COMPETITION EFFECT OF MIXED NON-LEGUME CROPPING SYSTEM ON NITROGEN UPTAKE

Zuhdi S. Wibowo*)

Abstract

An experiment which aimed to study the competition effect of mixed non-legume cropping system has been conducted at the Laboratory of Biotechnology of IAEA, Seibersdorf, Austria. Sorghum and Sudangrass as non-legume plants were used which planted in pure and mixed stands with planting distance betweem rows of 50 cm, 25 cm and 12,5 cm. The pures and the mixtures were put in one plot. The plots were equally fertilized with N^{15} labelled ammonium sulfate at rate 50 kg N ha^{-1}.

The results of the experiment have shown clearly that no competition effect on N^{15} uptake has been observed between sorghum and sudangrass with different row planting distances in mixed stand.

Introduction

A plant in a mixed cropping system has a different environmental growth compared to the monoculture, which is actually caused by competitions among crops. One of the competition is in nutrient uptake and this includes nitrogen (Haynes, 1980; Drapala & Johnson, cit. Donald, 1963).

It is obvious that nitrogen in soils is very mobile in respect to other nutrients, especially when it is in nitrate form. Any ammonium fertilizer given to soils of pH neutral of slightly alkaline will be quickly nitrified by soil microorganisms. This nitrogen transformation occurs if the soil temperature is favourable and by means of irrigation or rain shower nitrate will be homogeneously distributed over the soil surface and the rooting zone. The fertilizer users of farmers are assuming this situation to ensure the nitrogen supply to their crops. In a mixed cropping system, the competition on nitrogen uptake is encountered due to the root pattern and the nitrogen uptake rate of the individual plant in the system.

Besides competition, there were discoveries that legume plants are able to transfer nitrogen to other plants if they are put in mixtures. The mechanism of transferring nitrogen from pasture legumes to pasture grasses was described by Henzell & Vallis (1977) that it mainly caused by initial flush of mineralization of legume residues. The size of transferred nitrogen, therefore, will depend on the amount and the nitrogen content of the residues. The same explanations were given by Vallis et al. (1967), Haytead and Lowe (1977) and also quoted that the size of nitrogen transfer was not significant. But in addition to the above mechanism, Simpson (1965) had an evidence result that the transfer of nitrogen in a pasture legume-grass association was due to direct excretion of nitrogen from the intact root system.

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In a previous experiment with alfalfa and ryegrass, the % ^{15}N atom excess of both alfalfa and ryegrass was changed in a mixture compared to the pure crops (Table 1). This was interpreted as increased N_2 fixation of alfalfa in a mixed stand and transfer of N from alfalfa to ryegrass following cutting of the stand and decomposition of some roots and nodules. This would, however, also have occured due to different ^{15}N uptake of crops in a mixed stand compared to pure stand. The present experiment was therefore conducted to investigate the effect of competition between two non-legume crops on ^{15}N uptake, with the objective of measuring whether similar changes in N uptake would occur when non-N_2-fixing plants were grown in a mixed stand as observed in the previous experiment.

Table 1. **Percentages and amounts of nitrogen transferred from alfalfa to ryegrass in a two-year mixed sward (Hardarson, IAEA Laboratory, unpublished data).**

