1
8. Spray with β indolyl-acetic acid 100 ppm.	3000		12,587	113·0	3273	104·2	8254	104·6	3381	93·7	5458	102·2
9. (3) plus (8)	3575		13,057	117·2	3325	105·8	8248	104·1	3477	96·4	5533	103·7
Whether differences are significant or not		Yes.	Yes.		No.		Yes.		No.		Yes.	
Critical difference, at 5% level	592 lb.		3,015 lb.				698 lb.				919 lb.	