

The effect of potassium nitrate based foliar sprays on growth and yield of soybean fertilized with increasing KCl dose rates at basal dressing.

Aim of the trial

The aim of the trial was to study the effect of potassium nitrate (PN) based foliar applications on soybean growth and yield parameters. Soybean was fertilized with potassium chloride (KCl) as base dressing at four K dose rates: respectively 0%, 50%, 75% and 100% of the supposed crop K-removal, based on an expected yield of 4.0 – 4.5 MT/ha.

Materials and Methods

The trial was conducted by Landlab R&D company at their research station in Quinto Vicentino (VI) in Italy.

Prior to the trial, the area was cultivated with barley in order to deplete residual fertility of the soil; Barley plants and straw were removed before the soybean sowing and the soil structure was amended with sand. First a 6-7 cm layer of silica sand (ϕ 0-2 mm) was worked in the top 20-25 cm of soil. Mid-May 2015, two weeks before sowing, another 3-4 cm layer of silica sand was worked in the top 20-25 cm of soil. After the addition of silica sand, the soil texture was changed from a loamy-sandy-clay soil into a sandy loam soil.

Base dressing of KCl was applied on the 26th of May, one day before sowing. No other fertilizers were applied in the base dressing.

Sowing of soybean with Rhizobium inoculum was carried out on the 27th of May 2015. Harvesting was done on the 20th of October 2015.

The effect of the treatments was tested in a completely randomized design with two factors:

1. K dose rate in basal dressing with KCl (Table 1).
2. Foliar treatments (Table 2).

In total, the trial consisted of 80 plots (4 K dose rates x 4 foliar treatments x 5 replicates). Plot size was 2.0 m x 1.5 m = 3.0 m².

Foliar treatments were applied two times: at the growth stages V3 (Third node, 29th of June) and R3 (Beginning pod development, 28th of July 2015). Foliar application was done plot by plot at a spray volume of 600 L/ha.



Table 1. Basal dressing with KCl at increasing dose of K.

Level	K dose in basal dressing as percentage of crop K-removal	Potassium chloride (KCl) applied at basal dressing
	%	Kg K ₂ O/ha
1	0	0
2	50	50
3	75	75
4	100	100

Table 2. Foliar treatments.

Level	Foliar treatments*, applied twice: at growth stage V3 and R3.
1	No foliar treatment (control)
2	PN 5 kg/ha/application
3	PN 5 kg/ha/application + UP 3 kg/ha/application
4	PN 5 kg/ha/application + MAP 2.2 kg/ha/application

*) PN = potassium nitrate; MAP = monoammonium phosphate; UP = urea phosphate.

The following parameters were assessed:

- plant development as number of germinated plants/m², 22 days after sowing
- phytotoxicity, 3 days after each foliar treatment
- maximum height of the plants at time of harvest
- yield
- number of pods/plant
- number of seeds/pod
- weight of 1000 seeds
- % of oil and protein in the grains

Statistical Analysis

Statistical analysis was performed using GenStat data analysis software version 16.1. (VSN International). Significant differences were assessed with ANOVA, using Generalized Linear Model (GLM), followed by Fisher's protected least significant difference test to compare means wherever ANOVA indicated significant effects. Means were considered significantly different from one another at $\alpha=0.05$ (5%).

Weather conditions

During the summer time (May- August) rainfall was not consistent and high evapotranspiration values were reached. Also temperatures were high (between 25°C and 36°C). to the trial field was

irrigated 4 times during summer. In September and October, weather data were in line with expectations.

Results and Discussion

Phytotoxicity

Three days after each foliar treatment phytotoxicity was assessed as the % of damaged leaf area (necrosis, chlorosis or deformations). No symptoms of phytotoxicity were seen at any stage comparing the foliar treated plots to the non-treated ones.

Plant development

The number of germinated plants was assessed on the 17th of June (22 days after sowing). The grand mean for germination was 33 plants/m². There was no statistically significant effect of neither of the two treatment factors.

Maximum plant height

The maximum plant height was affected both by the K dose rate in the basal dressing and by the foliar treatments. No statistically significant interaction ($P=0.05$) was found between the trial factors basal dressing K dose and foliar treatments.

Increasing the K-dose rate in basal dressing resulted in taller plants (Table 3).

Table 3. The effect of increasing K dose rate as KCl in basal dressing on the maximum plant height.

K dose in basal dressing as percentage of crop K-removal	Maximum plant height *
%	cm
0	106.2 a
50	117.3 b
75	119.4 bc
100	121.5 c

*) Means followed by the letter same are not statistically significantly different (Fisher's protected least significant difference test at 5% level).

Potassium nitrate based foliar spray applications resulted in statistically significantly taller plants compared to untreated plants. No statistically significant differences ($P=0.05$) were found between the three potassium nitrate based foliar treatments (Table 4).

Table 4. The effect of potassium nitrate based foliar spray applications on maximum plant height.

