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Research Article

EFFICACY OF BOTANICALS, BIO-CONTROL AGENTS AND FUNGICIDES AGAINST WILT/ROOT ROT COMPLEX OF LENTIL

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Abstract Locally available plant extracts, bio-control agents and fungicides were evaluated against lentil wilt/root complex caused by the association of fungi (wilt-Fusarium oxysporum f.sp. lentis/ root rot complex- Rhizoctonia solani, R. bataticola and Sclerotinia sclerotiorum) at Grain Legumes Research Program, Rampur, Chitwan, Nepal during two winter seasons of 2013 and 2014 AD. The experiment was conducted in wilt susceptible field using randomized complete block design with four replications. The treatment combinations were seed treatment with bavistin @ 2g/kg, seed treatment with vitavax @ 2.5g/kg , spraying of chlorothalonil @ 2ml/L of water, spraying of Iprodione @ 2g/L of water, seed treatment with Xanthoxylum armatum @ 2g/kg, soil incorporation of Lantana camara @ 250g/m^2, Trichoderma viride (PPD isolate) @ 350g/8m^2 plot and Trichoderma harzianum (PPD isolate) @ 350g/8m2 plot. The control plots received no treatment. In 2013, the higher percent disease control (PDC) i.e. 42.66% and 41.70% with higher percent yield increase (PYI) i.e. 186.33% and 174.37% were found in plot where lentil seed was treated with Vitavax (carboxin) and Bavistin (carbendazim) respectively prior to sowing. Almost similar trends of disease control with higher yield was observed in subsequent year 2014. The plot where lentil seeds were sown after treatment with vitavax had lower percent disease index (PDI) i.e. 47.67% with higher yield value of 850 kg/ha. The result revealed that the fungicides Vitavax and Bavistin were most effective in controlling wilt/root rot complex disease of lentil.
Keywords: disease management, lentil, wilt/root rot complex

Introduction

Lentil (*Lens culinaris* Medik) is a major grain legume crop grown under a broad range of climates in many developing countries (Turk *et al*. 2004; Abd-Allah and Hashem 2006). It is a cool season annual grain legume or pulse crop that is considered a cousin of the bean. It is one of the oldest cultivated crops and has been a major food source of many civilizations for more than 8000 years (Oplinger *et al.* 1990). Lentil has been cultivated in Nepal long ago and the crop is found to grow everywhere. In Nepal, it is one of the most important and highly commercialized pulse crops among the grain legumes in terms of area (206969 ha), production (254308 t) and productivity (1229 kg/ha), sharing about 62% of total area and 65% of total production of pulses and also rates the higher consumer preference (MoAD 2017). It is rich in protein and carbohydrate, and crop residues are used as animal feed. This crop has been grown mainly as an inexpensive source of high quality protein in human diets (Salehpour *et al.* 2009; Rahman *et al.* 2010). In the developing world, it is often referred to as poor man's meat because of its high protein content and easy accessibility by the lower economic class. Like many other pulses, it is rich in cholesterol-lowering soluble fiber and high in folate, a valuable functional food in the human diet (McVicar *et al.* 2005).