No. of harvest	Stands*) alfalfa ryegrass	N yield (kg/ha) alfalfa	N yield (kg/ha) ryegrass	% ^{15}N a.e. alfalfa	% ^{15}N a.e. ryegrass	% N in ryegrass transf. from alfalfa	N in ryegrass (kg/ha) transf. from alfalfa
1	100 — 0	101	—	0.078	—	—	
	66 — 34	82	32	0.032	0.354	0	0
	34 — 66	63	48	0.028	0.303	0	0
	0 — 100		56	—	0.262	—	
2	100 — 0	94		0.208	—	—	—
	66 — 34	82	21	0.103	0.734	14	3
	34 — 66	60	25	0.029	0.718	16	4
	0 — 100		23	—	0.851	—	
3	100 — 0	128	—	0.163	—	—	—
	66 — 34	134	31	0.031	0.869	6	2
	34 — 66	116	31	0.019	0.840	9	3
	0 — 100	—	30	—	0.921	—	—
4	100 — 0	180	—	0.111	—	—	—
	66 — 34	141	9	0.076	0.374	11	1
	34 — 66	95	13	0.047	0.396	5	1
	0 — 100	—	22	—	0.419		
5	100 — 0	70	—	0.241		—	—
	66 — 34	54	3	0.161	0.549	3	1
	34 — 66	39	9	0.095	0.473	16	1
	0 — 100	—	22		0.565		

*) Percentage weight of seed in mixtures at planting.

Materials and Methods

The experiment was conducted at the experimental field of the IAEA Seibersdorf Laboratory, Austria, from July 16 to October 8, 1984. The non-legume plants used were sudangrass (.......) and Sorghum (.......), which were sown in pure and mixture stands. There were three planting distances between rows, i.e. 50 cm, 25 cm and 12.5 cm and in each planting distance the pures and the mixture were put in one plot. Each plot was divided into three equal areas of which one third of one end was planted with sudangrass, the other one third at the other end was planted with sorghum and one third at the middle was planted with mixture. The mixed stands of those three row planting distances were made in such a way that the distance between rows of sorghum was maintained similar at 50 cm. The treatment combinations of the experiment became 10 and they were replicated 4 times.

N fertilizer in the form of ^{15}N labelled $(NH_4)_2SO_4$ with 1.027% atom excess was applied two weeks after seeding, where the young plants of both sorghum and sudangrass had 3 — 4 levels. The rate of application per plot was 50 kg N/ha. During the course of the experiment the plots were maintained free from weeds and frequently irrigated by means of sprinkler irrigation 2 — 4 hours a day, depending on the dryness of the field at a particular time.

All plots were harvested on October 8, 1984. The harvested areas were different for each row planting distance, however row borders had been taken into account. The plants with 50 cm row distance were harvested at 1.2 × 1.5 m, with 25 cm at 1.2 × 1.25 and with 12.5 cm at 1.2 × 1.125 m. The fresh weights of the harvested material and its subsamples were recorded. The subsamples were subsequently dried at 70°C and the dry weights again recorded. The plant samples were analysed for ^{15}N and total nitrogen.

Just one day before harvest, a quantitative assay of nitrogen fixation was conducted by means of acethylene reduction technique for both sudangrass and sorghum. No N_2 fixation was observed.

Results and Discussion

The first step to understand whether mixing non-legumes does affect N uptake is to determine the ^{15}N atom excess of pure and mixed stands. The result of ^{15}N assay is summarized in Table 2. A LSD test at 95% confidence level by one way analysis of variance shows that there were no differences in % ^{15}N atom excess among the pure and the mixture stands. It also shows that even among the row distances the % ^{15}N atom excess are not different. From this then it is clearer that the non-legume crops recognized the available nitrogen from two sources (i.e. soil and fertilizer) in the same proportion, both in the pure and mixed stands.

This can also be observed from the figures of nitrogen derived from fertilizer and available soil nitrogen in Table 2. No effect on ^{15}N uptake could be found by mixing the two non-fixing crops. The difference in ^{15}N uptake by alfalfa and ryegrass (Table 1), when grown in mixed stand compared to pure stand is therefore likely to be due to increased N_2 fixation of alfalfa and the decreased ^{15}N atom excess in ryegrass due to transfer of N from alfalfa to ryegrass after cutting the stand.

Conclussion

No competition effect on ^{15}N uptake has been observed between sorghum and sudangrass with different row planting distances in mixed stand.

