Neth. J. Pl. Path. 87 (1981) 193-199

The effect of growing beans together with maize on the incidence of bean diseases and pests

H. A. VAN RHEENEN, O. E. HASSELBACH and S. G. S. MUIGAI

Ministry of Agriculture, National Horticultural Research Station, Grain Legume Project, Thika, Kenya

Accepted 19 May 1981

Abstract

Compared with mono-cultures, beans grown in association with maize showed generally less incidence of the following diseases and pests: halo blight, bean common mosaic, anthracnose, common blight, scab, *Phoma*, mildew, bolworm and to a lesser extent angular leaf spot. For white mold and the black beetle *Systates* the opposite was observed. Rust and aphids were erratic in this respect.

Apparently a kind of cultural control of the major bean diseases in Kenya is effected by growing beans in association with maize.

Additional keywords: mono-cropping, mixed cropping, *Phaseolus vulgaris,* bean, *Zea mays,* maize, bean diseases, *Pseudomonas phaseolicola,* halo blight, bean common mosaic virus, *Colletotrichum lindemuthianum,* anthracnose, *Xanthomonas phaseoli,* common blight, *Elsinoe phaseoli,* scab, *Phoma exigua var. diversispora,* black node disease, *Erysiphe polygoni,* powdery mildew, *Sclerotinia sclerotiorum,* white mold, *Phaeoisariopsis griseola,* angular leaf spot, *Uromyces appendiculatus var. appendiculatis,* rust, bean pests, *Heliothis armigera,* bolworm, *Systates pollinosus,* black beetle, *Aphis fabae,* aphid, disease score, pest score, Kenya.

Introduction

Until the sixties of this century the Extension Services of the Ministries of Agriculture in Africa generally propagated mono-cropping and discouraged mixed cropping, and even up to the present time such tendency is occasionally observed.

However, because of a persistant refusal by farmers to abandon the system of mixed cropping, doubts arose in the minds of agricultural researchers, whether the advices of the Extension Services were sound in this respect, and consequently their interest to study cropping systems was awakened.

Probably one of the first well planned mixed cropping experiments was carried out at Mokwa Agricultural Research Station, Nigeria in 1965 by C. Harkness and F. de Wolff (personal communications) with groundnuts and maize. A considerable amount of research effort followed in Nigeria and elsewhere and thus it became possible to organise a 'Symposium on Intercropping in Semi-Arid Areas' in Morogoro, Tanzania in 1976. This was the first of its kind and a second of the same title and venue was held in 1980.

Most of the work on mixed cropping concerns the agronomy of the crops' associations, and very little has been published on the effect of mixed cropping on disease and pest indidence (Monyo et el., 1976; Bean Improvement Cooperative, 1976-1980; Centro Internacional Agricultura Tropical, 1976, 1978a, 1978b, 1979). However, it is generally recognised that diseases and pests form a major constraint for bean production, and that the environment of the bean plant is drastically changed by intercropping. So it may be anticipated that the complex equilibrium between crops and their diseases and pests shows shifts due to cropping systems, which may be of such importance that they influence the farmers' choice of cultivation practice.

The authors started their observations on disease and pest incidence in bean mono-cultures and bean-maize associations in 1976, and were astonished to note often such significant differences, recognisable in the field from a far distance. They continued their work during a five-year period, always making use of the agronomy and selection trials of the bean programme in Kenya, the results of which are reported in this paper.

Materials and methods

The data collected and presented here are from breeding and agronomy trials carried out at six different research stations of the Ministry of Agriculture of Kenya, and at the Kabete Campus of the University of Nairobi. The stations and the climatic zones to which they belong are listed in Table 1 (Anonymous, 1970; Njuguna et al., 1980).

The breeding experiments were basically cultivar trials where the mono-crop beans were grown as recommended by the Kenya Ministry of Agriculture (1976-1979) at row distances of 50 cm and with 10 cm between the plants in the rows. Fertilizers were applied at a rate of 40 kg P_2O_5 and 40 kg N per ha as superphosphate and calcium-ammonium nitrate, respectively, until 1979, when the recommendation changed to 200 kg diammonium phosphate per ha.

The mixed crop in 1976 had alternating rows of maize and beans, these being 50

Table 1. Experimental stations where bean trials were executed.

Station	Province	Town	Climatic zone[1]
Dryland Farming Research Station	Eastern	Machakos	C
Embu Agricultural Research Station	Eastern	Embu	B
National Horticultural Research Station	Central	Thika	B
National Seed Quality Control Service	Rift Valley	Nakuru	B
Nyanza Agricultural Research Station	Nyanza	Kisii	A
Western Agricultural Research Station	Western	Kakamega	A
Kabete Field Station, University of Nairobi	Central	Nairobi	B

[1]A: Equatorial, humid to sub-humid; B: Dry sub-humid to semi-arid; C: Semi-arid.

