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Effect of Potash Application on Needle Cast of the Korean Red Pine(Pinus densilfo a S.et Z.)

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ABSTRACT

NPK experiment with two year old Korean red pine tree seedlings produced in Kangwon Province has been conducted during four years from 1963 to 1966 through pot trial.

In order to minimize experimental error, this experiment laid out 27 treatments with 8 replications. The result of this experiment revealed that responses to nitrogen and phosphorus fertilizers were distinct whilst its response to potassium fertilizer was negligible when seedlings were free from the needle cast infection.

After needle cast disease was seriously infected, however the response to potassium was very outstanding and followed by phosphorus effect. The response to nitrogen was not able to be observed among the levels of nitrogen application. Therefore, it may be said that potassium application could produce healthy pine seedlings those which tolerant to the needle cast infection.

Introduction

This experiment which is originally designed as NPK factorial trial made plantation with seedlings produced in Kangwon Province on march 20, 1963 in the pot where filled with infertile soil derived from granite mother rock and the investigation and analysis were made in every October during four years through 1966.

Although this experiment was originally aimed to evaluate the optimum quantities of NPK application for pine tree seedlings, the response of seedlings to NPK was varied between the period before the infection of needle cast and after the infection period.

In other, word a distinct NP effect and a minor K effect were observed before the infection of needle cast disease, however, an adverse phenomenon has been observed after the severe infection of needle cast disease which high K effects were resulted on seedlings. With this

result, it was revealed that infected seedlings showed great response to potassium application and seedlings adequately supplied with potassium fertilizer showed strong tolerance from needle cast infection.

History of related experiment

1. Ishizuka and Tanaka reported in 1951 that potassium deficiency symptom can be appeared on rice plant when it contains less than 1.01 percont of K_2O in rice straw. (11)

2. Delter Bruning observed in 1959 that trunk diameter of pine tree at potassium and magnesium supplied plot showed more than 1 cm greater than that of deficient plot and potassium and magnesium application also helped drought resistance on seedlings and young trees and they accelerated growth of the poor growing trees. (4)

3. Ogihara found in 1960 that potassium deficiency could occur in the soil which contains less than 12 mg exchangeable K_2O per 100 gram dried soil.

4. Shibamoto reported in 1961 that potassium application in the half amount of NP dose could contribute for increasing tree root weight but not distinct effect on the growth and it produced bigger leaf in the early growing stage but not so in the later stage. An excess quantity of potassium application may inhibit other nutrients uptake and could lead to poorer growth. (15)

5. Chung observed through fertilizer experiment on larch, alder, pitch pine, Korean white pine and oak trees in 1964 that potassium effect was obviously distinct on rigida pine than other trees. (2)

6. Shibamoto found in 1965 that defoliation disease on Japanese larch started infection to two year old trees after transplantation and the most severe damage was reported among 7-20 year old trees and densed plantation. In this study with relation to the soils, the heavier damage was found where available phosphorus, potassium and nitrate from nitrogen deficient soils with high content of exchangeable calcium. (15)

7. Herman Mayor-Kropoll observed in 1965 a healthy poplar stand can be maintained by applying 80-120 kg/ha K_2O. (7)

8. Tsutzumi found in 1965 througih NPK treatment to Japanese larch with being inoculated fungus of the defoliation disease that the most severe damage was reported from potassium deficient treatment and followed by phosphorus deficient. Plot where completely treated with NPK had very slight damage by defoliation disease. Potassium, in the plant, does not included in the organic compound but exist either ion or status to be easily ionize and by translocating from old tissues to the new one it influences on the physio-chemical composition of cell plasma and permeability of the plasma membrane. The function of potasium was also known to increase carbohydrate content and by increasing cellulose and lignin, it build strong plant tissue thereafter to improve disease resistant. (8)

9. G.K. Voigt observed in 1965 that potassium mineral released from biotite and muscovite was found more in quantities from 28 month old slash pine than that of 16-19 month old seedling and weathering was closely related with the function of root tip and bacteria activity in top soil. (6)

10. Lee, Shi Chong reported in 1966 that potassium application was effective to prevent the occurrence of bacterial leaf blight disease on rice plant. However, an excess amount of potassium application seemed to be helped further occurrence of this disease.

