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INTEGRATED CONTROL OF COMMON BEAN *(Phaseolus vulgaris, L.)* RUST IN RELATION TO VEGATATIVE GROWTH, POD CHARACTERISTICS AND TOTAL GREEN YIELD

M.M.El- Hamady*; Eisa, Nour-Jehan, M.M.**; Ghada Abd-El-Ghani El-Kolaly**

** Plant Production Department. Vegetables Branch, Efficient Productivity Institute, Zagazig University, Egypt.*

***Plant Path. Research, Institute, Agriculture Research Center, Cairo, Egypt.*

ABSTRACT

Common bean rust is wide spread in different governorates in Egypt . Disease severity varied among the governorates whereas Ismailia showed the highest disease levels, while, Giza exhibited the lowest infection. Different cultivars bean showed different disease reaction, whereas Amy and Concessa were resistant, while Paulista was the highly susceptible. Protective spraying against the disease, using different nutritive salts, growth regulators and contact and systemic fungicides was much more effective than curative spraying for disease control and yield quality and quantity. Integrated management using potassium sulphate(as a salt). Ethyphone (as a growth regulator), micronized sulphur (contact fungicide) and Sumi Eight (systemic fungicide) achieved lower disease occurrence and higher yield. Alternation in using the different tested materials gave better results than repeated application of any of those materials alone.

Key words: Common bean (*Phaseolus vulgaris, L.)*, rust, integrated control, summer and fall plantations.

INTRODUCTION

The common bean *(Phaseolus vulgaris L,)* is one of the most important vegetable food legumes in Egypt consumed either as green pods or as dry seeds. It represents a cheap source of proteins and carbohydrates in human diets for relatively a broad sector of the Egyptian inhabitants, mostly for those who cannot afford the high cost of animal protein, especially in the rural areas (Davidson, 1975).

Bean is commonly grown in the open field in Egypt in two main growing seasons, i.e. summer plantations (sowing date during April) and fall plantations (sowing takes place during early Septemper). However,

limited areas are currently grown during winter months, under protected cultivations, either under plastic houses or low plastic tunnels.

The total cultivated area in Egypt in 2009 amounted to 67596 feddans that yielded 282897 tons of green beans and 55577 feddans that yielded 65866 tons of dry beans. Majority of the production is consumed locally, however, a considerable amount of the production, mainly as green pods, is exported to different foreign countries, reaching to 80.0 tons in 2006 (Anonymous, 2006).

Bean rust pathogen is the basidiomycete fungus *Uromyces appenddiculatus* (Pers,: Pers.) Unger. The disease occurs worldwide but is most common in humid tropical and subtropical areas. Severe epidemics occur periodically in humid temperate climates. Yield losses can approach 100% and are directly related to earliness and severity of infection (Stavely, 1991). Fall and winter plantations in Egypt suffer from severe infections while summer plantations do not exhibit significant infection due to the lack of favorable weather conditions during summer Most bean cultivars are resistant to most races (Stavely, 1991).

The present study aimed to:

a. Survey bean rust occurrence at different Egyptian governorates.
b. Evaluate different bean cultivars for their reaction against rust disease.
c. Investigate the effect of spraying bean plants with different salts, growth regulators and contact and systemic fungicides either protectively (before disease occurrence) or curatively (after disease occurrence) on rust infection, vegetative growth, pod characteristics and total green yield.
d. Study the effect of integrated management measures on disease development, vegetative growth and yield quality and quantity.

MATERIALS AND METHODS

Disease survey:

Bean rust was surveyed under field conditions at six governorates namely, Sharkia, Ismailia. Giza, Minofyia, Beheira and Gharbia during the two successive fall seasons 2008 and 2009.

Three centers were investigated in each governorate. Centers under study were Faqous. Abo Kabir and Mashtol El-Sook in Sharkia; Kantarah Gharb, Ismailia and Fayed in Ismailia; El-Saff, El-Ayyat and Imbaba in Giza; Shebin El-Kom, Queesna and Ashmon In Minofyia; Etay El-Barood, El-Delengat and Hoosh Eisa in Beheira, and Samannod, Tanta and Basion in Gharbia. Two field were investigated in each center. The survey was carried out during late October and early November in both 2008 and 2009 seasons.

