

## THE EFFECT OF FUNGICIDES AND FOLIAR FERTILIZERS ON BEAN RUST

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The common bean, *Phaseolus vulgaris* L., is the most popular and widely grown of all legumes not only in Tanzania but also all over eastern Africa. In Tanzania, apart from the Masai and their related pastoral tribes, every household grows beans mainly for home consumption and the little surplus is normally sold at local markets. In eastern Africa and particularly Tanzania, the term "beans" stands for a number of bean names, dwarf beans, snap beans, dry beans, pole beans, bush beans, string beans and common beans. Under local conditions, however, bean types are distinguishable by colour, shape, and size.

Generally, bean production in Tanzania is not satisfactory. Jacobson (1976a) puts yields per hectare at between 200 and 670 kg but potential yields have been suggested to be about 1,500 kg/ha (Anon 1980). Karel *et al* (1980) associated low yields with diseases, pests, and unsuitable varieties.

The most important bean diseases in Tanzania are anthracnose (*Colletotrichum lindemuthianum*), angular leaf spot (*Phaeoisariopsis griseola*) and bean rust (*Uromyces appendiculatus*). While anthracnose and angular leaf spots can be regarded as sporadic and rarely economically serious, bean rust is omnipresent and very often destructive particularly to less resistant varieties. Attempts to breed rust resistant varieties have sometimes not been successful due to break down of resistance during seasons when climatic conditions are very favourable to the growth of the rust-causing fungus (Jaffer, 1971). Small holding growers, however, have no access to the newly bred resistant varieties because either they are not available or they are expensive. Resistant varieties are sometimes not locally acceptable due to colour and/or taste. Local seeds and especially the most popular lines always succumb to rust infection with varying degrees of susceptibility.

There is need, therefore, to identify fungicides which can protect the crop during bad seasons at least at the commercial farm level. Trials conducted by Hudson and Jaffer revealed that Plantvax (Oxycarboxin) El-273, Deconil 1787, and Sapro (triforine) were effective against *Uromyces appendiculatus* (Hudson and Jaffer 1970 and Jaffer, 1971a). In 1972, Okioga and Jaffer tried a number of fungicides. Sicarol (Pyracarbolid), Plantvax and Sapro significantly controlled bean rust (Okioga and Jaffer, 1972). Seed dressing by using systemic fungicides such as Plantvax was found ineffective against rust (Jaffer, 1971b). Bazirake (1975) recommended the use of Plantvax at 3.5 kg/ha and Sicarol in heavily infected fields. With lower disease pressure, he recommended Plantvax at 2.5 kg/ha and also rated BAS 3172 F as an excellent fungicide for bean rust control.

Between 1975 and 1980, new fungicides were developed and trials carried out thereafter (1980-1982) investigated the efficacy of new fungicides as compared to those already recommended. Since bean yields have for a long time been far below the Tanzania yield potential (Karel *et al*, 1980), in 1981-1982 two additional trials were conducted to check on crop response to foliar fertilizer when mixed with fungicides. Fungicides and foliar fertilizers were not sprayed separately to avoid additional labour costs. Results from these trials are summarized in this paper.

### MATERIALS AND METHODS

A very susceptible bean variety (*Phaseolus vulgaris* L.) N. 3300 was used during all three seasons. Altogether five trials (Tables I and II) were conducted between 1980 and 1982 as follows:

- (1) 1980—One trial using fungicides only.

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(2) 1981—Two trials (i) Fungicides sprayed alone

(ii) A fungicide mixed with foliar fertilizers.

(3) 1982—Two trials conducted as in 1981.

Bean planting was always done during the first and second week of May every year. A complete randomized block design replicated four times was used in all trials. Each plot measured (5 × 6)m<sup>2</sup> and had 11 rows of beans. Spacing was 50 cm between rows and 10 cm between plants. Fifty cm and one m clear spaces were left between plots and blocks respectively. Two to four guard rows were planted around all trial fields. All fungicides, except the ULV formulation, and fertilizers were suspended in water volumes of 100 l/ha. Fungicides sprayed alone are given in Table I while the mixtures (a fungicide together with foliar fertilizers) are given in Table II

Spraying was started as soon as the first symptoms were noticed during the daily scouting as follows: 1980—1st, 6th, 13th, 20th and 27th June; 1981—(i) 13th, 20th, 27th June and 10th July; (ii) 17th, 22nd June and 1st, 15th, 30th July;

1982—(i) 16th and 24th June; 2nd, 10th and 17th July, (ii) 4th, 12th, 25th June and 2nd July.

Triforine (ULV) was sprayed with an ULVA sprayer type "Micron, Bromyard England" (1982), while the rest were sprayed using knapsack solo sprayers.