In other word, potassium application is effective to build rice plant tolerant from the infection of bacterial leaf blight but its effect is not proportionate to increased quantities of potash application and its over dose showed even an adverse effect. (11)

11. Cho, Han Yong found potassium effect

from the stuby of NPK treatment and rice stripe disease in 1966 as in the followings:

Nitrogen application induced disease infection proportionate to the application amount while phosphate application showed the maxim um disease infection at the standard amount of phosphate application but disease infection was declined as to increasing the amount of phosphate application. Potassium was not significantly effective to the infection of rice stripe disease but the standard amount of potassium application showed a slight effect over no potassium applied plot. (11)

12. Hiroshi, Kawada observed in 1966 that K_2O uptake was greater in pine tree root while N uptake was greater in the trunk. P_2O_5 and Mg uptake were not distinctive between the root and trunk. (9)

Materials and methods

1. Materials used

(1) Tested tree

Tree	Age of seedling	Height	Root diameter	Root length	Remarks
Pinus densiflora S. et Z.	2-6	8cm	3.5mm	16cm	Produced in Pyogchang, Kangwon province

(2) Soils used

Horizon	Chemical						
B/C	pH	Yl	O.M%	Total N%	Available P_2O_5 ppm	Cation capacity	Exchange me/100g
	5.36	14.8	0.36	0.161	25.31	7.70	

properties						
Exchangeable (me/100g)					Total base	Base saturation %
H+	K+	Na+	Ca++	Mg++		
4.40	0.24	0.06	1.63	0.88	2.86	37.2

Physical properties					
Gravel	clay	silt	fine sand	coase sand	texture
46	2.5	1.8	15.0	34.7	sandy loam

(3) Fertilizer used: Urea, Triple superphosphate, Muriate of Potash

2. Method

An amount of 0.027 kg soil was filled into a pot(30cm in diameter, 40cm in height) and fertilizers applied in accordance with the following fertilizer treatment and planted a tree per pot.

Plot layout was 3^3 factorial design and complete randomize block with 8 replications. Fertilizer

treatment is as in the following table:

	N_0			N_1			N_2			Remarks
	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2	N_0)
	N_0	N_0	N_0	N_1	N_1	N_1	N_2	N_2	N_2	P_0) 0
K_0	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2	K_0)
	K_0	K_0	K_0	K_0	K_0	K_0	K_0	K_0	K_0	N_1····· 3g
	N_0	N_0	N_0	N_1	N_1	N_1	N_2	N_2	N_2	P_1····· 6g
K_1	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2	K_1····· 2g
	K_1	K_1	K_1	K_1	K_1	K_1	K_1	K_1	K_1	N_2····· 6g
	N_0	N_0	N_0	N_1	N_1	N_1	N_2	N_2	N_2	P_2····· 12g
K_2	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2	
	K_2	K_2	K_2	K_2	K_2	K_2	K_2	K_2	K_2	K_2····· 4g

Experimental result

1. The average tree height by treatment and year (1963-1966)

The tree height investigated in October from 1963 to 1966 are as follow:

Treatment			Year			
N	P	K	1963	1964	1965	1966
0	0	0	12.50	19.26	26.2	32.9
0	0	1	11.65	19.21	26.5	33.0
0	0	2	12.25	18.91	27.1	37.1
0	1	0	12.50	20.06	27.3	32.2
0	1	1	12.00	19.81	27.7	30.8
0	1	2	12.50	19.53	28.0	34.4
0	2	0	13.00	21.30	28.1	33.8
0	2	1	12.50	21.56	29.1	47.1
0	2	2	11.65	20.90	29.6	39.1
1	0	0	11.50	21.91	23.5	33.1
1	0	1	12.50	21.66	28.8	37.0
1	0	2	12.25	21.91	30.1	43.2
1	1	0	12.50	23.07	29.2	37.5
1	1	1	13.25	24.70	31.2	40.2
1	1	3	13.75	25.81	34.5	44.9
1	2	0	14.25	24.90	29.0	41.9
1	2	1	12.75	24.25	30.8	44.5
1	2	2	12.50	25.08	33.3	49.4

