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Response of fenugreek (*Trigonella foenum-gracecum* L.) to sodicity

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Abstract

Field trials were conducted at Lucknow (Uttar Pradesh) to study the effect of sodicity on growth, yield and cation composition of fenugreek (*Trigonella foenum-graecum* L.). The treatments included five exchangeable sodium percentage (ESP) levels (10, 20, 30, 40 and 50) and four varieties namely, HM-346, RMt-1, Hissar Sonali and Kalyanpur Selection. The results showed that the crop was able to endure sodicity at germination stage but an adverse effect was noticed on emergence of branches plant^{-1} rather than plant height. The yield attributes were unaffected up to ESP 30. The variety Kalyanpur Selection produced greater biomass and seed yield than other genotypes up to ESP 30. The cation composition of plant revealed Na inclusion mechanism and showed narrow K/Na and Ca/Na ratio in the foliage indicating the potential of fenugreek crop to withstand medium level of sodicity.

Keywords: cation composition, exchangeable sodium percentage, sodic soil, yield

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is grown on wide range of soils but flourishes on well drained loams or sandy loam. Fenugreek is also adapted to dry land including slightly alkaline soils or marginal lands (Acharya *et al*. 2006). Though salt affected soils occur throughout the world under almost all climatic conditions, there is dearth of information on salt tolerance of spice crops. However, there is some information indicating the potential of crop to withstand salt stress (Agarwal & Gupta 1968). This study was undertaken to know the effect of sodicity on growth, yield and cation composition of fenugreek.

Materials and methods

The field experiments were conducted for two consecutive years from 2001–02 to 2002–03 at Banthra Research Station of National Botanical Research Institute, Lucknow (Uttar Pradesh) located at 80° 45′–53′E longitude and 26° 40′–45′ N latitude. The soil was sandy loam with pH 8.8, EC< 2.0 dSm^{-1} having 0.57% organic C, 12.0 kg ha^{-1} available P_2O_5 and 300 kg ha^{-1} available K_2O. The soil belongs to fine silty, illitic and calcareous hypothermic family of Typic Natrustalfs. Before sowing, desired grades of soil exchangeable sodium percentage (ESP) was created artificially using Na_2CO_3/gypsum.

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Soil samples from surface (0–15 cm) were analyzed for different soil chemical attributes following standard methods (Jackson 1971). Site soil characteristics before sowing of crop are presented in Table 1. The experiment was laid out in micro plots (1 m × 1 m) in a split plot design with five ESP levels namely, 10, 20, 30, 40 and 50 as main plot treatments and four varieties namely, HM-346, RMt-1, Hissar Sonali and Kalyanpur Selection with three replications. Each plot was protected by 1 m border from all sides to prevent sodicity from neighbouring beds. The crop was sown at a spacing of 40 × 25 cm at a seed rate of 30-35 kg ha^{-1} fertilized with 80 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 25 kg K_2O $ha^{-1}$and FYM @ 20 t ha^{-1} during last week of October each year. The entire dose of P and K and half of N was applied at the time of sowing; remaining dose of N was given one month after sprouting. Cultural operations including irrigation and plant protection measures were followed uniformly. The crop was harvested during 2nd week of April each year. Observations were recorded on germination at 10 days interval up to 30 days, till maximum sprouting occurred and plant growth attributes such as plant height and number of branches $plant^{-1}$, yield attributes such as number of pods $plant^{-1}$, number of seed pod^{-1} and pod length were determined at harvest. At harvest, samples of leaf and stem were collected separately and washed with deionised water, dried in an oven at 70°C and powdered in a mill and analyzed for determination of cation composition. Oven dried sample (1 g) was digested in perchloric and nitric acid following wet digestion method. K, Ca, Mg and Na were estimated following standard methods (Richards 1954). The data recorded for both the years were pooled and mean data over two years were subjected to statistical analysis for test of significance (Panse & Sukhatme 1961).