Table 2. **^{15}N atom excess (%), NdfF and available soil nitrogen of sorghum and sudangrass in pure and mixture stands harvested two months after seeding.**

Row distance	Stand	% ^{15}N a.e.	% NdfF	Soil avail. N [kg($(NH_4)_2SO_4$/ha]
50 cm	sorghum pure	0.195	18.9	226
	Sudangrass-pure	0.192	18.7	220
25 cm	sorghum-pure	0.218	21.2	189
	sorghum-mixture	0.209	20.3	204
	sudangrass-pure	0.184	18.0	261
	sudangrass-mixture	0.198	19.3	215
12.5 cm	sorghum-pure	0.198	19.3	211
	sorghum-mixture	0.220	21.4	196
	sudangrass-pure	0.200	19.5	212
	sudangrass-mixture	0.201	19.6	209
LSD 0.05		0.059 NS	5.75 NS	94.7 NS

References

1. Haynes, R.J. (1980) Competition aspects of the grass-legume association. *Advances in Agronomy,* 33, 250 — 253.
2. Donald, C.M. (1963) Competition between crops and associate plants, *Advances in Agronomy,* 15, 53 — 77.
3. Henzell, E.F., Vallis, I. (1977) Transfer on nitrogen between legumes and other crops. *Biological Nitrogen Fixation in Farming Systems of the Tropics,* John Willey & Sons, 73 — 87.
4. Vallis, I., Henzell, E.F., Evans, T.R. (1977) Uptake of nitrogen by legumes in mixed swards. *Aust. J. Agric. Res.,* 28, 413 — 425.
5. Haystead, A., Lowe A.G. (1977) Nitrogen fixation by white clover in hill pasture. *Journal of Brit. Gras. Soc.,* 32, 57 — 63.
6. Simpson, J.R. (1965) The transference of nitrogen from pasture legumes to an associated grass under several systems of management in pot culture. Aust. J. Agric. res., 16, 915 — 926.

Appendix 1. **Data obtained from the field and laboratory (Exp. XII/84 — WIBOWO)**

Row distance	Stand & Rep.		Fresh w.h.p.	DM yield/ha	% N	% ^{15}N a.e.	% NdfF
50 cm	Su-P	1.	3.105	2950	1.78	0.162	15.7
		2.	3.170	2889	1.83	0.214	20.7
		3.	2.069	1794	1.89	0.215	20.8
		4.	2.261	1972	1.90	0.180	17.4
	So-P	1.	8.065	6988	1.59	0.140	13.6
		2.	9.526	8416	1.32	0.173	16.8
		3.	7.397	6822	1.50	0.228	22.1
		4.	8.063	7794	1.25	0.238	23.1
25 cm	Su-p	1.	3.743	4086	1.51	0.099	9.6
		2.	4.344	5039	1.37	0.204	19.6
		3.	3.168	3860	1.20	0.196	18.9
		4.	4.007	4380	1.54	0.239	23.2
	Su-M	1.	1.348	1626	1.64	0.139	13.5
		2.	1.514	1940	1.11	0.217	21.0
		3.	1.471	1993	1.14	0.228	22.1
		4.	1.881	2233	1.18	0.209	20.3
	So-P	1.	7.619	8226	1.72	0.174	16.9
		2.	8.529	9152	1.22	0.231	22.4
		3.	9.633	10145	1.05	0.234	22.7
		4.	8.190	8732	1.16	0.234	22.7
	So-M	1.	6.525	7219	1.68	0.164	15.9
		2.	6.031	6226	1.14	0.263	25.5
		3.	5.328	5786	1.02	0.223	21.6
		4.	4.314	4686	1.29	1.188	18.2
12.5 cm	Su-P	1.	4.489	6348	1.19	0.166	16.1
		2.	4.712	6140	1.27	0.210	20.3
		3.	3.450	4726	1.14	0.246	23.8
		4.	3.200	4244	1.38	0.179	17.3
	Su-M	1.	1.811	2504	1.23	0.185	17.9
		2.	1.660	2348	1.28	0.175	16.9
		3.	1.395	1889	1.15	0.248	24.0
		4.	1.485	2059	1.27	0.199	19.3
	So-P	1.	8.202	10206	1.05	0.186	18.0
		2.	9.953	10621	8.98	0.175	16.9
		3.	9.320	11043	1.00	0.208	20.1
		4.	7.825	1002	1.02	0.225	21.8
	So-M	1.	5.065	6155	1.23	0.192	18.6
		2.	5.266	5696	1.14	0.156	15.1
		3.	4.147	4637	1.19	0.290	28.1
		4.	5.156	6266	1.17	0.243	23.5

