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Research Article

Sufficient application of NPK fertilizers: A practical and efficient strategy in the management of Verticillium wilt of potato var. Agria

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Abstract: Field experiment was conducted in 2010 and 2011, in order to study the effects of NPK fertilizers on the incidence of Verticillium wilt of a commercial variety 'Agria' in deficient soil at Eghlid Agriculture Research Station in the north of Fars province, Iran. Experimental design was randomized complete blocks and each treatment replicated three times. Treatments were the amounts of recommended NPK rate (180N, 125P, 100K), 20% and 40 % less and more than the rate based on the soil tests. Soil at planting sites was inoculated with 5 ml of microsclerotia suspension (70 ms/ml). Tubers weight, plant height and disease scores were recorded. Two-year combined analysis indicated that there were significant differences at 1% level between the treatments. The results showed a marked decrease in Verticillium wilt incidence and increase in yield when NPK was used at the recommended rate. Lowest disease score and highest yield even more than the cultivar potential were obtained in the plots when N was used 40 % more than the recommended level of the soil test (252 N), combined with K at the level of the soil test (100 K). P was essential for plant growth but had no effect on the disease.

Keywords: Potato early dying, *Verticillium dahliae*, Disease control, Fertilizers, NPK

Introduction

Among several soil-borne diseases, Verticillium wilt (Potato Early Dying, PED), causes by *Verticillium dahliae* Kelb and *Verticillium albo-atrum* Reinke & Berthold is the main disease of potato worldwide (Stevenson *et al*., 2002). The disease is prevalent in Fars province, Iran (Mansoori, 1995). In spite of a lot of works on the management of disease, still high losses occur throughout the world (Row and Powelson, 2002).

To date, management of early dying is largely achieved by crop rotation and soil fumigation using metam sodium (Vapam). Crop rotation is not successful as microsclerotia of *V. dahliae* persist in soil for a long time (Schnathorst, 1981). Vapam is partially effective in reducing the propagule density only at the beginning of the potato season, but it did not reduce disease incidence compared to the control (Monila *et al*., 2014). Indeed, this chemical is expensive and can potentially have significant negative impacts on the environment (Taylor *et al*., 2005; Kirk and Wharton, 2014).

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Fertilizers have been shown to have a significant effect on reducing certain diseases (Datnoff *et al*., 2007). In case of PED, incidence of Verticillium wilt decreased and tuber yield increased for potato variety Russet Burbank, as the rate of nitrogen and phosphorus were increased (Davis *et al.*, 1994). However, Platt and Arsenault (2001) reported these elements did not suppressed PED in Yokun Gold variety. However, fertilizers formulas said to have different effects on certain diseases. Huber and Watson (1974) reported highest level of NH_4-N increased resistance to PED, meanwhile, Davis and Everson (1986) reported resistance to PED decreased in response to NO_3-N. More recently in a list, NPK were shown to increase, decrease or have no effect on fungal diseases (Datnoff *et al*., 2007). Except N which it was indicated to decrease PED (Pennypacker, 1996), there is no data regarding the effects of P and K on the disease. However, the results were conflicting and not conclusive as no data were given on initial levels of soil fertility, pH, cation exchange capacity, etc.

Verticillium wilt of potato is highly prevalent in Fars province, Iran (Mansoori, 1995). The objective of this study was to examine the effects of N (Urea), P (Super triple phosphate) and K (Potassium phosphate) fertilizers on PED and yield of a commercial variety 'Agria' in the north of Fars province-Iran.

Materials and Methods

The study was undertaken in two successive years, 2010 and 2011, in separate locations in Eghlid Agriculture Research Station in north of Fars province, Iran. The soil at the experimental sites was sandy loam, deficient in NPK (Table 1).