Only fields receiving no fungicidal sprays were considered. One hundred bean leaves were randomly taken from different parts, representing the whole field, and used for disease assessments. Data were averaged for each field, then data from the six fields in each governorate were averaged**.**

Varietal reaction:

Six bean cultivars namely, Concessa, Amy, Lexus, Balsas, Paulista and Xera were cultivated under Ismailia field conditions during the two successive fall seasons of 2008 and 2009. Experiments were designed in a complete randomized block design with four replicates. Each plot consisted of five rows each 7 m in length and 0.6 m in width ($^{1}/_{200}$ of feddan). Planting took place during early September whereas disease assessments were made during late November in both growing seasons. Ten plants from each bean cultivar were randomly taken from each replicate for rust evaluation.

Effect of spraying bean plants with different materials, either protectively or curatively, on rust severity, vegetative growth, pod characteristics and total yield:

Four experiments, each in a complete randomized block design, with four replicates were performed under Ismailia field conditions during the two successive fall seasons 2008 and 2009. One experiment was devoted for protective spraying while the other was devoted for curative spraying. Plot area was $^{1}/_{200}$ of feddan.

Two salts, i.e. Potassium sulphate and calcium chloride; two growth regulators namely, Berlex (Gebberllic acid) and Ethyphone; two contact fungicides, i.e. Micronized sulphur and Agrocopper; and two systemic fungicides, i.e. Plantvax and Sumi Eight were sprayed on bean plants either protectively before disease appearance (35 days after planting) or curatively after disease appearance (50 days after planting).The susceptible bean cultivar Paulista was used in this study. Each material was sprayed four times at 10 days intervals. Table (1) shows the trade name, active ingredient (s), and rate of application for the tested materials.

Table 1. Materials sprayed protectively or curatively on bean plants.

Trade name	Active ingredient (s)	Rate of application per 100 L water
A- Salt:		
Potassium sulphate	k_2SO_4	300 g
Calcium chloride	$Ca(Cl)_2$	300 g
B-Growth regulators:		
Berlex	Gebberellic acid (GA_3)	3.0 g
Ethyphone	2-chloroethyl phosphonic acid	2.0 g
C-Contact fungicides:		
Micronized Sulphur	80% Sulphur	250 g
Agrocopper	20% Copper sulphate, 6.5% S, 0.1 %Ca, 3% N and 19% amino acids	250 g
***D-Systemic fungicides*:**		
Plantvax	Oxycarboxin	100cc
Sumi Eight	Diniconazole	35cc

Effect of applying a package of integrated measures on bean rust development, vegetative growth and yield quality and quantity:

The most promising treatments resulted from the previous experiments were integrated together in this study. Two experiments, each in a complete randomized block design, with four replicates were executed at Ismailia governorate during the two successive fall seasons of 2008 and 2009. The Paulista bean cultivar was planted in these experiments. The four most promising materials were Potassium sulphate. Ethyphone, Micronized sulphur and Sumi Eight. Each materials was repeatedly sprayed for four times at 10 day intervals or the four materials were alternatively sprayed at the same intervals. Curative sprays were only adopted in these experiments.

Assessments:

One hundred bean leaves, representing each plot, were randomly sampled for estimating both infection percentage and disease severity as follows:

Infection percentage = Number of infected leaves/ Total number of leaves χ 100

Disease severity was estimated as percentage of infected leave area relative to the whole leave area, with the aid of a disease index of eleven categories including a disease free category (0 %infection) according to **horsfall and Barratt (1945).**

Twenty plants, sampled randomly from each plot were used for estimating vegetative parameters. Number of branches per plant was

counted. Plant height was estimated by calculating the average length of the all branches. One hundred bean pods were randomly sampled from each plot for estimating pod characteristics. Pod length was measured in cm, while pod width and thickness were measured in mm, Spherical index was calculated by dividing pod thickness by pod width.Total green yield was estimated in kg per plot by calculating the entire harvest pod yield starting from the beginning of harvesting till the end of the season.