*)% ^{15}N a.e. of fertilizer = 1.032 with rate of application of 50 kg N/ha.

NITROGEN RECOVERY AS AFFECTED BY FORM AND TIME OF FERTILIZER APPLICATION

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Abstract

The experiment to know the nitrogen recovery as affected by form and time of fertilizer application has been conducted at the Laboratory of Biotechnology of IAEA, Seibersdorf, Austria. The fertilizer used was ammonium sulfate with 1,027% ^{15}N atom exess applied in liquid and solid form. The fertilizer application was done three days before seeding (T_1 and T_2) and two weeks after seeding (T_3 and T_4). Sudangrass was used as test plant which fertilized with rate of 100 kg N ha-1.

The results of the experiment shows that ammonium sulfate applied in liquid form on an alkaline soil with high content of caleium carbonate had undergone a significant lost. This loss was probably due to ammonia volatilization and this could not be avoided although the fertilizer was applied two weeks after seeding.

Introduction

One of the processes which affects the nitrogenous fertilizer recovery is loss of nitrogen from soil in gaseous form by two major mechanisms, ammonia volatilization and denitrification. Ammonia gas may be lost to the atmosphere whenever ammonium compounds are applied to the soil surface and the greatest losses will occur from cal soil at high soil pH (Fenn & Kessel, 1976 cit. Rolston, 1978). Fertilizers such as urea and ammonium sulphate will undergo loss of more than 50% of the amount applied, if precautions are not taken. The best solution for minimizing ammonia loss is to incorporate or place ammonium compounds approximately 10 cm below relatively dry surface soil (Rolston, 1978).

On a dry land farming, loss of nitrogen due to denitrification may not occur except at a particular period when soil oxygen becomes depleted in narrow soil-water content range near saturation.

In this experiment, instead of measuring nitrogen losses to atmosphere by sophisticated equipments (Denmead et al., 1974, 1976, cit. Rolston, 1978), an object of the present experiment was to quantify the recovery of applied ammonium sulphate expressed in % ^{15}N atom excess, nitrogen derived from fertilizer (NdfF) and fertilizer use efficiency (% FUE). The calculations of the above parameters can only be carried out by using isotope techniques and in this case ^{15}N labelled ammonium sulphate was used.

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Materials and Methods

The experiment was conducted in the field of the IAEA Seibersdorf Laboratory, Austria, from July 13 to October 9, 1984. The soil characteristics of the field are as follows, pH (H_2O) 8.3 and (Kal) 7.7, texture clay loam with clay content 35.9%, loam content 30.0% and sand content 34.1%, gravel at 0 — 40 cm soil depth 0.2 — 5 mm ranging from 15 — 30%, total nitrogen content 0.3%, humus content 6.76%, $CaCO_3$ content 14.3% and high content of available K and P (Claus et al., 1984).

The fertilizer used in this experiment was ammonium sulphate with 1.027% ^{15}N atom excess applied in solid and liquid form. Application of fertilizer was done first at three days before seeding (T_1 and T_2) and the second at two weeks after seeding (T_3 and T_4) when the young plants had 3 — 4 leaves. The solid form was broadcasted on the plot surface and followed by incorporation into the soil about 5 cm depth. The liquid form was made by dissolving solid fertilizer into 400 ml demineralized water per plot and applied by means of spray on the plot surface. In order to have the same condition with solid application after spraying the soil surface was also worked in. Soon after application of the fertilizers, the field was irrigated about one hour using sprinkler irrigation just to get it homogeneously moist. The rate of application per plot was calculated equal to the amount of 100 kg N/ha. This relatively high rate of application was aimed to keep enough nitrogen supply during the plant growth and a better experimental result.