Results and discussion

Germination

Germination commenced first at 10th day after sowing and was complete in the next 30 days. Emergence of seed was affected by different ESP levels and showed decreasing trend ranging from 81%–90% at ESP 10 (control) to about 43%–60% at ESP 50. In general, sprouting declined beyond ESP 30 in all varieties. Greater reduction was observed at highest level of sodicity compared to control. Lowest germination was noticed in var. RMt-1 while highest in var. HM-346 at ESP 50 (Fig. 1). Traditionally, fenugreek seed sprouts within a week and is completed in 2 weeks period. In the present study increased sodicity caused decreased and delayed germination probably due to lower osmotic potential of the soil. Such adverse effect of emergence in fenugreek and other vegetable crops has been observed by Jamil *et al*. (2008) and Abdelmoumen & El Idrissi (2009). Our results showed that the crop is able to germinate well under sodic soil conditions. Sodicity tolerance of crops is affected by many factors like variety, growth stage and environment. Hence, fenugreek appears to be tolerant at the germination stage.

Table1. Soil analysis before sowing of experimental (fenugreek) crop

ESP	pH (1:2)	EC (dSm^{-1})	Org. C (%)	Total N (%)	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	ESP
10	7.83±0.04	0.81±0.21	0.74±0.15	0.11±0.007	13.482.87	753.33±103.54	15.24±0.65
20	8.57±0.16	1.21±0.22	0.62±0.02	0.09±0.003	11.72±1.64	625.70±38.58	19.44±0.04
30	8.51 ±0.05	0.90±0.03	0.77±0.17	0.11±0.01	19.71±2.75	796.67±57.99	29.38±2.09
40	8.89±0.14	0.90±0.07	0.67±0.08	0.10±0.012	9.74±3.06	606.60±17.96	44.55±4.50
50	9.28±0.08	1.14±0.19	0.59±0.18	0.09±0.006	6.87±2.68	554.77±85.12	54.63±6.84

Values indicate Mean+SD; Av=Available; EC=Electrical conductivity; ESP=Exchangeable sodium percentage.

