文章编号: 0564-3945(2001)03-0110-03

氮磷配合对土壤氮素径流流失的影响

张兴昌, 郑剑英, 吴瑞浚, 翟连宁, 马炳召

(中国科学院、水利部水土保持研究所, 陕西 杨陵 712100)

摘 要: 大田试验研究结果表明: 增施 N、P 均能增加作物的产量和减少水土流失; 当 N、P 用量分别达到 55.2kg N/hm^2 和 90kg P_2O_5/hm^2 时, 泥沙有机质和全氮流失最少, 流失量分别为 2089 和 175kg/km^2; 当 N、P 用量分别为 55.2kg N/hm^2 和 45kg P_2O_5/hm^2 时, 土壤矿质氮流失最小, 其流失量仅为 27.9kg/km^2; 作物对土壤氮素的吸收, 可减少土壤氮素的流失.

关 键 词: 氮肥; 氮磷配合; 土壤氮素流失

中图分类号: S147.3 文献标识码: A

化肥的施用促进了农业发展, 但也带来一些环境问题, 越来越多的研究表明[4, 5], 径流中氮素的富集严重危害人类生存的自然环境, 坡耕地土壤氮素的流失是造成土壤肥力退化和生产力低下的主要原因.

由于氮素径流流失污染环境, 人们开始注意到施肥对土壤无机氮和有机氮流失的影响. Schuman[6] 发现连续三年种植玉米的流域, 径流水中硝态氮平均浓度为 1.5mg/kg, 年平均流失量为 168kgN/hm^2; Schurman 和 Burwell[7] 研究表明, 如果给该流域补施 168kg N/hm^2 氮时, 通过流域径流水流失的无机氮素含量仅占到降水输入氮量的 69%. White 和 Williamson[8] 的研究表明, 流域内氮肥对径流中硝态氮浓度影响不大, 通常在 1mg/kg 以下. Klausner[9] 研究, 在土壤肥力较低的坡耕地上, 氮肥的施入并不能增加土壤无机氮素的流失。Jackson[10] 研究发现, 当施氮量达到 240kg/hm^2, 径流中硝态氮的平均浓度仍低于 1mg/kg, 仅在产流初期, 径流中硝态氮浓度偏高, 但也未超过 3mg/kg. Kilmer[11] 在两种坡度耕地上进行施肥试验, 发现在 35% 和 40% 坡度上, 径流和淋溶流失的硝态氮分别占施氮量的 6% 和 10%, 在 4 年研究期限内, 当氮素年用量达到 112kg/hm^2 时, 径流中硝态氮浓度超过 10mg/kg. Smith[12] 研究发现径流中硝态氮浓度偏高是与施肥方式和时期有关, 在产流前表施氮肥, 径流中无机氮浓度高. 施肥与泥沙氮素富集的关系也进行不少工作. 一种观点[13, 14] 认为增施氮肥可减少泥沙氮素的流失, 有的则[15] 认为增施氮肥并不完全减少泥沙氮素的流失, 氮肥用量和施肥方式是影响泥沙氮素流失的关键因素. 氮磷配合一方面在增加作物对土壤氮素利用的同时, 也会对土壤侵蚀产生影响[16]. 然而, 迄今为止, 有关氮磷配合对土壤氮素径流流失影响方面的研究未见报道.

本项研究利用大田径流小区研究资料, 分析和评价氮磷合理配合对土壤氮素和有机质流失的影响.