Treatment			Year			
N	P	K	1963	1964	1965	1966
2	0	0	14.00	22.66	32.7	38.0
2	0	1	13.00	23.52	32.0	40.0
2	0	2	13.25	23.55	34.8	45.6
2	1	0	15.75	26.07	30.3	40.5
2	1	1	13.00	25.13	30.7	41.1
2	1	2	12.75	26.97	32.5	48.2
2	2	0	14.00	27.21	32.2	38.0
2	2	1	12.50	25.52	34.1	46.2
2	2	2	15.00	28.92	37.3	50.4
Total average			12.93	23.09	30.4	40.03

year			K_0	K_1	K_2	Sum	Mean
1963	N_0	P_0	12.50	11.65	12.25	36.40	12.13
		P_1	12.50	12.00	12.50	37.00	12.33
		P_2	13.00	12.50	11.65	37.15	12.38
		Sum	38.00	36.15	36.40	110.55	12.28
		Mean	12.66	12.05	12.13		
	N_1	P_0	11.50	12.50	12.25	36.25	12.08
		P_1	12.50	13.25	13.75	39.50	13.16
		P_2	14.25	12.75	12.50	39.50	13.16
		Sum	38.25	38.50	38.50	115.25	12.08
		Mean	12.75	12.83	12.83		
	N_2	P_0	14.00	13.00	13.25	40.25	13.41
		P_1	15.75	13.00	12.75	41.50	13.83
		P_2	14.00	12.50	15.00	41.50	13.83
		Sum	43.75	38.50	41.00	123.25	13.69
		Mean	14.58	12.83	13.66		
1964	N_0	P_0	19.26	19.21	18.91	75.38	19.12
		P_1	20.06	19.81	19.53	59.40	19.80
		P_2	21.30	21.56	20.90	63.76	21.25
		Sum	60.62	60.58	59.34	180.54	20.06
		Mean	20.20	20.19	19.78		

year			Ko	K_1	K_2	Sum	Mean
1964	N_1	P_0	21.91	21.66	21.91	65.48	21.82
		P_1	23.07	24.70	25.81	73.58	24.52
		P_2	24.90	24.25	25.08	74.23	24.74
		Sum	69.88	70.61	72.80	213.29	23.69
		Mean	23.29	23.53	24.26		
	N_2	P_0	22.96	23.52	23.55	69.73	23.24
		P_1	26.07	25.13	25.97	.78.17	26.05
		P_2	27.21	25.52	28.92	81.65	27.21
		Sum	75.94	74.17	79.44	229.55	25.50
		Mean	25.31	24.72	26.48		
1965	N_0	P_0	26.2	26.5	27.1	79.80	26.60
		P_1	27.3	27.7	28.0	83. 0	27.66
		P_2	28.10	29.1	29.6	86.8	28.93
		Sum	81.60	83.3	84.7	249.6	27.73
		Mean	27.20	27.76	28.23		
	N_1	P_0	23.5	28.8	30.1	82.4	27.46
		P_1	29.2	31.2	34.5	94.9	31.63
		P_2	29.0	30.8	33.3	93.1	31.03
		Sum	81.7	90.8	97.9	270.4	30.04
		Mean	27.23	30.26	32.63		
	N_2	P_0	32.7	32.0	34.8	99.5	33.16
		P_1	30.30	30.7	32.5	93.5	31.16
		P_2	32.2	34.1	37.3	103.6	34.53
		Sum	95.2	96.8	104.9	296.6	32.95
		Mean	31.73	32.26	34.86		
1966	N_0	P_0	32.9	33.0	37.1	103.0	34.33
		P_1	32.2	30.8	34.4	97.4	32.46
		P_2	33.8	47.1	39.1	120.0	40.00
		Sum	98.9	110.9	110.6	320.4	35.60
		Mean	32.96	36.96	36.86		
	N_1	P_0	33.4	37.0	43.2	113.6	37.86
		P_1	37.5	40.2	44.9	122.6	40.86
		P_2	41.9	44.5	49.4	135.8	45.26
		Sum	112.8	121.7	137.5	372.0	41.33