Experimental design was randomized complete blocks and each treatment replicated three times. Plots size was 12 × 5 meters. Certified seed tubers (3000 kg h^{-1}) of variety 'Agria' susceptible to *V. dahliae* (Mansoori, 2004) were planted in April. The amounts of N (Urea), P (Super triple phosphate) and K (Potassium phosphate) fertilizers used in this experiment were adjusted to the recommended rates (180N, 125P, 100K) for potato in Iran (Malakouti and Ghibi, 1987) based on the data obtained from critical soil tests before planting. Other treatments were 20 and 40 % less and more than the recommended rate to examine the effects of each fertilizer. P and K were applied at the time of planting, but N was split in two halves and applied at planting and tuber initiation (60 days after planting). Soil at the planting site (diameter ≥ 12 cm) was inoculated with microsclerotia of the fungus (70 ms ml^{-1}) before planting of tubers.

For assessment of plant growth parameters and disease incidence, 10 plants per plot were randomly selected at the time of flowering (90 days after planting), and height was measured and was tried to re-isolate *V. dahliae* from lower stem tissue. Disease severity was assessed according to Nachmias *et al.* (1990) by scoring symptoms on a whole plot basis using a 0 to 4 scales (0 = No symptoms, 1 = No stunting, not more than 10% of the foliage chlorotic and necrotic, 2 = Stunting and 25-30% of the foliage chlorotic and necrotic, 3 = Severe stunting and less than 75% of the foliage chlorotic and necrotic, 4 = Severe stunting and more than 75% of the foliage chlorotic and necrotic, 5 = Dead plant), and yield obtained at the end of growing season (after 120 days from planting) was also recorded.

Results and Discussion

Comparing treatments the results indicated that in a deficient sandy loam soil (Table 1), macronutrients (NPK) affected the yield, hight and disease score of potato plants variety 'Agria' infected by *V. dahlia*e (Table 2). Changing the level of each macro-element had separate effects on disease and yield (Table 3). Increasing the level of N (T_9) to 252 kg ha^{-1}, more than the amount calculated on the basis of the soil tests (T_1 = 180 kg ha^{-1}), increased the yield in the infested plots in both years of experiment. Nitrogen delays senescence and maturity of plants (Davis and Everson, 1986), which is the feature of PED (Isaac and Harrison, 1968).

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Table 1 Some physicochemical characteristics of the soil sample from experimental site.

EC (ds/m)	Soil pH	Saturation (%)	TNV	OC (%)	Macronutrients (Mg / kg Soil)			Composition (%)		
					P	K	Zn	Sand	Silt	Clay
0.8	7.7	41	34	0.53	5	225	0.6	38.4	40	21.6

EC: Electrical conductivity, TNV: Total neutralizing value, OC (%): Percent of organic carbon.

Table 2 Combined analysis of variance (ANOVA) of the effects of NPK on the yield, height and disease score of potato plants infected by *Verticillium dahliae*.

Sources of variance	df	Mean Square		
		Yield	Height	Disease score
Year	1	196023296.20 ^{ns}	57.55 *	1.038 ^{ns}
Error	4	108600292.52	135.436	1.308
Treatments	12	84899158.83*	97.61**	0.850*
Treatment ×Year	12	43197973.52 ^{ns}	73.88 *	0.538 ^{ns}
Error	48	44878991.05	28.99	0.544
CV%		19.78	14.11	30.43

* and **: Significant at 5% and 1% level of probability, respectively.

Table 3 The effects of NPK on the yield, height and disease score of potato plants infected by *Verticillium dahliae* (2010 and 2011).

Treatments	Level (kg / ha)	Yield (kg / ha)	Plant hight (10 plants / cm)	Disease Score[1]
T_1	180N,125P,100K	34590 abc	43 a	2a
T_2	180N,125P,80K	33120 abc	40 ab	2a
T_3	180N,125P,60K	29520 bc	34 c	3bc
T_4	180N,125P,120K	33440 abc	41 ab	2b
T_5	180N,125P,140K	36320 ab	39 ab	2b
T_6	144N,125P,100K	30820 bc	38 ab	3c
T_7	108N,125P,100K	26400 c	34 c	3bc
T_8	216N,125P,100K	36260 ab	45 a	1a
T_9	252N,125P,100K	40360 a	45 a	1a
T_{10}	180N,100P,100K	36450 ab	39 ab	3bc
T_{11}	180N,75P,100K	38210 ab	34 bc	3c
T_{12}	180N,150P,100K	33030 abc	32 bc	3c
T_{13}	180N,175P,100K	31750 abc	36 bc	2ab