Disease is one of the major biotic constraints to optimum lentil yield and also deteriorate the quality of product that ultimately reduce the market price. The reason behind the low productivity of most of the crops in Nepal is due to the attack of many plant diseases at different stages of crop growth. Lentil plants are affected by a wide range of pathogens with fungal diseases being the most important. Fungal diseases cause a decrease in productivity through infection and damage to leaves, stems, roots and pods as well as reduce marketability by discolouring seeds (Taylor *et al.* 2007). Among the diseases, wilt/root rot complex caused by the association of fungi (wilt-*Fusarium oxysporum* f.sp. *lentis*/ root rot complex- *Rhizoctonia solani*, *R. bataticola* and *F. solani*) is a solemn menace to lentil cultivation. The disease was first reported in Nepal in 1975 (Manandhar 1975). Seedling mortality in lentil was mainly due to collar rot (*Sclerotium rolfsii*), black root rot (*F. solani*), wet root rot (*Rhizoctonia solani*) and wilt (*F. oxysporum f. sp. lentis*) (PPD 2006). Many fungi (including *F. oxysporum* f.sp *lentis, F. solani, R. solani,* and *Rhizoctonia* spp) have been isolated from lentil fields at seedling and flowering stages (PPD 2007). Karki (1993) reported that wilt and root- rots of lentil are commonly observed during October –November and February– March in the plains of Nepal and are responsible for poor stands in the field. The yield losses due to this disease depend on the crop stage at the time of infection (Vasudeva and Srinivasan 1952), environment and crop variety (Khare *et al.* 1979). The wilt root rot complex disease incidence as high as 50-70% with yield loss of more than 60% and sometimes complete crop loss have been reported from lentil fields of Chitwan (GLRP 2012). In west Asian countries like Syria, the yield losses range from 5-72% (Bayaa *et al*. 1986). There is a strong correlation between wilt/root rot complex and grain yield of lentil estimating 9% yield loss for every 10% WRR complex incidence (Erskine and Bayaa 1996). Although wilt/root rot complex in lentil results in severe yield losses, very nominal research activities with respect to disease management have been carried out against this disease in Nepal. Therefore, this experiment was designed and undertaken to evaluate the efficacy of some botanicals, bio-control agents and fungicides against lentil wilt/root rot complex disease under field condition.

Materials and Methods

The experiments were carried out during winter of 2012-2014 at Grain Legumes Research Program, Rampur, Chitwan (27°40' N latitude and 84°19' E longitude, altitude of 228 masl**)** using Randomized Complete Block Design having 8 treatments with different botanicals, bio-control agents and fungicides against one control with four replicates of each. During lentil season, a susceptible variety Sindur (2n==2x=14 chromosomes) was sown on wilt/root rot sick plot in the first week of November in a unit plot size of 4m×2m with 25cm intra-row spacing. The treatment combinations were seed treatment with bavistin (carbendazim) @ 2g/kg, seed treatment with vitavax (carboxin) @ 2.5g/kg, spraying of chlorothalonil @ 2ml/L of water, spraying of iprodione @ 2g/L of water, seed treatment with *Xanthoxylum armatum* @ 2g/kg, soil incorporation of *Lantana camera* @ 250g/m^2, *Trichoderma viride* (PPD isolate) @ 350g/8m^2 plot and *Trichoderma harzianum* (PPD isolate) @ 350g/8m^2 plot. The control plots received no treatment. The first spray was done following appearance of disease symptoms in the field. Three sprays were given at an interval of 7 days. For the bio-control agents, the PPD isolates of *T. viridae* and *T. harzianum* were colonized on rice husk substrate separately and incorporated in the soil at the rate of 350g/8 m^2 during field preparation. Green leaves of *Lantana camara* were collected, shade dried for 5 days, chopped and incorporated in the plot during field preparation prior to sowing. After completion of the sowing, the plots were kept under constant watch from sowing to harvest. Agronomic practices were followed as recommended.

Data were recorded before every spray using 1-9 scoring scale on 25 randomly tagged plants/plot (Morrall and Mckenzie 1974). Percent Disease Index (PDI) was calculated according to Wheeler 1969 with the calculation based on the final data recorded at one week interval after the last spray. Percent Disease Control (PDC) was calculated on the basis of the formula developed by Shivankar and Wangikar (1993). Early Plant Stand (EPS) and Final Plant Stand (FPS) were recorded based on the scale developed by ICARDA (2012). At harvest, 100 seed weight (in grams) and grain yield (kg/ha) were recorded. Yield increase over the control was computed. All data were statistically analyzed using MSTAT-C version 4 (1987). Treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Hosseinzadeh *et al.* 2018). The correlation among disease control and yield increase was calculated.