Foliar treatments*, applied twice: at growth stage V3 and R3.	Maximum plant height *	
	cm	
No foliar treatment (control)	111.6	a
PN 5 kg/ha/application	117.2	b
PN 5 kg/ha/application + UP 3 kg/ha/application	117.7	b
PN 5 kg/ha/application + MAP 2.2 kg/ha/application	117.9	b

*) Means followed by the letter same are not statistically significantly different (Fisher's protected least significant difference test at 5% level).

Soybean yield:

The trial was harvested on the 20th of October. Additional to the total yield in MT/ha and thousand seed weight, the number of pods/plant and number of seeds/pod were assessed by counting the number of pods of 40 plants per replication and the number of seeds of each pod of these plants.

The average soybean yield was 4.5 ton/ha, which is in line with the soybean potential of the area.

Main effects on total yield were found for both the K dose rate in basal dressing and for the foliar treatments. No statistically significant interaction (at P=0.05) was found between the trial factors basal dressing K dose and foliar treatments.

Increasing K dose in the basal dressing had a positive effect on soybean yield. Yield was statistically significantly 20% - 30% higher at all doses of K compared to no KCl application in the basal dressing (Table 5).

Table 5. The effect of increasing dose rates of K applied as KCl in basal dressing on soybean yield.

K dose in basal dressing as percentage of crop K-removal	Soybean yield *	Relative soybean yield increase compared to 0% treatment	
		MT/ha	%
0	3.8 a	-	-
50	4.6 b	+0.8	+20%
75	4.9 c	+1.1	+30%
100	4.7 bc	+0.9	+24%

*) Means followed by the letter same are not statistically significantly different (Fisher's protected least significant difference test at 5% level).

Soybean yield was increased with 5% - 12% by two applications of the foliar PN based sprays, compared to the not foliar treated control. Foliar spray application of potassium nitrate (without addition of P source) resulted in the greatest statistically significant yield increase of 12%, followed by PN+MAP with 10% yield increase (Table 6).



Table 6. The effect of various foliar spray applications with potassium nitrate on soybean yield.

Foliar treatments*, applied twice: at growth stage V3 and R3.	Soybean yield *	Soybean yield increase compared to the control treatment	
	MT/ha	MT/ha	%
No foliar treatment (control)	4.2 a	-	-
PN 5 kg/ha/application	4.7 b	+ 0.5	+12%
PN 5 kg/ha/application + UP 3 kg/ha/application	4.4 ab	+ 0.2	+5%
PN 5 kg/ha/application + MAP 2.2 kg/ha/application	4.6 b	+ 0.4	+10%

*) Means followed by the letter same are not statistically significantly different (Fisher's protected least significant difference test at 5% level).

No statistically significant effects of the treatments were found on the thousand grain weight nor the number of seeds per pod.

Inconsistent results were found for the number of pods per plant. There were no statistically significant main effects of increasing K dose rates in basal dressing nor of the foliar spray applications with potassium nitrate. Compared to the control receiving no K in the base dressing and no foliar treatments, the number of pods per plant was higher for plants foliar treated with PN+UP and PN+MAP when no K was applied in the base dressing, and for plants treated foliar with PN and receiving 50% or 75% of the basal K application. It was highest for plots with 75% of K-requirement in the base dressing and no foliar treatment (Table 7).

Table 7. The effect of increasing K dose rates in basal dressing and various foliar spray applications with potassium nitrate on the number of pods per plant.

K dose in basal dressing as percentage of crop K-removal	Foliar treatments, applied twice: at growth stage V3 and R3.	Number of pods/plant*
0%	No foliar treatment (control)	41 abc
	PN	45 abcde
	PN + UP	49 def
	PN + MAP	51 ef
50%	No foliar treatment (control)	45 abcde
	PN	49 def
	PN + UP	42 abcd
	PN + MAP	43 abcd
75%	No foliar treatment (control)	53 f
	PN	50 ef
	PN + UP	46 bcde
	PN + MAP	39 a
100%	No foliar treatment (control)	41 abc
	PN	46 abcde
	PN + UP	40 ab
	PN + MAP	47 cdef

*) Means followed by the letter same are not statistically significantly different (Fisher's protected least significant difference test at 5% level).

Protein content (%) and oil content (%)

The grand mean protein content was 39.3% and the grand mean oil content was 20.8%. No effect on protein content (%) and oil content (%) was found for neither the basal K application rates nor the foliar treatments.

Main conclusions

1. Soybean yield increased with foliar applications of potassium nitrate based sprays, compared to untreated plots.
2. The addition of spray-applied MAP or UP to potassium nitrate did not result in yield increases compared to straight potassium nitrate sprays.
3. Soybean yield was positively correlated with increasing basal soil K dose rates, applied as KCl.
4. No symptoms of phytotoxicity were observed after potassium nitrate based foliar sprays at total fertilizer dose rates ranging from 5-8 kg/ha/spray.
5. Increasing basal K application dose rates and foliar nutrient spray treatments did not affect the number of seeds per pod and 1000-seed weight nor soybean protein content (%) and oil content (%).