Values with the same letter in each column are not significantly different at 5% level according to Duncan's multiple range tests.
[1] Disease score 0 = no symptoms, 1 = No stunting, not more than 10% of leaves chlorotic or necrotic, 2 = Stunting and 25-30% of the foliage chlorotic and or necrotic, 3 = Stunting and up to 75% of the foliage chlorotic and necrotic, 4 = Stunting and more than 75% of the foliage chlorotic and necrotic, 5 = Dead plants.

Phosphorus had no effect on PED syndrome in the potato variety 'Agria'. However, phosphorus favors disease resistance by promoting plant health, thereby enabling the physiologic, morphologic, or functional resistances inherent in the host to actively ward off infection. If plant growth is promoted, roots and shoots can sometimes outgrow the pathogens or plants can escape the disease entirely (Davis *et al*., 1994).

Potassium affected PED more than nitrogen and phosphorus as plant height decreased and disease index increased at low K (T_3). A positive trend in yield was observed as the

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amount of K was increased. However, increasing the amount of K (T_1), more than the soil test level, had no significant effects on yield. Potassium nutrition status not only affects plant growth and development, but it also plays an important role in plant resistance to diseases by regulating various plant physiological metabolism pathways (Xiao *et al*., 2006).

It is concluded with optimal NPK, potato variety 'Agria' can escape Verticillium wilt and yield losses that normally occur in this variety in heavily infested soil. While N and K are essential for health and reduce disease severity through physiological effects, N increases yield to a maximum more than the cultivar potential.

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تأمین کافی عناصر غذائی ازت فسفر و پتاس: راه‌حلی مؤثر جهت کنترل بیماری پژمردگی سیب‌زمینی رقم آگریا

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چکیده: بیماری پژمردگی ورتیسیلیومی سیب‌زمینی یکی از بیماری‌های شایع در مزارع سیب‌زمینی استان فارس است که همه‌ساله خسارات زیادی به کشاورزان وارد می‌نماید. احتمالاً بخشی از این خسارت را می‌توان با مدیریت تغذیه گیاه کاهش داد. برای بررسی این موضوع اقدام به اجرای این آزمایش در ایستگاه تحقیقات کشاورزی اقلید گردید. در این آزمایش در قالب طرح بلوک‌های کامل تصادفی تعداد ۱۳ تیمار شامل کودهای نیتروژن، فسفر و پتاسیم براساس آزمون خاک و ۲۰ و ۴۰ درصد کم‌تر و بیش‌تر از آزمون خاک مورد بررسی قرار گرفت. صفات اندازه‌گیری شامل امتیاز بیماری، عملکرد، ارتفاع بوته و امتیاز بیماری بود. تجزیه واریانس مرکب ۲ سال نتایج آزمایش نشان داد که اختلاف معنی داری مابین تیمار ها وجود دارد. بیش‌ترین مقدار عملکرد (۴۱۰۰۰ کیلوگرم در هکتار) با مصرف عناصر غذایی پتاسیم و فسفر براساس آزمون خاک و نیتروژن ۴۰ درصد بیش‌تر از آزمون خاک به‌دست آمد. کم‌ترین امتیاز بیماری مربوط به تیماری بود که در آن فسفر و نیتروژن براساس آزمون خاک و پتاسیم ۴۰ درصد بیش‌تر از آزمون خاک مصرف شده بود. مصرف فسفر و پتاسیم براساس آزمون خاک و نیتروژن ۴۰ درصد بیش‌تر از آزمون خاک منجر به کاهش شدت بیماری پژمردگی ورتیسیلیومی و حداکثر محصول در سیب‌زمینی رقم آگریا گردید.

واژگان کلیدی: مرگ زودرس سیب‌زمینی، ورتیسلیوم دهلیا، کنترل بیماری، کود

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