1 试验设计与方法

1.1 试验设计

小区水平投影面积为 3m× 6.7m, 坡度 19°, 坡向北偏东 80°. 小区四周用水泥板围埂, 相邻小区留 50cm 人行道, 土壤为黄绵土, 小区 20 个分上下两排水平排列. 下排 10 个小区下方连接径流桶两个, 用于收集产流后的泥水样。1997 年种植谷子, 1998 年试验小区供试作物黄豆, 每小区播种 25 行, 每行留苗 30 株, 品种晋遗 19 号. 4 月 5 日播种, 10 月 8 日收获. 试验处理为: N_0P_0、N_0P_1、N_0P_2、N_1P_0、N_1P_1、N_1P_2、N_2P_0、N_2P_1、N_2P_2 和对照(不种作物, 不施肥)共 9 个, 两次重复, 仅下排 10 个小区一次重复布设径流装置. NP 具体用量为: N_0 不施肥, N_1 每 hm^2 施 55.2kg N, N_2 每 hm^2 施 110.4kg N, 氮肥品种为尿素; P_0 不施磷肥, P_1 每 km^2 施 45 kgP_2O_5, P_2 每 hm^2 施 90 kgP_2O_5, 磷肥品种为过磷酸钙(含 $P_2O_5$11.8%). 磷肥作种肥一次施入, 尿素 1/5 作种肥, 4/5 作追肥, 于 7 月 1 日沟施. 种肥施肥方式为: 每小区开沟 25 行, 沟深 20cm, 氮磷肥均匀条施于沟底, 覆土 2~ 3cm, 水平沟播种, 施肥深度 9~ 10cm; 追肥方式为: 每小区开沟 25 行, 沟深 10cm, 将氮肥均匀施于沟内, 覆土. 田间管理同一般大田.

1.2 采样和分析方法

于每次产流前, 测定 20cm 表层土壤水分并采土样供 N 分析用. 产流结束后, 测定盛水池泥水样体积.

收稿日期: 2000-01-14

基金项目: 国家自然科学基金(49871049), 中国科学院"九五"特别支持项目(KZ95T-04-13), 中国科学院"西部之光"项目和国家科技攻关专题(96-004-05-04)资助

作者简介: 杨兴昌(1965-), 男, 博士, 副研究员, 主要从事土壤侵蚀与土壤氮素营养方面的研究.

混匀泥水, 采集 1L 泥水样烘干测定泥沙浓度. 采集 2 ~ 5L 泥水样, 加 3~ 5 滴 1mol/L HCl, 2~ 3 滴甲苯, 过滤水样, 收集滤液并在 2~ 4℃冰柜中保存, 泥样阴干后保存. 利用自记雨量器, 自动记录整个降雨过程.

径流水中的铵态氮和硝态氮含量用连续流动分析测定, 泥沙中有机质用重铬酸钾氧化- 外加热法, 全氮用半微量开氏法.

2　结果与分析

2.1　氮磷配合对土壤矿质氮流失的影响

氮磷配合可有效提高豆类作物产量, 在提高产量的同时, 也会对土壤和径流养分含量产生影响. 表 1 研究结果表明: 在增加氮肥的同时, 土壤铵态氮、硝态氮和矿质氮含量也相应得到提高, 且不受施磷的影响, 径流中铵态氮、硝态氮和矿质氮含量变化规律与土壤雷同. 在黄绵土上, 黄豆是一种喜磷作物, 根瘤固氮作用加强了作物的氮素营养, 氮肥效应不明显, 增施氮肥促使土壤矿质氮累积, 特别是硝态氮的累积.

表 1　NP 配合对土壤、径流矿质氮含量的影响

处　理	铵态氮(mg/kg)			硝态氮(mg/kg)			矿质氮(mg/kg)		
	土壤 S	径流 R	R/S %	土壤 S	径流 R	R/S %	土壤 S	径流 R	R/S %
N_2P_2	2.91	0.80	27.5	6.54	3.20	48.9	9.45	4.00	42.3
N_2P_1	2.45	0.58	23.7	6.23	2.17	34.8	8.68	2.74	31.6
N_2P_0	2.45	0.29	11.8	6.98	3.18	45.6	9.43	3.47	36.8
N_1P_2	1.89	0.29	15.3	4.26	2.29	53.8	6.15	2.58	42.0
N_1P_1	1.92	0.27	14.1	4.65	1.91	41.1	6.57	2.21	33.6
N_1P_0	1.65	0.29	17.6	4.32	2.42	56.0	5.97	2.71	45.4
N_0P_2	1.20	0.39	32.5	3.78	1.75	46.3	4.98	2.13	42.8
N_0P_1	1.35	0.37	27.4	3.49	2.51	71.9	4.84	2.88	59.5
N_0P_0	1.19	0.29	24.4	3.98	1.80	45.2	5.17	2.09	40.4
CK	2.65	1.13	42.6	4.78	2.38	49.8	7.43	3.50	47.1