Sudangrass was seeded at 40 cm inter-row distance and 10 cm interplants distance. The plot size was 1.2 × 1.6 m located close to each other in 0.5 m rectangle distance. The whole experiment therefore consists of 4 treatment (T_1, T_2, T_3, T_4) with 5 times replication. The field was kept clean from weeds during the experimental time and frequently irrigated by means of sprinkler irrigation, 2 — 4 hours a day, depending on the dryness of the field at a particular time.

The plot was harvested on October 9, 1984, and the area harvested per plot 1.2 × 0.9 m after taking into account the plot border. Fresh weight of harvested plant per plot and its subsample was recorded. The subsamples were put dried at 70°C overnight and subsequently the dry weights recorded. After grinding, plant samples were analyzed for ^{15}N and total nitrogen.

Results and Discussion

The figures presented in Table 1 show very clearly that by applying ammonium sulphate in liquid form to such type of soil, the ^{15}N atom excess (%) decreased significantly (LSD 0.05). The ^{15}N atom excess was also used to calculate nitrogen derived from fertilizer (% NdfF) and the fertilizer use efficiency (% FUE).

A significant difference in ^{15}N at. exc. between solid compared to liquid application could be observed when the fertilizer was given before seeding. The soil surface was almost dry at the time of application of liquid form and the fertilizer got therefore into direct contact with time gravels which resulted in ammonia formation.

Table 1. **Fertilizer nitrogen recovery of three month old sudangrass (% ^{15}N at. exc., % NdfF, % FUE) applied with different times and forms of ^{15}N labelled ammonium sulphate.**

Time and form of fertilizer application	% ^{15}N excess	% NdfF	% F.U.E.
T_1 = solid, before seeding	0.294 bcd	28.8 bcd	28.5 bcd
T_2 = liquid, before seeding	0.170 a	16.4 a	13.9 a
T_3 = solid, after seeding	0.287 bc	28.0 abc	25.2 abc
T_4 = Liquid, after seeding	0.228 ab	22.4 ab	17.2 ab
LSD 0.05	0.117	11.5	13.2

The same letter on the figures refers to no significant difference at LSD 0.05.

Same trend in ^{15}N at. exc. was found between solid and liquid application two weeks after seeding. However, this was not statistically significant.

From the record of dry matter yield, it could lead to misinterpretation because of its unsensitivity compared to the figure on nitrogen fertilizer yield as shown in Table 2.

Table 2. **Dry matter yield (ton/ha) and nitrogen fertilizer yield (kg/ha) of three month old sudangrass applied with different times and forms of ^{15}N ammonium sulphate.**

Time and form of application	Dry matter yield (ton/ha)	N fertilizer yield (kg/ha)
T_1 = solid, before seeding	5.0 abc	28.5 bcd
T_2 = liquid, before seeding	5.4 bcd	13.9 a
T_3 = solid, after seeding	4.9 ab	25.2 abc
T_4 = liquid, after seeding	4.3 a	17.2 ab
LSD 0.05	1.06	13.2

Conclussion

Ammonium sulphate applied in liquid form on an alkaline soil with high content of calcium carbonate has undergone a significant loss. This loss was probably due to ammonia volatilization and this could not be avoided although the fertilizer was applied two weeks after seeding.

References

1. Rolston, D.E., (1978) Pratt, P.F. (ed.), *Volatile losses of nitrogen from Soil, Management of nitrogen in irrigated agriculture.* New York, 169 — 191.
2. Broeshart, H., (1974) Quantitative measurement of fertilizer uptake by crops. *Neth. J. Agric. Sci.*, 22 : 245 — 254.