Statistical analysis:

Obtained data were subjected to analysis of variance (Steel and Torrie, 1960), whereas the differences between treatments were compared by the calculated least significant difference at 5% level.

RESULTS AND DISCUSSION:

Disease survey:

Data in Table (2) demonstrate that bean rust is wide spread all over the different governorates. There are great differences among the governorates, whereas the highest percentages of infection and severity were recorded in Ismailia governorate followed by Beheira and Minofyia governorates. Meanwhile, Sharkia and Gharbia showed moderate infections, while the least infection was observed in Giza governorate. Infection was more pronounced in 2009 than in 2008 fall season. Variations, among the different governorates and between the two seasons as well, could be attributed to variations in weather conditions favoring disease development (cool temperature and high humidity and moisture) among the governorates and between the two seasons. Results are in accordance with those of Stavely, 1991 who indicated that bean rust occurs worldwide but is most common in humid tropical and subtropical areas. Severe epidemics occur periodically in humid temperate climates, but it is rare in arid climates. Results are also in agreement with those of Lashin *et al*. (1970); Pastor-Corrates and Correa (1983) and Stavely (1989).

Cultivar reaction:

Data in Table (3) revealed that both Concessa and Amy bean cultivars were entirely free from the rust, thus they are considered as resistant cultivars against the disease. Balsas followed by Lexus showed only slight infection consequently, they could be regarded as resistant cultivars. The other cultivars, i.e. Xera and Paulista showed relatively high disease susceptibility, they are considered as susceptible cultivars. Data also show that rust infection was generally more noticeable in 2009 than in 2008 season.

Table 2. Survey of bean rust infection at different Egyptian governorates in two successive fall seasons of 2008 and 2009.

Governorates	2008		2009		Means	
	% Infection	Disease severity	% Infection	Disease severity	% Infection	Disease severity
Sharkia	55.50	26.10	58.25	28.15	56.88	27.13
Ismailia	59.75	40.15	62.25	42.65	61.00	41.40
Giza	18.00	12.20	20.75	14.35	19.38	13.28
Minofyia	57.25	38.35	60.50	40.45	58.88	39.40
Beheira	58.00	39.10	61.25	41.55	59.63	40.36
Gharbia	50.25	34.25	52.50	35.10	51.38	34.68
Mean	**49.79**	**37.76**	**52.58**	**33.71**	-	-

Table 3. Reaction of six bean cultivars against rust disease under Ismailia field conditions during 2008 and 2009 fall seasons.

Cultivar	2008		2009		Mean	
	% Infection	Disease severity	% Infection	Disease severity	% Infection	Disease severity
Concessa	0.00	0.00	0.00	0.00	0.00	0.00
Amy	0.00	0.00	0.00	0.00	0.00	0.00
Lexus	12,50	8.10	15.00	10.25	13.75	9.18
Balsas	10.00	6.50	12.50	8.15	11.25	7.36
Paulista	25.00	17.15	28.00	18.35	26.75	17.75
Xera	23.50	15.50	25.75	16.45	24.63	15.98
L.S.D. at 5%	**1.28**	**1.16**	**1.97**	**1,67**	-	-

Stavely (1991) has graded resistant reactions as immune (no symptoms), nonsporulating necrotic spots and very small, small, or moderate uriedinia. Reduced number of uriedinia is another from the resistant. He added that a few cultivars are currently popular because of their resistance to all races present in particular areas. However, the existence of races to which these resistant varieties are susceptible has encouraged efforts to develop resistance with greater stability. Varietal reaction of bean against rust was also previously discussed by Lashin *et al*.

(1970); Abdalla (1979); Ali (1979); Stavely (1984 and1989) and Faris *et al*., (1991).