Year			K_0	K_1	K_2	Sum	Mean
1966	N_2	Mean	37.60	40.56	45.83		
		P_0	38.0	40.0	45.6	123.6	41.20
		P_1	40.5	41.1	48.2	129.8	43.26
		P_2	38.0	46.2	50.4	134.6	44.86
		Sum	116.5	127.3	144.2	388.0	43.11
		Mean	38.83	42.43	48.06		

2. The annual NPK effect evaluated by the analysis of variance

Treatment	df	1963 S.S	1963 M.S	1963 F	1964 S.S	1964 M.S	1964 F
Total	215	334.6			3,948.66		
Replication	7	4.6			106.10	75.14	
Treatment	26	200.0	7.69	10.77	1,603.4		
N	2	71.3	35.65	39.63**	1,107.8	553.9	45.03**
P_2O_5	2	15.6	7.8	10.9 **	340.0	170.0	13.81*
K_2O	2	20.4	10.2	14.28	19.8	9.90	
NP	4	6.7	1.67		33.8	8.45	
NK	4	21.2	5.25		49.6	12.4	
PK	4	6.9	1.72		13.1	3.25	
NPK	8	57.9	7.24	10.14	39.3	4.81	
Error	182	130.0	0.71		2,239.16	12.30	
L.S.D.		22,871			17.86		
Fertilizer effect		$N_0<N_1<N_2$ $P_0<P_1=P_2$ $K_0>K_1=K_2$			$N_0<N_1<N_2$ $P_0<P_1<P_2$ $K_0=K_1<K_2$		
Infection of needle cast		Healthy Seedling			very slightly infected (practically healthy)		

Treatment	df	1965 S.S	1965 M.S	1965 F	1966 S.S	1966 M.S	1966 F
Total	215	6 018.84			19,905.71		
Replication	7	148.34	21.19		262.61	41.81	
Treatment	26	2,276.04	87.54		6,652.71	255.87	3.59**
N	2	990.54	495.27	24.73*	2,191.51	1,095.75	15.38**
P_2O_5	2	132.84	66.42	3.32*	1,248.90	624.45	8.76**
K_2O	2	257.46	128.73	6.43**	1,863.51	931.75	13.09**
NP	4	80.60	20.15		289.05	72.26	
NK	4	58.54	14.63		277.69	69.42	
PK	4	31.29	7.82		411.46		
NPK	8	31.29	90.59		370.59		
Error	182	724.77	20,024.5		12,960.33		
L.S.D.			129.62			228.54	
Fertilizer effect		$N_0<N_1=N_2$ $P_0=P_1=P_2(P_0<P_2)$ $K_0=K_1<K_2$			$N_0<N_1=N_2$ $P_0=P_1<P_2$ $K_0<K_1<K_2$		
Infection of needle cast		All out infection			Severe		