Results and Discussion

All treatments had significant ($P \leq 0.05$) effect on Disease Severity (DS), Percent Disease Index (PDI), Final Plant Stand (FPS), Yield and Hundred Seed Weight (HSWT) on the experimental plots compared to the control in 2013. The lowest percent disease index (44.75%) with highest yield (899.30 kg/ha) was recorded in the plot with lentil seed treated with Vitavax followed by Bavistin (PDI-45.50% and grain yield-861.75 kg/ha). The lowest crop yield (314.08 kg/ha) and highest disease index (78.05%) was recorded from the control plot (Table 1).

In 2014, the trends of disease control and yield were similar when compared with the previous year (2013). The lowest percent disease index was recorded in the plot where lentil seeds were treated with Vitavax (47.67%) followed by plot where the seeds were treated with

Table 1: Effect of different treatments on Wilt root rot disease severity and yield performance of lentil at Rampur, Chitwan during 2013

Treatments	EPS %	DS (1-9)	PDI %	FPS %	Yield (kg/ha)	HSWT (g)
Seed treatment with bavistin @2g/kg	87.50[ab†]	3.63[d]	45.50 [d]	80.00[a]	861.75[b]	1.87 [b]
Seed treatment with vitavax @2.5g/kg	86.25[abc]	2.75[e]	44.75[d]	80.00[a]	899.30[a]	2.13[a]
chlorothalonil@2 mL/L of water	81.25[bcd]	4.13[cd]	50.78[c]	75.00[abc]	759.38[d]	1.85 [b]
iprodione @2 g/L of water	88.75[ab]	3.75[d]	50.65[c]	76.25[ab]	820.78[c]	1.86[b]
Seed treatment with *X. armatum* @ 2g/kg	75.00[d]	5.00[c]	55.55[b]	70.00[bc]	731.98[e]	1.79[b]
Soil incorporation of *L. camera* @ 250g/m^2	85.00[abc]	5.00[c]	56.83[b]	68.75[bc]	724.08[e]	1.77[b]
T. v. (PPD isolate) @ 350g/8m^2 plot	86.25[abc]	4.75[c]	54.48[bc]	73.75[abc]	755.53[d]	1.80[b]
T. h. (PPD isolate) @ 350g/8m^2 plot	78.75[cd]	6.50[b]	56.98[b]	67.50[c]	693.03[f]	1.76[b]
Control	90.00[a]	8.38[a]	78.05[a]	45.00[d]	314.08[g]	1.39[c]
F test	*	**	**	**	**	**
LSD (0.05)	6.84	0.85	3.83	7.07	12.92	0.11
CV %	5.56	11.94	4.78	6.85	1.21	4.11

[†]Means of 4 replication. Means in column with same superscript is not significantly different by DMRT$_{(P<0.05)}$. EPS- Early Plant Stand, DS-Disease severity, PDI = Percent Disease Index (25 plants), FPS-Final Plant Stand, Yield = Grain yield, HSWT = Hundred Seed Weight X. *Xanthoxylum*, L.- *Lantana*, *T.v.*- *Trichoderma viride* Pers, *T.h.*- *Trichoderma harzianum* Rifai, PPD- Plant Pathology Division-NARC, L- litre, kg/ha-kilogram per hectare, g – gram, m-meter, mL-mili liter, * Significant, **- highly significant at 1% level

Table 2: Effect of different treatments on Wilt root rot disease severity and yield performance of lentil at Rampur, Chitwan during 2014