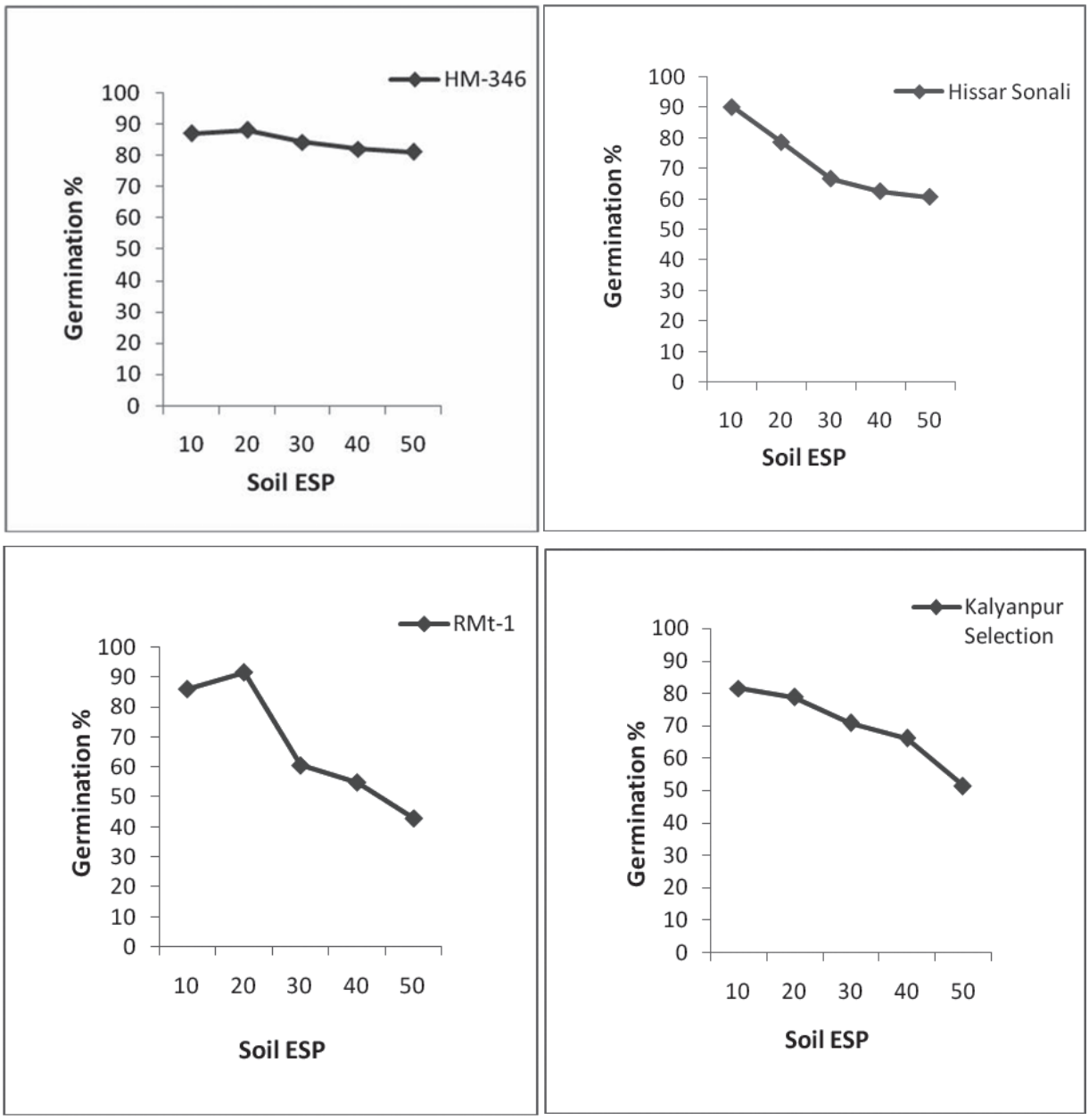

Fig 1. Germination (%) of fenugreek varieties grown at different levels of soil ESP

Growth

Plant height and number of branches plant^{-1} decreased significantly with increasing soil ESP. Since the plants failed to survive at ESP 50, the results are presented up to ESP 40. Mean plant height varied from 59.4 cm (Kalyanpur Selection) to 47.6 cm (RMt-1) in control and ranged from 38.6 cm (RMt-1) to 46.6 cm (Kalyanpur Selection) at ESP 40. There was less reduction in plant height of RMt-1 (18.9%) than Hissar Sonali (26.1%) that recorded the highest reduction (Table 2). Number of branches plant^{-1} was higher in Kalyanpur Selection followed by Hissar Sonali > RMt-1 > HM-346 at control. Minimum number of branches was noticed in RMt-1 followed by HM-346 > Hissar Sonali > Kalyanpur Selection at ESP 40. There was a non significant reduction in number of branches plant^{-1} in HM-346 whereas, they decreased significantly in all other varieties at

Table 2. Influence of sodicity on plant growth and yield attributes of fenugreek (mean of two years)

ESP	HM-346	RMt-1	Hissar Sonali	Kalyanpur Selection
		Plant height (cm)		
10	55.1	47.6	56.9	59.4
20	48.8	42.4	50.4	58.0
30	46.8	42.1	48.0	56.2
40	43.3	38.6	42.0	46.6
CD (P=0.05)	13.9	9.78	10.9	7.94
		Branches plant^{-1}		
10	6.1	8.6	10.2	9.0
20	5.8	7.3	9.8	8.9
30	5.1	5.6	8.4	7.7
40	4.3	3.3	7.2	3.6
CD (P=0.05)	3.9	1.13	2.34	0.9
		Pods plant^{-1}		
10	52.5	65.35	62.6	122.5
20	44.6	62.20	51.9	97.9
30	38.3	36.4	36.5	72.3
40	29.3	29.8	22.6	69.7
CD (P=0.05)	19.8	22.8	17.5	34.2
		Pod length (cm)		
10	12.0	10.1	10.9	11.0
20	10.6	10.0	9.9	10.5
30	10.3	9.9	9.4	9.1
40	10.2	9.0	9.4	8.8
CD (P=0.05)	1.83	1.68	2.33	1.79
		Seeds pod^{-1}		
10	16.5	15.8	18.0	17.5
20	16.0	15.2	16.4	17.0
30	16.0	15.1	16.3	16.4
40	15.7	15.1	16.0	15.8
CD (P=0.05)	4.38	3.85	4.96	5.67