3. Disease infection investigation by treatment (1966)

Treatment			Replication								
N	P	K	1	2	3	4	5	6	7	8	Sum
0	0	0	—	+	—	—	+	—	—	—	2
0	0	1	—	—	+	—	—	+	—	—	2
0	0	2	+	—	+	+	—	+	+	—	5
0	1	0	—	—	—	—	+	+	—	—	2
0	1	1	—	—	+	—	+	—	—	+	3
0	1	2	+	+	—	+	—	+	+	+	6
0	2	0	—	+	—	—	—	—	+	+	3
0	2	1	+	—	+	—	+	—	+	—	4
0	2	2	+	+	—	+	+	+	+	+	7
1	0	0	—	—	—	—	—	—	—	—	0
1	0	1	—	+	—	—	—	—	—	+	2
1	0	2	—	+	—	+	—	—	+	+	4
1	1	0	—	—	—	+	—	—	—	—	1
1	1	1	+	—	—	—	—	—	—	+	2
1	1	2	+	+	—	+	—	+	—	+	5
1	2	0	—	+	—	—	+	—	—	—	2
1	2	1	—	+	—	+	—	—	+	—	3
1	2	2	+	+	—	+	+	+	—	+	6
2	0	0	—	—	—	—	—	—	—	—	0
2	0	1	—	+	—	—	—	—	+	—	2
2	0	2	+	+	—	—	+	—	—	—	4
2	1	0	—	—	+	—	—	+	—	—	2
2	1	1	—	+	—	—	+	—	+	—	3
2	1	2	—	+	—	+	+	—	+	+	4
2	2	0	—	—	+	+	—	—	+	—	3
2	2	1	+	—	+	—	—	+	—	—	3
2	2	2	+	+	+	—	—	+	+	+	6
Total			10	15	8	9	10	10	12	12	86

*(—) indicate complete defoliation due to needle cast on May 20, 1966

**(+) indicate healthy seedlings from 1963 thru 1966.

4. Disease tolerance by NPK application

Year			K_0	K_1	K_2	Sum	Mean
1966	N_0	P_0	2	2	5	9	3.0
		P_1	2	3	6	11	3.7
		P_2	3	4	7	14	4.7
		Sum	7	9	18	34	3.7
		Mean	2.3	3.0	6.0		
	N_1	P_0	0	2	4	6	2.0
		P_1	1	2	5	8	2.7
		P_2	2	3	6	11	3.7
		Sum	3	7	15	25	2.7
		Mean	1.0	2.3	5.0		
	N_2	P_0	0	2	4	6	2.0
		P_1	2	3	4	9	3.0
		P_2	3	3	6	12	4.0
		Sum	5	8	14	27	3.0
		Mean	1.7	2.7	4.7		

5. Analysis variance of needle cast tolerance

Source of variation	d.f	S.S	M.S	F
Total	215	51.76		
Replication	7		0.17	
Treatment	26	10.54	0.41	
N	2	0.62	0.31	
P	2	1.78	0.89	4.06*
K	2	7.56	3.78	17.26**
NP	4	0.02	0.005	
NK	4	0.26	0.065	
PK	4	0.08	0.02	
NPK	8	0.19	0.024	
Error	182	39.98	0.219	

$K_0 = K_1 < K_2$

$P_1 = P_0 < P_2$

L.S.D. = 16.718

Discussion

1. N, P_2O_5, K_2O are essential nutrients for pine tree growth however, the effect of ferti izer application for pine seedlings in the first and second year appeared to be in order of N, P_2O_5 and K_2O.

2. From third year Which following the all out infection of needle cast, K_2O effect appeared far greater than those of N and P_2O_5.

3. With the above findings, it may be said that a single dose of small amount of fertilizer application on pine seedlings showed relatively high fertilizer effect in the first and second year however, in third year with diminishing fertilizer effect it may be induced all out infection of dormanted needle cast.

4. A distinct potassium effect showed after the infection of disease may be observed due to the function of Potassium in the plant to help carbohydrate and fiber formation which remains the plant healthy and disease resistant.

It was also observed that high potassium content in the plant could maintain green leaves and either aged or disease infected plant drastically reduced potassium but increased calcium content in the plant.

Conclusion

1. Pine tree responded most to the nitrogen application and NPK effect was in order of N> P_2O_5>K_2O.

2. In the third year when needle cast infected, potassium effect was highly significant and phosphorus showed significance at 5% level

3. Although potassium response on the tree growth was not as high as that of nitrogen, its response was clearly observed after the disease infection.