Yet, a resistant or even an immune bean cultivar is not necessarily the best choice for commercial cultivation, since the grower may prefer a susceptible bean cultivar having other desirable characters, while he is able to manage the disease using different means of control. However, varietal evaluation against bean rust is still a fundamental requirement needed by plant breeders who search for sources of resistance in order to combine resistance character side by side with other desirable characters into a new variety through breeding programs.

Effect of spraying bean plants with nutritive salts, growth regulators and fungicides, either protectively or curatively:

a- On disease development:

Data in Table (4) revealed that rust occurrence was more evident in 2009 than in 2008. Spraying any of the tested materials on bean plants resulted in obvious reductions in both percentages of infection and disease severity in the two growing seasons 2008 and 2009 compared with the untreated plot (control). Protective spraying, before disease appearance, was more efficient in controlling the disease than curative spraying, after disease occurrence. The systemic fungicide Sumi Eight was the best of all tested materials in reducing the disease. Micronized sulphur, as a contact fungicide, was better than the contact fungicide Agrocopper. Ethyphone, as a growth regulator, was more effective than Berlex. Meantime, Potassium sulphate, as a nutritive salt, showed higher disease reduction than calcium chloride.

b- On vegetative growth, pod characteristics, and total yield:

Data present in Tables (5 and 6) showed almost the same trend of those in Table (4) whereas, Sumi Eigh , Micronized sulphur, Ethyphone and Potassium sulphate were better in improving vegetative growth, pod characteristics and total yield, than their corresponding materials. This was true in the two growing seasons. Protective sprays were also more effective, in improving plant growth, and yield quality and quantity, than curative sprays. Yield components were generally higher in 2008 than in 2009 growing seasons. The improvement in yield quality and quantity due to spraying fungicides could be directly attributed to the action of those fungicides in controlling the disease whereas the improvement resulted from spraying potassium sulphate and calcium chloride could be interpreted on nutritive basis. The role of calcium in the formation of cell wall middle lamella cannot be ignored. Strengthened cellular walls have an adverse action on disease development leading to lower disease occurrence. Also,

potassium which acts as a catalyst, has a great role in enhancing biochemical reactions inside the plant. Consequently, spraying either calcium chloride or potassium sulphate may lead to vigorous plants that can resist disease development and improve both yield quality and quantity as well. Results of fungicidal treatments are in agreement with those of Melendez *et al*. (1986),Sherf and Macnab (1986) and Taha and Awad (1996). Results of other tested materials are in accordance with those of Beshir (1990), Walters and Murray (1992), Abd El-Kareem *et al*.(1993), El-Shami *et al*. (1995), Khafagi *et al*. (1995), Abada *et al*. (1997), Sallam (1997), Abd El-Kareem (1998) and Khafagi (2002).

Effect of integrated measures on rust development, vegetative growth and yield quality and quantity:

The four most promising materials resulted from the previous experiment were used in this study, whereas Potassium sulphate (as a salt), Ethyphone (as a growth regular), Micronized sulphur (as a contact fungicide) and Sumi Eight (as a systemic fungicide) were sprayed protectively on bean plants. Each material was repeatedly sprayed for four times at 10 day intervals or the four materials were alternatively sprayed at the same intervals.

Data in Tables (7 and 8) showed that spraying any of the tested materials repeatedly was far better in reducing rust infection and increasing yield quality and quantity when compared with the untreated control. Alternation of those materials in such a sequence of Micronized sulphur in the first spray followed by Sumi Eight in the second, Potassium sulphate in the third and Ethyphone in the fourth spray was more effective in reducing the disease and increasing the yield as compared with spraying any single material repeatedly for four times. This was true for the two growing seasons. Superiority of alternative sprays may be due to the competing different modes of action of the tested materials, Ibrahim *et al.* (2003 and 2006).

Several reports have revealed that frequent application of fungicides, especially those of the systemic behaviour, against a particular pathogen, resulted in many cases in acquired resistance by developing pathogenic strains that are resistant to the action of those fungicides (Pappas, 1985; Samoucha and Cohen, 1985; and Moss, 1987). Therefore, alternative sprays using different materials or fungicides, having different modes of action, could offer a good solution against the acquired resistance. Similar results were previously discussed by Skylakakis (1981).