ESP=Exchangeable sodium percentage

ESP 30 and beyond (Table 2). The varied response of plant growth may be attributed to the genotypic character of the varieties. However, the present study showed restricted growth probably due to soil sodicity causing decrease in water content of different parts of the plant (El Wahab 2006) indicating the adverse effect of sodicity on number of branches plant^{-1} rather than plant height.

Yield attributes

The mean number of pods plant^{-1} was higher at control and reduced significantly at ESP 40. However, they did not vary significantly from 20 to 40 ESP. Number of pods plant^{-1} was higher in Kalyanpur Selection than rest of the varieties at all ESP levels. Pod length was invariably superior in control but decreased with different grades of ESP. Pod length did not show any significant difference except in variety Kalyanpur Selection with rise of soil ESP. The number of seeds pod^{-1} was higher in control and showed no significant difference with increasing ESP (Table 2). In general, pod length and number of pods plant^{-1} declined beyond ESP 30; likewise there was reduction in number of seeds pod^{-1} at the same level of sodicity. Hence, formation of pod with greater number of seeds pod^{-1} seems to be a suitable index of sodicity tolerance.

Biomass yield

The mean yield (stover) indicated that the effect of variety and soil ESP was significant during both the years. However, the interaction of soil ESP X variety was significant only in the second year (Table 3). Mean yield of fresh biomass was higher in control and decreased by about 16% to 58% with rise in sodicity. Among the different varieties, Kalyanpur Selection (0.657 t ha^{-1}) recorded the highest biomass yield followed by Hissar Sonali (0.475 t ha^{-1}), HM-346 (0.442 t ha^{-1}) and RMt-1 (0.420 t ha^{-1}). There was a decrease of about 73.9%–85.6% in biomass due to highest level of sodicity in all varieties except RMt-1 which showed < 50% reduction at ESP 30. In general, green foliage or leaf yield varied from 1.5 t ha^{-1} to 2.4 t ha^{-1} under normal soil conditions with the application of macro and micro nutrients including FYM (Khiriya & Singh 2003; Chhibba *et al*. 2007; Sammauria & Yadav 2008). In the present study the crop was grown for seed only and no cutting was practiced for leaf yield. Assuming 50% reduction in biomass yield as criterion for sodicity tolerance, fenugreek may be grown up to 30 ESP.

Seed yield

The effect of variety was significant during both the years. The effect of different grades of soil ESP and the interaction of soil ESP X variety was not significant during the first year but was significant during the second year (Table 4). Mean seed yield was also higher in control and declined from 17.0% to 59.5% with increasing level of soil ESP. Kalyanpur Selection (0.214 t ha^{-1}) produced the highest seed yield followed by HM-346 (0.161 t ha^{-1}), Hissar Sonali (0.151 t ha^{-1}) and RMt-1 (0.126 t ha^{-1}). There was drastic reduction in seed yield from 55% to 85% in all varieties at ESP 40. However, the decrease in seed yield was < 50% in all varieties up to ESP 30 with no adverse effect of sodicity. Earlier information on seed yield indicated that it ranged from 0.5 t ha^{-1} to 1.2 t ha^{-1} with use of growth regulators, fertilizers, FYM and improved management practices (Khan *et al*. 2005; Vasudevan *et al*. 2008; Basu *et al*. 2008).