表 2　NP 配合对土壤矿质氮流失的影响

处理	径流量	土壤矿质氮流失量(kg/km²·a)		
	m³/km²·a	铵态氮	硝态氮	矿质氮
N_2P_2	9845	7.9	31.5	39.4
N_2P_1	13795	7.9	29.9	37.8
N_2P_0	13714	4.0	43.6	47.6
N_1P_2	13138	3.8	30.1	33.9
N_1P_1	12631	3.4	24.1	27.9
N_1P_0	15555	4.5	37.7	42.2
N_0P_2	14778	5.7	25.8	31.5
N_0P_1	15130	5.5	38.0	43.6
N_0P_0	18204	5.3	32.7	38.0
CK	19496	22.0	46.3	68.3

NP 的不同配合明显影响径流量, 表 2 表明: 径流量随 NP 用量的增大而减少。土壤硝态氮流失明显高于铵态氮。当氮肥用量处在 N_1 水平时, 土壤铵态氮流失最小, 当处在 N_2 和 N_0 水平时, 土壤铵态氮流失增强, 表明, 土壤铵态氮的流失并不完全随氮量的增大而增加, 合适的氮肥用量可减少土壤铵态氮的流失。表 2 也同时表明: 施用磷肥可增加铵态氮流失; 当氮肥用量为 N_1 时, 磷肥用量与铵态氮流失关系不明显, NP 的合理配比可减少铵态氮的流失。当磷肥用量处在 P_0 和 P_2 时, 增施氮肥可显著增加土壤硝态氮的流失; 当氮和磷肥用量中等时, 土壤铵态氮、硝态氮和矿质氮流失最小, 过高或过低都会加剧土壤矿质氮的流失。与裸地相比, 作物 NP 的不同配合均减少土壤矿质氮的流失, 减少程度与施肥有关。

2.2　氮磷配合对泥沙有机质、全氮含量和富集率的影响

当 N 分别为 N_0、N_1 和 N_2 时, 泥沙有机质含量平均为 6.26、7.37 和 9.59g/kg, 富集率(ER) 分别为 1.96、2.07 和 2.59。全氮含量为 0.465、0.559 和 0.676g/kg, 富集率依次为 1.75、2.23 和 2.62; 当 P 分别为 P_0、P_1 和 P_2 时, 泥沙有机质含量平均为 7.72、7.70和 7.79g/kg, 富集率分别为 2.04、2.25 和 2.32。全氮含量为 0.542、0.562 和 0.596g/kg, 富集率依次为 2.08、2.08 和 2.45(表 3)。表明, 当土壤养分含量差异不明显时, 随 N 用量的增加, 泥沙有机质和全氮含量显著增加。同理, 泥沙富集率也呈类似变化规律。在一定程度上反映了, 当坡面存在某一径流阻力时, 可减少水土流失, 延长了径流在坡面滞留时间, 使径流与表层土壤养分得到充分混合, 相对增加泥沙养分的含量; 随 P 用量的增加, 泥沙有机质和全氮含量及其富集率变化不显著。施 N、P 的作物小区泥沙有机质和全氮含量及其富集率均比裸地大。