Treatments	EPS %	DS (1-9)	PDI %	FPS %	Yield (kg/ha)	HSWT (g)
Seed treatment with bavistin @2g/kg	88.75 [a†]	3.50 [c]	51.03 [d]	83.75 [a]	773.40 [b]	1.85[a]
Seed treatment with vitavax @2.5g/kg	90.00 [a]	3.50 [c]	47.67 [e]	85.00 [a]	850.00 [a]	1.86[a]
chlorothalonil@2 mL/L of water	87.50 [ab]	5.50 [b]	52.40 [d]	80.00 [ab]	654.70 [c]	1.76[b]
iprodione @2 g/L of water	90.00 [a]	3.50 [c]	51.20 [d]	82.50 [a]	768.80 [b]	1.79 [b]
Seed treatment with *X. armatum* @ 2g/kg	78.75 [c]	6.00 [b]	56.26 [c]	70.00 [cd]	606.30 [d]	1.62[c]
Soil incorporation of *L. camera* @ 250g/m^2	81.25 [bc]	6.50 [b]	58.83 [c]	67.50 [d]	548.40 [e]	1.54[d]
T. v. (PPD isolate) @ 350g/8m^2 plot	90.00 [a]	5.50 [b]	56.00 [c]	75.00 [bc]	645.30 [c]	1.73[b]
T. h. (PPD isolate) @ 350g/8m^2 plot	78.75 [c]	6.50 [b]	72.01 [b]	65.00 [d]	421.90 [f]	1.34[e]
Control	86.25 [ab]	8.00 [a]	76.25 [a]	52.50 [e]	279.70 [g]	1.19[f]
F test	*	**	**	**	**	**
LSD (0.05)	6.66	1.38	3.03	6.22	32.60	0.03
CV %	5.33	17.59	3.58	5.80	3.62	1.28

[†]Means of 4 replication. Means in column with same superscript is not significantly different by DMRT$_{(P<0.05)}$. EPS- Early Plant Stand, DS-Disease severity, PDI = Percent Disease Index (25 plants), FPS-Final Plant Stand, Yield = Grain yield, HSWT = Hundred Seed Weight X. *Xanthoxylum*, L.- *Lantana*, *T.v.*- *Trichoderma viride* Pers, *T.h.*- *Trichoderma harzianum* Rifai, PPD- Plant Pathology Division-NARC, L- litre, kg/ha-kilogram per hectare, g – gram, m-meter, mL-milliliter * Significant, **- highly significant at 1% level

Table 3: Effect of different treatments on wilt / root rot complex disease control and yield increase percent of lentil at Rampur, Chitwan during 2013-2014

Treatments	Experiment year 2013		Experiment Year 2014	
	PDC %	YI %	PDC %	YI %
Seed treatment with bavistin @2g/kg	41.70	174.37	33.08	176.51
Seed treatment with vitavax @2.5g/kg	42.66	186.33	37.48	203.90
Chlorothalonil @ 2 mL/L of water	34.94	141.78	31.28	134.07
iprodione @ 2 g/L of water	35.11	161.33	32.85	174.87
Seed treatment with *X. armatum* @ 2g/kg	28.83	133.06	26.22	116.77
Soil incorporation of *L. camera* @ 250g/m^2	27.19	130.54	22.85	96.07
T. v. (PPD isolate) @ 350g/8m^2 plot	30.20	140.55	26.56	130.71
T. h. (PPD isolate) @ 350g/8m^2 plot	27.00	120.65	5.56	50.84
Control				

PDC-Percent Disease Control, YI-Yield Increase, X. *Xanthoxylum*, L.- *Lantana*, *T.v.- Trichoderma viride* Pers, *T.h.- Trichoderma harzianum* Rifai, PPD- Plant Pathology Division-NARC, L- litre, mL- milliliter, kg/ha-kilogram per hectare, g – gram, m-meter

bavistin (51.03%) prior to sowing. The highest crop yield was also recorded from the plot with Vitavax seed treatment (850 kg/ha), followed by Bavistin seed treatment (773.40 kg/ha). The lowest crop yield (279.70 kg/ha) was obtained from the control plot (Table 2).

The higher percent disease control (PDC) and Percent Yield increase (PYI), i.e. 42.66% and 186.33 % in 2013 and 37.48% PDC with 203.90% YI during 2014 respectively were found in the plots where lentil seeds were treated with vitavax followed by plots where seeds were sown after treatment with Bavistin compared to control plot which received no treatment (Table 3).