Table 7. Effect of integrated measures on bean rust development during the two successive seasons 2008 and 2009 under field conditions.

Treatments	2008			2009			Mean	
	% Infection	Disease severity	Reduction	% Infection	Disease severity	Reduction	% Infection	Disease severity
Micronized sulphur(a)	8.75	5.10	87.44	7.50	2.85	89.17	8.00	3.97
Sumi Eight (b)	5.00	3.25	92.98	4.00	2.75	94.39	4.50	3.00
Potassium sulphate(c)	13.75	8.35	80.76	12.25	7.25	82.81	13.00	7.80
Ethyphone (d)	11.50	6.45	83.86	10.00	5.50	85.96	10.75	5.97
(a + b + c)	2.25	1.15	96.84	1.75	0.95	97.61	2.00	1.05
Control	71.25	47.50	-	70.20	45.25	-	71.25	41.38
L.S.D.at 5%	**0.86**	**1.51**	**-**	**0.72**	**0.55**	**-**	**-**	**-**

Conclusively, the use of integrated control methods using the potassium sulphate "salts", and Ethyphone " growth regulators", Micronized Sulphur " Contact fungicides" and Sumi Eight " Systemic fungicides reduce the degree of infection with a high degree and gives a good crop, and rotate the use of the former leads to obtain the best results reported in the case of the use of the same substance, during the season and the best results in the yield and quality of beans pod yield resulted from the use of Sumi Eight followed by Plantvax " systemic pesticide".

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المقاومة المتكاملة لمرض صدأ الفاصوليا وعلاقة ذلك بالنمو الخضري وصفات وكمية المحصول

محمود محمد الحمادي*، نور جيهان محمد عيسي، غادة عبد الغني القللي****

* قسم الإنتاج النباتي – بساتين خضر - معهد الكفاية الإنتاجية – جامعة الزقازيق – مصر.

** معهد بحوث أمراض النباتات – مركز البحوث الزراعية – الجيزة – مصر.

نباتات الفاصوليا من أهم نباتات الخضر في مصر ، مرض صدأ الفاصوليا من الأمراض التي تنتشر على نطاق واسع بالمحافظات المختلفة بجمهورية مصر العربية ، وتختلف شدة الإصابة بين المحافظات المختلفة حيث تبلغ هذه النسبة في محافظة الإسماعيلية أعلاها ، وبالعكس تصل نسبة الإصابة إلى أقل حد ممكن بمحافظة الجيزة ، كما تختلف درجة إصابة أصناف الفاصوليا بالمرض فقد وجد أن الصنفين آمي وكونسيسا مقاومين نسبيا للمرض ، ومن ناحية أخرى ، كان الصنف بوليستا شديد القابلية للإصابة بالمرض وكان ذلك خلال موسمي الزراعة ٢٠٠٨، ٢٠٠٩ م وقد ثبت أن الرش الوقائي ضد المرض باستخدام بعض الأملاح المغذية ، ومنظمات النمو وكذلك المبيدات الفطرية الجهازية والغير جهازية أعطى نتائج أفضل من استخدام الرش العلاجي مما يؤدى إلى الحصول على محصول ذو نوعية وكمية أفضل . كما أن استخدام طرق المكافحة المتكاملة باستخدام سلفات البوتاسيوم" من الأملاح " ، ومادة إثيفون "منظم نمو" ، الكبريت الميكروني "مبيد فطرى غير جهازي " وسومي- إيت "مبيد فطرى جهازي" تقلل درجة الإصابة بدرجة عالية ويعطى محصول جيد ،

أن تناوب استخدام المواد السابقة يؤدى إلى الحصول على أحسن النتائج عنها في حالة استخدام نفس المادة خلال الموسم وكانت أفضل النتائج في محصول قرون الفاصوليا وجودتها ناتج من استخدام سومي ايت ثم يليها بلانتافاكس كمبيدات جهازية.