2.3　氮磷配合对土壤全氮和有机质流失的影响

同理, 随 N、P 用量的提高, 土壤侵蚀量逐渐减少(表 4)。但由于泥沙有机质和全氮富集的缓冲作用,

表 3 NP 配合对泥沙有机质、全氮含量和富集率的影响

处理	有机质(g/kg)			全 N(g/kg)		
	土壤	泥沙	ER	土壤	泥沙	ER
N_2P_2	3.60	9.74	2.71	0.226	0.682	3.02
N_2P_1	3.68	9.04	2.46	0.280	0.660	2.36
N_2P_0	3.86	9.99	2.59	0.275	0.686	2.49
N_1P_2	3.16	6.94	2.20	0.240	0.581	2.42
N_1P_1	3.95	7.60	1.92	0.255	0.586	2.30
N_1P_0	3.63	7.56	2.08	0.260	0.510	1.96
N_0P_2	3.27	6.70	2.05	0.275	0.524	1.91
N_0P_1	3.14	6.46	2.38	0.280	0.440	1.57
N_0P_0	3.87	5.61	1.45	0.242	0.431	1.78
CK	3.19	4.45	1.39	0.250	0.357	1.43

使 NP 配合对土壤全氮流失的减少作用下降。具体表现为:当 N 处在 N_0、N_1 和 N_2 水平时,土壤侵蚀量平均为 541、401 和 319t/km²•a,N_2 比 N_0 水平减少41.0%,土壤有机流失量则分别为 3338、2987 和 3058kg/km²•a,N_2 水平比 N_0 水平仅减少 8.4%,全氮流失量分别为 248、223 和 215kg/km²•a,N_2 比 N_0 水平仅减少 13.3%;当 P 处在 P_0、P_1 和 P_2 水平时,土壤侵蚀量平均为 507、410 和 346t/km²•a,P_2 水平比 P_0 水平减少 31.8%,相应土壤有机质流失量则依次为 3672、3072 和2640kg/km²•a,P_2 比 P_0 水平减少 28.1%,全氮流失量依次为 261、223 和 203kg/km²•a,P_2 比 P_0 水平减少 21.9%。结果表明,在黄绵土上,施肥具有减蚀效应,以氮肥减蚀效应较为突出;合理的 NP 配合,可有效地减少土壤有机质和全氮的流失。

表 4 NP 配合对土壤全氮和有机质流失的影响

处理	侵蚀量 t/km²•a	有机质流失量 kg/km²•a	全 N 流失量 kg/km²•a
N_2P_2	296	2883	202
N_2P_1	318	2875	210
N_2P_0	342	3417	234
N_1P_2	301	2089	175
N_1P_1	399	3032	234
N_1P_0	508	3840	259
N_0P_2	440	2948	231
N_0P_1	512	3308	225
N_0P_0	670	3759	289
CK	1592	7084	668

2.4 作物的生长情况与土壤氮素的流失

不同 N、P 配合显著影响产量和作物吸氮量(表 5),黄绵土 N、P 肥效应显著。

作物生长状况显著影响泥沙流失及养分的富集,相关分析表明,地上部产量与侵蚀和径流量的相关系数分别为 -0.9331^{**} 和 -0.8886^{**} ($n=10$, $r_{0.01}=0.7646$,下同),均达到极显著水准;与泥沙有机质和全氮富集率的相关系数为 0.7573^{*} 和 0.8287^{**};而与土壤有机质和全氮流失量的相关系数分别为 -0.9021^{**} 和 -0.8877^{**}。表明,随 N、P 用量的提高,作物地上部生物量显著增大,减少了水土流失,同时增加泥沙有机质和全氮的富集,从一定程度上,使作物减少土壤有机质和全氮流失得到削弱。

作物对土壤氮素的吸收,减少了土壤氮素流失,相关分析表明,作物吸氮量与土壤全氮流失量的相关系数为 -0.8148^{**},则作物对土壤氮素利用程度愈高,土壤氮素流失愈少。

表 5 NP 配合对作物性状的影响

处理	地上部产量 kg/km²	籽粒产量 kg/km²	地上部吸 N 量 kg/km²
N_2P_2	3261	1713	39.3
N_2P_1	2873	1537	36.0
N_2P_0	2415	1232	32.7
N_1P_2	2869	1479	35.9
N_1P_1	2494	1351	28.9
N_1P_0	2282	1205	26.7
N_0P_2	2690	899	19.9
N_0P_1	1639	807	18.0
N_0P_0	1462	731	13.9
CK			