Table 3. Effect of sodicity on biomass yield (g m^{-2}) of fenugreek (mean of two years)

Variety	Yield
HM-346	441.9
RMt-1	419.6
Hissar Sonali	475.2
Kalyanpur Selection	656.6
CD (P=0.05)	133.0
ESP levels	
10	684.2
20	575.8
30	447.7
40	285.4
CD (P=0.05)	131.8

Interaction effect of sodicity levels x varieties for 2002–03 (g m^{-2})

Variety × Sodicity	10	20	30	40
HM-346	753.3	553.3	445.0	108.3
RMt-1	758.3	333.3	318.3	173.3
Hissar Sonali	756.7	506.7	426.7	141.7
Kalyanpur Selection	691.7	750.0	645.0	180.0

ESP=Exchangeable sodium percentage

Table 4. Effect of sodicity on seed yield (g m^{-2}) of fenugreek (mean of two years)

Variety	Yield
HM-346	160.8
RMt-1	126.0
Hissar Sonali	150.8
Kalyanpur Selection	231.9
CD (P=0.05)	39.73
ESP levels	
10	229.3
20	180.7
30	158.5
40	92.8
CD (P=0.05)	56.0

Interaction effect of sodicity levels × varieties for 2002–03 (g m^{-2})

Variety × Sodicity	10	20	30	40
HM-346	248.3	216.6	206.7	112.3
RMt-1	226.7	110.0	106.7	63.3
Hissar Sonali	256.7	180.0	175.0	45.0
Kalyanpur Selection	291.7	270.0	253.3	43.3

ESP=Exchangeable sodium percentage

However, a yield as low as 0.25 t ha^{-1} seed was reported when the crop is raised for green leaves as well as seed (Pruthi 2001). The reduction in seed yield was < 50% at ESP 30. Considering this as criterion for sodicity tolerance, fenugreek appears to be a medium tolerant crop.

Cation concentration

The cation concentration of K and Ca was lower than Na in leaf tissue of all varieties growing either in non sodic or sodic soil, whereas Mg content showed inconsistent variation. There was a greater accumulation of Na in the foliage than the stem indicating that the crop is able to absorb large quantities of Na and transport to the leaf (Hasni *et al*. 2009). The concentration of Ca either in leaf or stem in all varieties declined due to sodicity (Table 5). In the present study, Na appears to be the most abundantly accumulated ion in the foliage and did not affect the growth and yield of crop up to ESP 30. Consequently Ca/Na ratio was reduced in leaf as well as stem whereas K/Na ratio fluctuated within narrow limits under sodic soil conditions. The study thus revealed that fenugreek has Na inclusion mechanism and is able to withstand medium level of soil sodicity.

The study indicated that fenugreek is tolerant enough to sodicity at germination but was affected adversely at branch emergence. The variety Kalyanpur Selection produced higher biomass and seed yield than the other varieties. The crop showed Na inclusion mechanism and has the potential to endure medium grade of sodicity.

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References

Abdelmoumen I I & El Idrissi M M 2009 Germination, growth and nodulation of

Table 5. Cation composition in leaf and stem of fenugreek grown in non sodic and sodic soils

Variety	Treatment	K (mg g^{-1})	Ca (mg g^{-1})	Mg (mg g^{-1})	Na (mg g^{-1})	Na/K	Ca/Na
			Leaf				
HM-346	Sodic	13.0±2.7	31.2±3.2	5.0±1.1	33.0±4.1	2.53	0.94
	Non sodic	15.0±2.4	34.0±3.7	9.0±1.2	32.0±3.8	2.10	1.06
RMt-1	Sodic	12.0±1.9	34.0±4.1	4.3±0.7	41.0±5.2	3.41	0.82
	Non sodic	18.0±3.1	35.0±3.9	3.0±0.5	35.0±4.7	1.94	1.0
H. Sonali	Sodic	14.6±2.2	32.3±3.3	6.0±0.9	41.3 4.6	2.83	0.78
	Non sodic	19.0±3.3	39.0±4.1	2.0±0.2	34.0±3.9	1.78	1.14
K. Selection	Sodic	9.60±1.1	32.6±3.8	3.3±0.4	41.0±5.1	4.27	0.79
	Non sodic	12.0±1.6	34.0±3.9	4.0±0.8	38.0±3.8	3.16	0.89
			Stem				
HM-346	Sodic	12.0±1.8	22.0±2.7	4.0±1.0	29.0±2.9	2.41	0.75
	Non sodic	17.0±2.3	30.0±3.1	11.0±1.9	25.0±2.7	1.47	1.20
RMt-1	Sodic	11.0±1.7	21.0±2.2	6.0±0.7	26.0±2.1	2.36	0.80
	Non sodic	13.0±1.9	23.0±2.4	5.0±0.3	24.0±2.4	1.84	0.95
H. Sonali	Sodic	13.0±1.7	23.0±2.1	5.0±0.2	29.0±2.6	2.23	0.79
	Non sodic	15.0±2.1	29.0±1.9	4.0±0.1	23.0±2.3	1.53	1.26
K. Selection	Sodic	12.0±1.7	21.0±2.3	5.0±0.2	27.0±3.0	2.25	0.77
	Non sodic	16.0±2.1	29.0±2.6	6.0±0.3	23.0±2.5	1.43	1.26