4. Prior to the infection of needle cast, potassium effect was negligeable contrary to the effects of nitrogen and phosphorus on the growth however, potassium application resulted to produce healthy and disease free seedlings afterwards.

5. This nitrogen and phosphorus were highly effective pre-infection period of needle cast whilst potassium was significantly effective postinfection period of the needle cast.

摘　　要

소나무 묘목을 이용하여 포지에서 비료 3요소 시험을 3^3요인 시험으로 3반복을 실시하여 1963년부터 1966까지 4년간 실시한 결과는 다음과 같다.

1. 소나무는 삼요소중 질소비료에 대하여 가장 비효가 컸으며 질소, 인산, 가리의 순위였으나

2. 3차년도 이후는 Needle cast가 발병하여 가리에 대하여 고도의 비효가 있었으며 인산에 대하여는 0.5%의 유의성이 있었다.

3. 가리는 소나무 생장에는 질소와 같이 크게 비효를 나타내지 못하였으나 Needle cast가 만연된 후에는 가리의 시용구에서는 비효를 나타 내었다.

4. 즉 소나무에 있어서는 Needle cast 발병전에는 질소 및 인산의 비효가 크게 나타났으며 가리의 시용구가 신장 생장에는 크게 영향을 주지 못했으나 건묘로서 내병성이 강하였으므로 결과적으로 비효가 크게 인정되었다.

5. Needle cast 발병 전에는 가리의 비효가 나타나지 않았으나 발병 후에는 질소나 인산보다도 가리의 시비효과가 크게 인정되었으며 그 효과는 가리, 인산, 질소의 순위이었다.

Literature cited

1. Chiba O. T. Hamak, 1965, Survey on the needle cast in Larch Forest (Gov. For. Exp. Sta. 178 P. 48-71)
2. Chung, In Koo, 1964, The response of Larch and Four other tree species to Basic applications of Commercial Fertilizer. (The Research Reports of the Office of Rural Development Vol. 7, No. 2 P. 45-51)
3. Chung, In Koo, 1966, N. P. K. quantitative Experiment on Alder at Forest Land, a

collection of papers in commemoration, the 60th anniversary of the foundation of Agriculture college Seoul National University.

4. Detlev Brung, 1959, Forest Dungung (P. 202-204)

5. Furukawa T.S. Takai and F. Hama, 1965, Effect of needle cast on growth and physiology of the host. (Gov. For. Exp. Sta. 178 P. 116-143)

6. Voigt, G.K., 1965, Biological Mobilization of potassium from primary Minerals. (Forest Soil Relationships in North America P. 33-44)

7. Hermann Mayer-Kropoll, 1956, The use of commercial Fertilizers particularly Nitrogen in Forestry (P. 70-87)

8. Kawada, Hiroshi, 1965, A study on correlation of the needle cast soil condition growth and composition of needles of young Larch Forest in Otaki National Forest (Gov. For. Exp. Sta. 178 P. 72-94)

9. Kawada, Hiroshi, 1966, A study on seasonal Variation of Nutrient Absorption of Two-year-old Pinus densiflora seedling.

10. Ito. K. Sato and N. Ota, 1957, Studies on the needle cast of Japanese Larch life history of the causal fungus mycosphaesella Larch. (Gov. For. Exp. Sta. 96 P. 69-88

11. Lee, Shi chong, 1966, The Influence of potash on the Resistance of the Rice plant against diseases (potassium symposium P. 77-83)

12. Lutz and chandler, 1960, Forest Soils P. 352-354

13. Makisaka, Saburo, 1963, On the action of potassium in the First-year Seedling of Pinus densiflora.

14. Tisdale Samuel L., 1956, Soil Fertility and Fertilizes (P. 78-87, 188-193)

15. Shibamoto Takeo, 1962, Theory and practice of Fertilization on Forest Land P. 115-117