3 结论

坡面土壤氮素和有机质流失受地貌、植被、土壤、耕作和施肥等多种因素的影响,在这些因素中,通过施肥方式的改进和施肥量的确定可有效地减少水土流失和养分流失。施肥减少水土流失的作用在于:通过施肥增加作物地表面的覆盖,减少雨滴直接打击地表,延缓和阻碍径流在坡面的形成和传递;但施肥量的增大并不能减少土壤有机质和全氮的流失,其原因在于:随施肥量的增大,作物生长旺盛,在有效减少水土保持的同时,急剧增加了泥沙养分的富集,这也在一些研究[3,6,7,11]中得到确认,泥沙养分富集作用的存在,在一定程度上增加土壤养分的流失。因此,合理施肥才是减少土壤养分流失的基础。黄绵土 N、P 俱缺,增施 N、P 均能增加作物的产量和减少水土流失,但只有 N、P 用量分别达到 55.2kg N/hm² 和 90kg P_2O_5/hm² 时,泥沙有机质和全氮流失量最少。施肥对土壤矿质氮和全氮流失影响不一,N、P 用量中等时,土壤矿质氮流失最小,当 P 用量达到最高时,全氮流失才达到最小。

参考文献:

[1] Wan Y and E1- Swaify S A. Sediment enrichment mechanisms of organic carbon abd phosphorus in well- aggregated Qxisol[J]. J. Environ. Qual. 1998, 27: 132-138.

(下转第 105 页)

3 结　论

半干旱黑垆土旱地上,产量因降水影响变异很大.有机肥的增产效益和后效较为显著,单施化肥效果较差.施肥后效的迭加效应是很明显的,以有机肥最为突出,但并未改变因水分胁迫导致产量低下,波动性大的特点.施肥时土壤养分的增加和物理性状的改善也是十分明显的,特别是土壤全氮、有机质、有效磷在施用有机肥时增加最为显著.实践表明,旱地上施肥应以有机肥为主,并配以适量的化肥.应特别注意改善土壤水分状况,这是充分有效利用肥料和土壤肥力的前提.

参考文献:

[1] 兰晓泉.半干旱黑垆土区梯田培肥定位研究[J].土壤肥料,1998,(3).

[2] 丁宁平,周广业.旱地土壤定位有机培肥研究[J].土壤通报,1990,(5).

(上接第 101 页)

[2] Lahiri A N. Interaction of water stress and mineral nutrition on growth and yield, in Adaptation of plants to Water and High Temperature Stress[M], Turner, N. C. and Kramer, P. J., Eds., New York; John Wiley & Sons 1980, 341.

[3] Begg J E and Turner N C. Crop water deficits[J]. Adv. Agron 1976, 28: 161.

[4] Viets F G., Water deficits and nutrient availability, in Water Deficits and Plant Growth[M]. Vol. 3, Kozlowski, T. T., Ed., New York; Academic Press, 1972, 217.

[5] Nelsen C E., and Safir G R., The water relations of well watered, mycorrhizal and nonmycorrhizal onion plants[J]. J. Am. Soc. Hortic. Sci., 1982, 107, 271.

[6] 李晓林,周文龙,曹一平. VA 菌根菌丝对紧实土壤中磷的吸收[J].土壤学报,1994,31,增刊,193－200.

[7] Li X L, Marschner H, George E. Acquisition of phosphorus and Copper by VA－mycorrhiza hyphae and root to shoot transport in white clover[J]. Plant and Soil, 1991, 136: 49－57.

[8] Mosse B, Stribley D P F Le Tacon. Ecology of mycorrhizae and mycorrhizal fungi[J]. Adv. Microb. Ecol. 1981, 5: 137－210.