Tabel 1. Proefstations waar onderzoek werd verricht.

cm apart, with 10 cm between the plants in the rows for both maize and beans. Since 1977 throughout, the maize was grown as recommended by the Kenya Ministry of Agriculture (1977) at a row distance of 75 cm and an intra-row distance of 30 cm. Superphosphate and calcium-ammonium nitrate were applied at rates of 40 kg P_2O_5 and 40 kg N per ha, respectively. The beans, until 1979, were planted in a single row in between two maize rows with 15 cm between the plants, and without extra fertilizer; but since 1979 two rows of beans were sown in between the maize rows, with 25 cm between the rows and 10 cm within the rows, while 100 kg diammonium phosphate per ha was applied to the beans.

The agronony experiments varied in spacings and fertilizers depending on the treatments applied (Table 2).

Tabel 2. Main characteristics of breeding and agronomy trials contributing to the disease and pest comparisons.

Type of experiments	Discipline	Treatments[1]	Bean population[2] plants × 10^3/ha	
			mono	mixed
1	Breeding	c	200	100
2	Breeding	c	200	89
3	Breeding	c	200	267
4	Agronomy	d×f×c	178-267	89
5	Agronomy	t×f×d	200	74-167
6	Agronomy	d×f×m	E	E
7	Agronomy	d×f	E	E
8	Agronomy	t×f×c	178-267	89
9	Agronomy	r	E	E
10	Agronomy	d×f×c	E	E

[1] c: cultivar; d: density; f: fertilizer; t: time of planting; m: manure; r: replacement maize/beans.
[2] E: Equal densities compared.

Tabel 2. Voornaamste karakteristieken van de selectie- en teeltproeven, die zijn gebruikt voor het vergelijken van ziekten en plagen.

The severity of the disease and pest incidence was for all diseases and pests in all trials scored for on a symptoms scale from 0 to 5, where 0 indicated absence of symptoms, and 5 a totally destructive occurrence of the disease or pest. Although arbitrarily performed and subjective to some extent, this widely adopted system of scoring provides a fair estimate of the disease incidence as expressed by symptoms. Moreover, here the comparative incidence under mono-cropping and mixed cropping was of main importance and the subjectivity in scoring then matters less. The diseases scored for are shown in Table 3.

The breeding trials were split-plot experiments. The main plot treatments were mono-cropping versus mixed cropping, while different cultivars formed the sub-plot treatments. The disease scores and pest scores of the same variety within a

Table 3. Differential disease and pest incidence in beans grown in mono-culture and in association with maize.

Disease or pest and its causing organism	Average score[1]		Number of comparisons with score ratios[2] mono-: mixed crop			Chi-square[3]	P[3]
	mono	mixed	> 1	= 1	< 1		
Halo blight *(Pseudomonas phaseolicola*	1.7	0.9	880	842	258	195.4	< 0.01
Bean common mosaic (bean common mosaic virus)	1.3	0.9	638	351	178	1181.3	< 0.01
Anthracnose *(Colleto-trichum lindemuthianum)*	1.0	0.8	228	173	119	22.8	< 0.01
Common blight *(Xantho-monas phaseoli)*	1.2	0.9	830	570	300	165.2	< 0.01
Scab *(Elsinoe phaseoli)*	1.0	0.6	157	127	54	31.4	< 0.01
Black node disease *Phoma exigua* var. *diversispora)*	3.0	2.6	49	43	16	10.1	< 0.01
Powdery mildew *Erysiphe polygoni)*	2.0	1.7	31	25	11	6.0	< 0.05
White mold *(Sclerotium sclerotiorum)*	1.8	2.0	23	16	45	5.8	< 0.05
Angular leaf spot *(Phaeo-isariopsis griseola)*	1.5	1.4	737	648	464	40.3	< 0,01
Rust *(Uromyces appendicul-atus* var. *appendiculatis)*	1.1	1.1	575	637	459	8.1	< 0.01
Bolworm *(Heliothis armigera)*	0.7	0.3	123	74	34	34.3	< 0.01
Black beetle *(Systates pollinosus)*	1.2	1.7	17	457	367	145.7	< 0.01
Aphid *(Aphis fabae)*	1.0	1.0	53	53	50	0.1	0.8-0.9

[1] Mean of all trial averages.

[2] Within a replication: $\frac{\text{score mono-crop}}{\text{score mixed crop}}$ for corresponding cultivars and treatments; totals over all trials are shown.

[3] To test 0-hypothesis, that cropping sytem has no effect.