Disease assessment was started roughly two weeks after the second spray and continued as indicated in Tables III—VI. Nine leaflets randomly selected from each of the ten central plants per plot were rated as follows:

- 0 = no rust.
- 1 = slightly rusted: 6—15 spots per leaflet.
- 3 = heavily rusted: more than 15 spots per leaflet but more than 50 per cent of surface still green.
- 4 = more than 50 per cent of leaflet rusted.
- 5 = no green tissue left.

All bean pods were harvested, dried and then threshed. Seeds were later weighed in kg/plot and then calculated into kg/ha.

TABLE I—TREATMENTS AND THEIR APPLICATION RATES (FUNGICIES SPRAYED ALONE)

Treatment		Rates/ha product	Year of trial
Trade name	Common name		
Kocide 101	Cupric hydroxide	2kg	1980, 1981&1982
Plantvax	Oxycarboxin	3.5kg	1980, 1981&1982
Dithane M45	Mancozeb	2.5kg	1980, 1981&1982
Polyram combi	Metiram	1.8kg	—do—
Bravo 500	Chlorothalonil	3.5 l	—do—
Baycor	Bitertonol	1.0kg	1980, 1982
Cuprox	Cuprous oxide	2.5 kg	1981
Benlate	Benomyl	2.5kg	1980, 1981
Copper Nordox	Cuprous oxide	2.5kg	1981
Saprol	Triforine 20	2.0kg	1980
	Triforine (ULV)	2.5 l	1982
Colloidox	Copper oxychloride	2.5 kg	1980, 1981
Galben	M9834	1.2kg	1982
Nemisor	(34/0077)%	1.5kg	1982
control	—	—	1980, 1981&1982

TABLE II—TREATMENTS AND THEIR APPLICATION RATES (FUNGICIDE+FOLIAR FERTILIZERS)—  
1981–1982

Trade name/code	Common name	Rate product/ha
— Control		
— Kocide 101	Cupric hydroxide	2 kg
— Kocide +	—do—	2 kg
Nitrophoska	NPK 10:4:7*	5 l
— Kocide +	C. hydroxide	2 kg
Fetrilon-Combi	Trace elements**	1 kg
— Nitrophoska	NPK 10:4:7	5 l
Fetrilon-Combi	Trace elements	1 kg

\*NN-N-10, P<sub>2</sub>O<sub>5</sub>-4 and K<sub>2</sub>O - 7

(Nitrogen Phosphoric acid Potash)

\*\*4.0% Magnesium M<sub>2</sub>O

1.5% Manganese

1.5% Iron  
0.5% Copper

0.5% Zinc

0.5% Boron, Molybdenum cobalt

8.3% Sulfur

## RESULTS

### *Fungicides alone:*

Table III gives a summary of the 1980 results. Plantvax, Dithane M45, Triforine and Baycor were superior to all other fungicides throughout the season. Colloidox and Bravo 500 were slightly inferior compared to the unsprayed check (control) in reducing rust infection.

Results for the 1981 trials are summarized in Table IV. Plantvax, Dithane M45, Bravo 500 and Kocide 101 were significantly better than the control at 1 per cent almost throughout the entire growing period. The rest of the chemicals were also good at least during one of the recording periods.

In 1982 rust infection was less serious (Table V). Bravo 500 Baycor and Nemispor were all significantly better than the unsprayed check at 5 per cent level. Triforine Polyram combi Dithane

M45 and Plantvax were next as they were significantly better than the check during at least two assessments.

### *Crop yield*

In 1980, the highest yields (over 700 kg/ha) were realized from plots sprayed with Kocide 101 and Bravo 500. They both had a significant crop increase over the control, closely followed by Benlate (Table III). Shortened plant and crinkled leaves were observed in plots sprayed with Triforine indicating phytotoxicity.

Yields in 1981 were better than those in 1980 when plots sprayed with Dithane M45 and Polyram combi produced slightly over a metric ton per hectare. However, plots sprayed with Cuprox gave less yields than the unsprayed control. Yields in 1982 were satisfactory, the highest being above 800 kg/ha. Polygram combi and Galben gave lower yields than