Appendix 1. Data obtained from the field and laboratory (Exp. XIII/84 — Wibowo)

Treatment	Rep.	Fresh w.h. plant	DM Yield/ha	% N	N Yield/ha	% ^{15}N a.e.	NdfF	% F.U
	1	3.282	4907	2.14	105.0	0.367	0.36	37.8
	2	2.723	4283	2.36	101.1	0.309	0.30	30.3
	3	3.720	6255	1.52	95.1	0.325	0.32	30.4
	4	3.499	5572	2.07	115.3	0.326	0.32	36.9
	5	2.390	4027	1.26	50.7	0.142	0.14	7.1
$\overline{X}$								28.5
T_2	1	3.345	5382	1.68	90.4	0.275	0.27	24.4
	2	3.126	4894	1.73	84.7	0.310	0.30	25.4
	3	2.424	4212	1.13	47.6	0.052	0.05	2.4
	4	3.347	5432	1.84	99.9	0.054	0.05	5.0
	5	3.897	6877	1.17	80.5	0.158	0.15	12.1
$\overline{X}$								13.9
T_3	1	3.284	4868	2.41	117.3	0.275	0.27	32.7
	2	2.869	4582	1.75	80.2	0.373	0.36	28.9
	3	3.187	5137	1.99	102.2	0.286	0.26	28.6
	4	3.204	4888	1.98	96.8	0.239	0.23	22.3
	5	2.681	4798	1.16	55.6	0.264	0.26	14.4
$\overline{X}$								25.2
T_4	1	2.775	4128	1.99	82.1	0.311	0.30	24.6
	2	3.294	4876	2.02	98.5	0.261	0.26	25.6
	3	1.816	2924	1.34	39.2	0.141	0.14	5.5
	4	2.924	4805	1.82	87.4	0.143	0.14	12.2
	5	2.775	4725	1.38	65.2	0.286	0.28	18.3
$\overline{X}$								17.2

^{15}N at. exc. of fertilizer — 1.022% with rate 100 kg N/ha.

Catatan untuk pengarang.

Naskah dapat ditulis dalam bahasa Indonesia atau bahasa Inggris, diketik pada satu muka, dengan kertas putih ukuran kwarto, dengan jarak 1½ spasi, kecuali : Ringkasan, Abstrak. Tabel, Keterangan gambar, Daftar pustaka, dan keterangan lain, diketik dengan 1 spasi.

Naskah diserahkan rangkap 2 (dua), harus dibuat yang jelas dan rajin dengan diberi ruang tepi (margin) yang cukup.

Gambar, grafik, lukisan-lukisan lain, digambar dengan tinta Cina, paling besar sama dengan ukuran majallah ini (kwarto).

Gambar potret, jika ada, harus pada kertas mengkilat, jelas dan tidak kabur.
Untuk menghemat mahalnya ongkos penerbitan, harap jumlah potret dibatasi melulu untuk hal-hal yang perlu sekali.

Gambar-gambar (lukisan atau potret) dan tabel diberi nomer urut dalam naskah itu dan letaknya gambar perlu diberi petunjuk pada tepi (margin) kertas tersebut. Tabel, gambar, potret, diberi judul, keterangan singkat, satuan ukuran, dan nomer urut.

Nama Latin (binomial) diberi garis bawah.
Jika tidak memakai mesin tik khusus, maka rumus-rumus dan persamaan ilmu pasti, dapat ditulis tangan asal jelas.

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9. Kesimpulan (Conclusion).
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10. Ucapan terima kasih (Acknowledgement), bila perlu.
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    b. Year of publication between brackets; if more than one article appeared in the same year by the same author(s) use additional small letters a, b, c, etc.
    c. Full title of article.
    d. Name of periodicals abbreviated according to List of Periodicals Abstracted in current usage; if in doubt give name in full.
    e. Volume number.
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