(上接第 112 页)

[2] Schnitzer M, Ivarson K C. Different forms of nitrogen in particle size fractions separated from two soils[J]. Plant and Soil 1982, 68: 383-389.

[3] Sharpley A N. The selective erosion of plant nutrient in runoff[J]. Soil Sci. Soc. Am. J. 1985, 49: 1527-1534.

[4] Pimental D. World Soil Erosion[M]. Cambridge University Press. 1993, P1-5.

[5] Frye W W. Restoration of crop productivity on eroded or degraded soil. In R. F. Follet & B. A. Steward eds. Soil Erosion and Crop Productivity[M]. USA Madison, Wisconsin, 1985, 339-354.

[6] Schuman G E, Burell R E. Piest R F, Spomer R G. Nitrogen losses in surface runoff from agricultural watersheds on Missouri Valley loess[J]. J. Environ. Qual. 1973, 2: 299-302.

[7] Schuman G E, Burwell R E. Precipitation nitrogen contribution to surface runoff discharges[J]. J. Environ. Qual. 1974, 3: 366-368.

[8] White E M and Williamson E J. Plant nutrient concentrations in runoff from fertilized and cultivated erosion plots and prairie in eastern South Dakota[J]. J. Environ. Qual. 1973, 2: 453-455.

[9] Klausner S D, Zwerman R J, Ellis D F. Surface runoff losses of soluble nitrogen and phosphorus under two systems of soil management[J]. J. Environ. Qual, 1974, 3: 42-46.

[10] Jackson W A, Asmussen L E, Hauser E W, White A W. Nitrate in surface and subsurface flow from a small agricultural watershed[J]. J. Environ. Qual. 1973, 2: 480-482.

[11] Kilmer V J, Gillian J W, Lutz J F, Joyce R F, Eklund C D. Nutrient losses from fertilized grassed watersheds in western North Carolina[J]. J. Environ Qual. 1974, 3: 214-219.

[12] Smith S J. Nutrient losses from agricultural land runoff in Oklahoma Proc. 22th OKla. Agric. Chem. Conf[C]. 1988, 13: 23-26. Oklahoma State Univ. Pub., Stillwater. OK.

[13] More P G, Mannering J V, Johnson C B. Loss of fertilizer nitrogen in surface runoff water[J]. Soil Sci. 1967, 104: 389-394.

[14] More P G, Mannering J V, Johnson C B. A comparison of nitrogen losses from urea and ammonium nitrate in surface runoff water[J]. Soil Sci. 1968, 105: 428-433.

[15] Dunigan E P, Phelan R A, Mondart CL, Surface runoff losses of fertilizer elements[J]. J. Environ. Qual. 1976, 5(3): 339-342.

[16] 郑剑英,吴瑞浚,翟连宁.氮磷配施对坡地谷子吸 N、P 量及土壤养分流失的影响[J].土壤侵蚀与水土保持学报,1999,(5):94-98.

GUO Cheng-da (Department of Geography, Fujian Teachers' University, Fujian Fuzhou 350007, China)
Abstract: The results indicated that nutrient, HA/FA, the aromaticity of humic acid, K_{OS}, and the contents of loosely and tightly bounded humus in highly mellowing vegetable soils are improved greatly by vegetable growing. The content and activity of micro-aggregates increased. This indicated acceleration of organic matter renewing and nutrient cycling.
Keywords: Vegetable soil; Micro-aggregates; Soil nutrient; Property of humus

ZHANG Xing-chang, ZHENG Jian-ying, WU Rui-jun, et al. (Institute of Soil & water Conservation, Chinese Academy of Sciences & the Ministry of Water Resources, Shanxi Yangling 712100, China)
Abstract: The field experiment of soil erosion was conducted. With increasing amounts of N and P fertilization, soil erosion and runoff yields are decreased gradually. Losses of soil organic matter and total nitrogen in sediment reached a minimum under the fertilization of 55.2kg N/ha ad 90kg P_2O_5/ha. However, when 55.2kg N/ha and 45kg P_2O_5/ha were used, soil available N loss was decreased to a minimum of 27.9kg/ha. The decrease in soil N loss in erosion was due to crop absorbing of soil N.
Keywords: N and P fertilizers; soil erosion; Soil N loss