TABLE III—MEAN PERCENTAGE OF RUSTED LEAFLETS AND CROP YIELD IN THE 1980 TRIAL

	14/6/80	21/6/80	28/6/80	5/7/80	12/7/80	Mean plot (kg)	kg/ha	Increase over control
Kocide 101	1.0 <sup>a</sup>	2.1	3.2	4.5	3.7	2.12	705.8	136.6
Plantvax	0.5 <sup>a</sup>	0.5 <sup>a</sup>	0.8 <sup>a</sup>	0.6 <sup>a</sup>	0.4 <sup>a</sup>	1.93	641.2	72.1
Dithane M45	0.8 <sup>a</sup>	1.8 <sup>a</sup>	2.4	1.9 <sup>a</sup>	1.5 <sup>a</sup>	1.86	620.8	51.7
P. Combi	0.9 <sup>a</sup>	1.8 <sup>a</sup>	2.5	2.4 <sup>a</sup>	2.5 <sup>a</sup>	1.99	661.7	92.6
Bravo 500	0.9 <sup>a</sup>	1.8	3.3	2.6	2.1 <sup>a</sup>	2.16	720.0	150.9
Baycor	0.5 <sup>a</sup>	1.3 <sup>a</sup>	1.3 <sup>a</sup>	0.8 <sup>a</sup>	1.0 <sup>a</sup>	1.91	635.0	65.9
Benlate	0.7 <sup>a</sup>	1.8 <sup>a</sup>	2.8	2.6	2.0 <sup>a</sup>	2.02	672.5	103.4
Triforine 20	0.8 <sup>a</sup>	0.9 <sup>a</sup>	1.7 <sup>a</sup>	1.2 <sup>a</sup>	3.4	1.77	589.2	20.1
Colloidox	1.1 <sup>a</sup>	2.0	3.2	3.4	4.4	1.76	586.7	17.6
Control	1.3	2.8	5.2	4.0	5.8	1.71	569.1	—
S.E.	0.37	0.74	0.69	0.9	1.12	0.12		
LSD P=0.05	0.77	1.53	1.4	1.91	2.3	N.S		

a—b: Figures followed by the same letter are not significantly different from each other.

TABLE IV—MEAN PERCENTAGE OF RUSTED LEAFLETS AND CROP YIELD IN 1981 TRIAL

Treatment	26/6/81	13/7/81	30/7/81	kg/plot means	kg/ha	Increase over control
Kocide 101	4.7 <sup>a</sup>	17.5 <sup>b</sup>	20.9 <sup>a</sup>	2.91	970	80
Plantvax	0.2 <sup>a</sup>	4.3 <sup>a</sup>	18.1 <sup>a</sup>	2.90	967	77
Dithane M45	4.9 <sup>a</sup>	14.2 <sup>a</sup>	19.2 <sup>a</sup>	3.26	1,087	197
Pol. Combi	10.8 <sup>b</sup>	26.2 <sup>b</sup>	31.4 <sup>b</sup>	3.18	1,060	170
Bravo 500	6.7 <sup>a</sup>	15.4 <sup>a</sup>	26.0 <sup>b</sup>	2.68	893	3
Cuprox	6.5 <sup>a</sup>	18.4 <sup>b</sup>	32.0 <sup>b</sup>	2.50	833	-57
Benlate	6.5 <sup>a</sup>	23.6 <sup>b</sup>	29.3 <sup>b</sup>	2.76	920	30
Copper Nordox	8.7 <sup>b</sup>	26.7 <sup>b</sup>	20.7 <sup>a</sup>	2.92	973	83
Colloidox	7.1 <sup>a</sup>	28.1 <sup>b</sup>	32.1 <sup>b</sup>	2.89	953	63
Control	17.6	56.2	45.8	2.67	890	—
S.E.	4.0	6.37	3.11	0.32		
LSD P=5%	8.28	13.10	6.38	0.66		
LSD P=1%	11.18	17.63	8.62	0.89		

TABLE V—MEAN PERCENTAGE OF RUSTED LEAFLETS AND CROP YIELDS IN THE 1982 TRIAL

Treatment	29/6/82	9/7/82	27/7/82	kg/plot	kg/ha	Increase over control
Kocide 101	6.3	7.32*	18.7	2.06	686.7	—
Plantvax	2.05*	2.97*	13.87	3.53	1,176.7	490
Dithane M45	4.62	5.22*	11.6*	2.31	770	83.3
P. Combi	4.77	7.7*	12.32*	2.05	683	-3.7
Bravo 500	4.2*	5.55*	13.3*	2.54	846.7	160
Baycor	2.57*	1.15*	9.17*	2.49	830	143.3
Triforine ULV	3.4*	2.35*	15.45	2.24	746.7	60
Galben	6.65	7.27*	21.25	1.97	656.7	-30
Nemispur	4.1*	6.2*	13.17*	2.20	733.3	46.6
Control	8.0	13.8	22.42	2.06	686.7	—
S.E.	1.59	2.83	4.27	0.27		
LSD P= 5%	3.26	5.81	8.76	0.55		