Tabel 3. Het ongelijk optreden van boneziekten en -plagen bij monocultures en mengteelten met mais.

replication under mono-cropping and mixed cropping were compared and the score ratios calculated. For example, if variety A received for halo blight in replication I of a cultivar trial a score of 3 when mono-cropped and a score of 2 when grown in association with maize, the ratio mono-: mixed crop was: 3 : 2 = 1.5. For the agronomy trials a similar procedure was followed for treatments which differed only in cropping system; otherwise average disease scores per experiment were

calculated only, but separate over the monocrop bean plots and the plots with beans grown in assocation with maize.

Where disease score ratios were calculated in a trial, they were grouped in classes where the ratio was more than, equal to, or less than 1. The number of ratios per trial was equal to half the number of plots per trial. The hypothesis that the cropping system had no effect on the disease incidence was tested by dividing the members of the equal-to-1 class evenly over the more-than-1 and less-than-1 classes, and by calculating the chi-square value at a then expected ratio of 1 : 1.

Results

Each trial yielded a number of disease comparisons between mono-cropping and mixed cropping equal to the number of replications times the number of varieties or treatments allotted to the sub-plots. In general the trials at the various stations during the different seasons showed similar trends in respect of these comparisons per individual disease and pest, and the results have therefore been summarized in Table 3 by giving the total number of comparisons, the score data as an average of the trial means, the chi-square values and the corresponding P estimates.

Discussion

The two different systems of bean production appeared to have a differential effect on the indidence of a number of diseases and pests. Most of these were less severe in the mixed than in the mono-crop and the associated maize crop effected a kind of cultural control of the pathogens and pests. White mold and the black *Systates* beetle were exceptions in this respect, but their damage is usually of minor importance anyway. Rust and aphids behaved somewhat erratic, showing sometimes higher scores in the mixed than in the mono-crop beans.

Shoyinka (in: Monyo et al., 1976) observed that cowpeas in Nigeria were less attacked by virus when they were intercropped with maize, rice or soya beans. Moreno (1977) examined the severity of angular leaf spot of beans in six different cropping systems in which beans were grown alone and in association with maize, sweet potatoes, cassava, maize plus sweet potatoes, and maize plus cassava. Mora (1978) however noticed in Costa Rica less incidence of angular leaf spot and rust in beans when these were grown in associaton with maize. Reduced insect damage in crop mixtures has been reported by Monyo et al. (1976), Altieri (1976) and Altieri et al. (1977).

Usually beans grown in association with maize yield considerably less than when grown in mono-culture, even though the plant density may be about the same. In Kenya under farmers' conditions yields for mono-crop and mixed crop beans are estimated at 750 and 375 kg per ha respectively. The relation depends on the cultivation method; for instance the bean: maize density ratios are of importance in this respect, and so are the relative planting dates. When diseases are of minor importance, the ratios between bean yields from associations and bean yields from mono-crops usually range from 0.5 to 0.6 in experiments where beans and maize are planted the same day at recommended spacings. However, in the wetter areas of Kenya where diseases often plague bean crops such ratios frequently exceed the

value 1, and the obvious protection the maize crop provides to the beans may well be a factor in the farmers' preference to practice in most cases in Kenya mixed rather than mono-cropping.

White mold, as an exception, was more severe on beans grown in association with maize than on mono-cropped beans. The disease is known to be more damaging when the crop canopies are densely closed and the environment is moist and humid (Steadman et al., 1973; Abawi and Crogan, 1975; Schwartz and Steadman, 1978). It seems, therefore, understandable that beans in association with maize show more white mold infection than beans grown as mono-crop with a more open habitat. Regarding the other diseases listed: the associated maize crop causes the temperature to decrease, and the humidity to increase, it greatly intercepts light, it forms an umbrella over the bean crop and so probably prevents spreading of spores by splashing, and it also operates as a kind of wind break, reducing the spread of spores by wind. The environmental differences between mono- and associated crops and their influences on disease incidence are complex, largely unexplored and very interesting, and the observations presented here may encourage further studies in a field most relevant to agriculture in the tropics.

Acknowledgement

The authors are most grateful to the Technical Officers and Technical Assistant at the various stations who carried out the trials and in many cases did the disease and pest scoring; also to Dr Mukunya of the University of Nairobi for his contribution and always inspiring interest in bean growing; to Ir N. Hubbeling, who as Advisor to the Project greatly helped in the identification of diseases; to the Senior Pathologist of the National Agricultural Laboratories, Nairobi for identifying diseases in plant samples, and to the Senior Entomologist of the same institution for similar work on pests; and to the Members of Staff of the Grain Legume Project for their valuable comments on the manuscript. The work of the Editorial Committee of the National Horticultural Research Station, Thika in editing the paper is gratefully acknowledged. Finally, thanks are due to the Director of Research of the Ministry of Agriculture for his permission to publish this paper.