WANG Jing-kuan, ZHANG Ji-hong, WANG Lei, CHEN En-fen (Research Laboratouy of Soil Fertility, Faculty of Resources and Environment, shenyang Agricultural University, Liaoning Shenyang 110161, China)
Abstract: The phosphorous retention and supply capacities changed greatly in microaggreates of brown earths with different fertility level in Liaoning Province. The results showed that the average of total P in soil with high fertility level was 0.611 ± 0.183g/kg, whereas 0.379 ± 0.095g/kg in soil with lower fertility level. The absorbed P was 127.1 ± 73.17mg/kgin fertile samples and 233.2 ± 47.28mg/kg in infertile soils. And the desorbed P and desorption rate were higher in the fertile soil than that in the infertile soil. In different microaggrates, the total P, desorbed P and desorption rate were higher in fertile sample than that in infertile soil. And it was found that the $< 10\mu$m microaggregate played a great role in the P retention and $> 10\mu$m microaggregate contributed greatly in the P desorption, which means that the ratio of $< 10\mu m / > 10\mu m$ microaggrate could be as one index of evaluating fertility level in brown earth.
Keywords: Brown earth, Microaggregate; Phosphorous; Absorb and desorb

HAN Yan-lai[1], JIE Xiao-lei[1], TAN Jin-fang[1], et al. (Henan agricultural University, Henan Zhengzhou 450002, China)

SUN Geng-yin (Institute of Soil & Fertilizer, Jiangsu Academy of Agricultural Sciences, Jiangsu Nanjing 210014, China)

WANG Wen-zhong (Taiyuan Teacher's college, Shan Xi Taiyuan 030001, China)
Abstract: A pot experiment was conducted on red and white soils by using millet *(Setaric L. Beauv)* as an indicator. The soils and plants were sampled at different stages of growth. The dynamic characteristics of K in the soils and its relationship with K uptake by millet plant were studied in terms of direct observation and chemical analysis. (1) The amount of K uptake by root was insignificant and the soil readily available K content did vary greatly at the seeding stage, while the slowly available K content increased instead. (2) At the elongation and sprouting stages, the ability of K uptake by plant increased with the rapid decrease in soil readily available and slowly available K, which reached the "minimum". (3) At the later stage, the K amount taken up by root reduced, while the content of the two kinds of K in the soil gradually raised up in the red soil.
Keywords: Soil; Potassium; Dynamics

ZHOU Tao[1], YANG Wen[2], BAI Guo-sheng[1], YU Zhen-huan[2] (1. institute of soil & Fertilizer of Ningxia Academy of Agricultural Forestry sciences; 2. The Research Center of Wine-Grapes of Ningxia, China)

LIN Bao, ZHOU Wei, LI Shu-tian, et al. (Institute of Soils & Fertilizers, Chinese Academy of Agricultural Sciences, Beijing 100081, China)
Abstract: A long-term fertilization experiment has been carried out for 20 year on fluvio-aguic soil. It was found that soil available S was almost exhausted gradually when mere chemical fertilizers were applied, whereas its level was relative high in the treatment with organic manure only. Both water soluble and exchangeable Ca were rich and its content was similar in all treatments except for the control due to the fertilizers and irrigation water containing Ca. The status of Mg was different from the above two elements. Water and acid soluble, exchangeable and total Mg behaved similar but were affected by fertilization differently, and hence the concentrations of the three forms were in the order: oringinal soil> organic treatment> control> chemical tertilizer plus organic fertilizer> chemical fertilizer. Nevertheless, soil Mg was still poor even in the organic treatment.
Keywords: Long-term fertilization; Sulfur; Calcium; Magnesium