Values indicate Mean+SD; ESP=Exchangeable sodium percentage

Trigonella foenum-graecum (Fenugreek) under salt stress. African J. Biotech. 8: 2489–2496.

Acharya S N, Thomus J E & Basu S K 2006 Fenugreek: an 'old world' crop for new world Biodiversity 7(3&4): 27–30.

Agarwal R R & Gupta R N 1968 Saline Alkali Soils in India. Indian Council of Agricultural Research, New Delhi.

Basu S K, Acharya SN & Thomas J E 2008 Application of phosphate fertilizer and harvest management for improving fenugreek (*Trigonella foenum-graecum* L.) seed, forage yield in a dark brown soil zone of Canada. KMTTI Sci. Tech. J. 8(1): 1–7.

Chhibba I M, Nayyar K & Kanwar J S 2007 Influence of mode and source of applied iron on fenugreek (*Trigonella foenum-graecum* L.) in a Typic Ustocrept in Punjab, India. Intl. J. Agric. Biol. 9: 254–256.

El Wahab A M A 2006 The efficiency of using saline and fresh water irrigation as alternating methods of irrigation on the productivity of *Foenum vulgare* Mill. subsp vulgare var. vulgare under north sinai conditions. Res. Agric. Biol. 2: 571–577.

Hasni I, Ahed B, Bizid I I, Raies E, Samson A G & Zid E 2009 Physiological characteristics of salt tolerance in fenugreek (*Trigonella foenum-graecum* L.) In Proceedings of the International Plant Nutrition Colloquium XVI, University of California Davis.

Jackson M L 1967 Soil Chemical Analysis, Prentice Hall of India, New Delhi.

Jamil M, Lee D B, Jung K Y, Ashraf M, Lee S N & Rha E S 2006, Effect of salt (NaCl) stress on germination and early seedling growth of four vegetable species. Central European Agric. 7: 273–281.

Khan M B, Khan M A & Sheikh H 2005 Effect of phosphorus levels on growth and yield of fenugreek (*Trigonella foenum-graecum* L.) grown under different spatial arrangements. Int. J. Agric. Biol. 7: 504–507.

Khiriya K D & Singh B P 2003 Effect of phosphorus and farm yard manure on yield,

yield attributes and nitrogen, phosphorus and potassium up take of fenugreek (*Trigonella foenum-graecum* L.), Indian J. Agron. 48: 62–65.

Panse V G & Sukhatme P V 1961 Statistical methods for agricultural workers, Indian Council of Agricultural Research, New Delhi.

Pruthi J S 2001 Minor spices and condiments crop management and post-harvest Technology. Directorate of Information and Publication of Agriculture, Indian Council of Agricultural Research, New Delhi.

Richards I A 1954 The Diagnosis and improvement of saline and alkali soil. Agricultural Handbook 60, Washington.

Vasudevan S N, Sudarshan J S, Kurdikeri M B & Dharmatti P R 2008 Influencing of pinching of apical bud and chemical sprays on seed yield and quality of fenugreek. Karnataka J. Agric. Sci. 21: 26–29.