Samenvatting

Het effect van mengteelt bonen met mais op het voorkomen van ziekten en plagen in bonen

Bonen in mengteelt met mais vertoonden over het algemeen in vergelijking met bonen in monocultuur minder aantasting door de navolgende ziekten en plagen: vetvlekkenziekte, bonerolmozaïek, vlekkenziekte, gewone vlekkenziekte, schurft, zwarte knopenziekte, meeldauw, peulenboorder en, in mindere mate, veelhoekvlekkenziekte. Het tegenovergestelde was het geval voor sclerotiënrot en de bladrandkever *Systates*. Roest en de zwarte bonenluis gedroegen zich wat wisselvallig in dit opzicht. Geconstateerd mag worden, dat door mengteelt met mais een soort teeltkundige beheersing van de belangrijkste ziekten en plagen in Kenya wordt bewerkstelligd.

References

Abawi, G.S. & Grogan, R.G., 1975. Source of primary inoculum and effects of temperature and moisture on infection of beans by *Whetzelinia sclerotiorum*. Phytopathology 65: 300-309.

Altieri, M.A., 1976. Ecological regulation of pests in tropical ecosystems: Bean and maize mono- and polycultures diversified with weeds. Tesis Mag. Sc. Bogota, Universidad Nacional de Colombia, Instituto Colombiano Agropecuario. In: Abstracts on field beans. Vol. III. Centro Internacional de Agricultura Tropical (1978b).

Altieri, M.A., Doll, J. & Schoonhoven, A. van, 1977. Insect / weed interactions in maize/bean mono- and polyculture systems. Revista Comalfi 4: 171-208. In: Abstracts on field beans. Vol. III. Centro Internacional de Agricultura Tropical (1978b).

Anonymous, 1970. National atlas of Kenya. Survey of Kenya, Nairobi.

Bean Improvement Cooperative, 1976, 1977, 1978, 1979, 1980. Annual Rep., Vol. 19, 20, 21, 22, 23.

Centro Internacional de Agricultura Tropical, 1976, 1978a, 1978b, 1979. Abstracts on field beans. Vol. I, II, III, IV.

Kenya Ministry of Agriculture, 1976-1979. Growing food beans in Kenya. Advisory Leaflet, Grain Legume Project, National Horticultural Research Station, Thika, Kenya.

Kenya Ministry of Agriculture, 1977. Maize production. Crops advisory Leaflet No. 261.

Kenya Ministry of Agriculture, 1977-1980. Interim Reports, Grain Legume Project, National Horticultural Research Station, Thika, Kenya.

Monyo, J.H., Ker, A.D.R. & Campbell, M., 1976. Intercropping in semi-arid areas. Report of a symposium held at the Faculty of Agriculture, Forestry and Veterinary Science, University of Dar es Salaam, Morogoro, Tanzania, 10-12 May, 1976. Intern. Dev. Res. Centre, Ottawa, Canada.

Mora, L.E., 1958. Effect of soil tillage on incidence and severity of maize and bean leaf diseases in different cultivation systems. Tesis Mag. Sc. Turrialba, Universidad de Costa Rica, Centro Agronomico Tropical de Investigacion y Ensenanza. In: Abstracts on field beans. Vol. IV. Centro Internacional de Agricultura Tropical (1979).

Moreno, R.A., 1977. Effect of different cropping systems on severity of angular leaf spot of beans, caused by *Isariopsis griseola*. Agronomia Costarricense 1: 39-42.

Njugunah, S.K., Ndegwa, A.M.M., Rheenen, H.A. van & Mukunya, D.M., 1980. Bean production in Kenya . Paper presented at the Regional Workshop on potentials for field beans in Eastern Africa, Lilongwe, Malawi, 9-14 March, 1980.

Schwartz, H.F. & Steadman, J.R., 1978. Factors affecting sclerotium populations of, and apothecium production by *Sclerotinia sclerotiorum*. Phytopathology 68: 383-388.

Siderius, W. & Muchena, F.N., 1977. Soils and environmental conditions of agricultural research stations in Kenya. Kenya Soil Survey, Miscellaneous Soil Paper No. 5.

Steadman, J.R., Coyne, D.P. & Cook, G.E., 1973. Reduction of severity of white mold disease on Great Northern beans by wider row spacing and determinate plant growth habit. Pl. Dis. Reptr. 57: 1070-1071.

Address

Grain Legume Project, National Horticultural Research Station, Ministry of Agriculture, P.O. Box 220, Thika, Kenya.