Relationship between disease control and yield increase

During experimental period (2013-2014), the yield increase was found significantly positive correlation (r = 0.92) with the lentil wilt root rot complex disease control using different botanicals, bio-control agents and fungicides in field condition. The predicted linear regression line was i.e. $y = 4.024X + 20.41$, with regression coefficient $R^2 = 0.84$, where 'y' denoted predicted yield increase of lentil and 'x' stood for disease control with different management means (Figure 1). The estimated regression line indicated that the unit rise in the percent disease control of lentil wilt root rot complex (within 1-9 scale) due to different treatments, there existed possibilities of yield increase by 4.02 percent.

Management of plant disease could be successfully achieved with application of botanicals, synthetic chemicals, bio-control, host plant resistance, cultural control and other methods. From this experiment, for 2 consecutive years, it has been established that the lowest wilt/root rot index, highest plant survival and highest disease reduction with increased yield over control were achieved from the plot where lentil seeds were treated with Vitavex @ 2.5 g/kg and followed by Bavistin @ 2g/kg. This finding is in close agreement with Sharma and Sohi (1981) who reported from field trials with 10 seed dressing fungicides against foot and root rot, the best protection was given by Bavistin (Carbendazim) and Vitavax (Carboxin) and mortality was reduced from 56-14%. Khalequzzaman (2008) stated the best treatment for controlling foot and root rot of lentil and chickpea was dipping seeds in 0.25% suspension of Vitavax 200 for 3 hours. Gupta (2006) found that Vitavax 200 reduced chickpea wilt caused by *Fusarium oxysporum* f. sp. *ciceris* and improved seedling emergence which was at par with the standard fungicide Bavistin (carbendazim). Vitavax 200 significantly decreased damping off disease

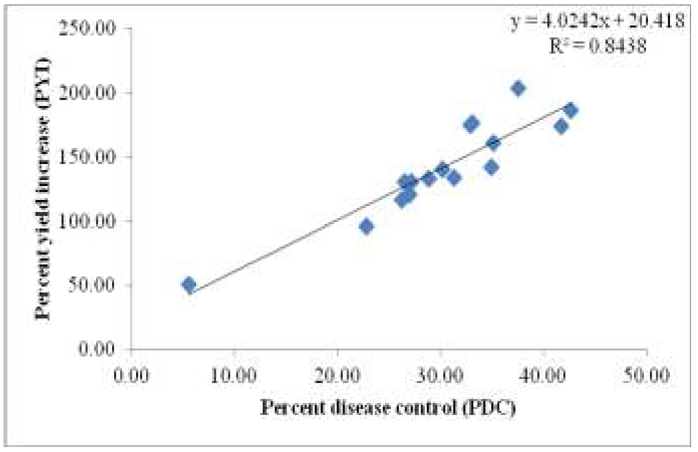

Figure 1: Relationship between disease control and yield increase using different botanicals, bio-control agents and fungicides against wilt/root rot complex of lentil

and increased percentage of surviving plants of faba bean, lentil and chickpea (Zeid *et al.* 2003). Kaur and Mukhopadhyay (1992) reported that seeds treated with Vitavax 200 and Ziram resulted in 29.9% disease control, and carboxin for seed treatment was the best to reduce wilt incidence (44.1-60.3%) during experimentation. Singh et al. (2014) found that Vitavax showed efficacy against seed borne fungi viz*., Aspergillus spp, Penicillium spp, Alternaria alternata, Rhizopus* and *Fusarium spp* followed by neem, garlic and *T. harzianum.*

Conclusion

From the present study, it is obvious that seeds treated with fungicides Vitavex (2.5 g/kg) and Bavistin (2 g/kg) had lesser disease severity with higher yield than untreated ones. So it is recommended that lentil seed should be treated with either Vitavex (2.5 g/kg) or Bavistin (2 g/kg of seed) prior to sowing against wilt/root rot complex of lentil for disease severity reduction and yield maximization.

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