TABLE VI—MEAN PERCENT OF RUSTED LEAFLETS IN THE 1981-82 FOLIAR FERTILIZER TRIAL

Treatments	24/6/81	13/7/81	27/7/81	9/7/82	27/7/82	2/8/82
Control	21.40	44.7	44.7	9.82	22.25	22.77
Kocide 101	5.88 <sup>a</sup>	12.5 <sup>a</sup>	19.9 <sup>a</sup>	7.45 <sup>a</sup>	23.8	20.65
Kocide + Nitrophoska	7.88 <sup>a</sup>	14.2 <sup>a</sup>	17.6 <sup>a</sup>	7.65 <sup>a</sup>	23.47	21.65
Kocide + Fetrilon Combi	13.90 <sup>b</sup>	16.1 <sup>a</sup>	19.8 <sup>a</sup>	5.7 <sup>a</sup>	20.57	20.20
Nitrophoska	11.23 <sup>b</sup>	23.1 <sup>b</sup>	42.0 <sup>b</sup>	10.15	25.75	26.80
Fetrilon Combi	14.1 <sup>b</sup>	23.2 <sup>b</sup>	41.2	7.32 <sup>a</sup>	23.12	29.77
S.E.	3.45	4.84	2.9	1.67	1.38	2.74
LSD P= 0.05	7.36	10.3	6.2	3.56	2.94	5.84
P= 0.01	10.17	14.26	8.55	4.92	4.09	8.08

TABLE VII—CROP YIELD FROM THE 1981-1982 TRIALS

Treatments	1981			1982		
	kg/plot	kg/ha	Increase	kg/plot	kg/ha	Increase
Control	2.54	846.7	—	1.14	380	—
Kocide 101	2.89	963.3	116.6	1.47	490	110
Kocide + Nitrophoska	2.71	903.3	56.6	1.41	470	90
Kocide + Fetrilon Combi	2.73	910.0	63.3	1.60	533.3	153.3
Nitrophoska	2.71	903.3	56.6	1.44	480.0	100.0
Fetrilon Combi	2.70	900.0	53.3	1.12	373.3	-6.6
S.E.	0.28			0.19		
LSD P = 0.05	0.60			0.40		

the control while Bravo 500, Plantvax and Baycor had an outstanding crop increase over the control (Table IV and V).

*A fungicide with foliar fertilizer trials:*

There was more disease pressure in the 1981 season than in 1982 (Table VI). All sprayed plots had considerably fewer rusted leaves than the unsprayed controls. In 1982, plots sprayed with foliar fertilizers had more leafage than unsprayed controls, thus giving more chances to more rust infection. However, the disease intensity was almost uniformly distributed.

*Crop yield*

There was no appreciable crop gain by adding foliar fertilizers to a fungicide spray, particularly in 1981 (Table VII).

DISCUSSION

The 1980 season was almost free of bean rust considering that the highest mean number of rusted leaflets was only 5.8 in the unsprayed control plots. Most fungicides, however, kept the disease infection at a very low level particularly Plantvax, Baycor Triforine, and Dithane M45. In spite of controlling rust effectively, these same chemicals had no appreciable crop increase over the control.

Disease pressure was much higher in 1981 and the plant stand was vigorous. Yields were very good too. All chemical treatments were significantly better than the unsprayed check in disease control but crop increase was only economically significant where Dithane M45, Polygram combi, Kocide 104, Copper nordox and Plantvax were sprayed. Since Triforine 20 sprayed at 2 l/ha caused phytotoxicity, the ULV formulation was used at the rate of 2.5 l/ha in trials started in 1982.

The 1982 season was again poorer than expected. Leaf rust infection was slightly higher than in 1980 but much less than that of 1982. Over all, Plantvax, Dithane M45, Polygram combi, Bravo 500, Baycor and Nemisor were significantly better than the unsprayed check throughout the trial period. Crop increase was on the average not impressive except for Plantvax, Kocide 101, Bravo 500, Polygram combi, Benlate Baycor and Dithane M45.

CONCLUSIONS

During seasons when crop loss due to rust is anticipated, the application of 3 to 4 sprays of recommended fungicides as listed below is advisable. Around Arusha where the soil is purely volcanic ash, the spray of additional foliar fertilizers was not found necessary since no additional crop yield was realized after two seasons. From the three years trial results Plantvax, Kocide 101, Dithane M45, Benlate, Bravo 500 and Triforine (2.5 l/ha) are recommended for use against bean rust. Baycor, Polygram combi and Nemisor could also be used particularly where disease pressure is less serious. However, further trials will be conducted on these fungicides including Triforine at lower rates to avoid phytotoxicity.

SUMMARY

Thirteen fungicides were tested against rust between 1980 and 1982. One additional trial with a mixture of foliar fertilizer and a fungicide was also conducted in 1981 and 1982 in order to improve yields. After 3 seasons, 6 fungicides were found effective against *U. appendiculatus* and recommended for use in Tanzania. These were Plantvax, Kocide 101, Dithane M45, Benlate, Bravo 500 and Triforine (ULV) at 2.5 l/ha.

Addition of foliar fertilizers into fungicide sprays did not improve yields significantly.

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