Soil Moisture-Based Nutrient Management of Red Pepper

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Abstract

A shortage in soil moisture for crops prevents plants from growing normally. Moreso, lack of moisture suppresses nutrient availability. On the other hand, excessive nutrients make water more scarce. Thereby, water and nutrients should be managed mutually to minimize yield reduction under drought conditions.

This research aimed to find out the response of red pepper to fertilizer, and to improve nutrient management to increase yield production under several soil moisture deficit conditions. Irrigation started at three soil matric potential levels, -30, -50, and -80 kPa in 2002 and at four soil matric potential levels, -30, -50, -100, and -150 kPa, in 2003. The amount of fertilizer applied was at four levels: recommended fertilization with soil test (RFST), 50% of RFST, 150% of RFST, and no-fertilization. Yield at -30 kpa-irrigation and 150% RFST plot was the largest, and it was regarded as 100 at yield index. At -30 kPa-irrigation, yield increased linearly with fertilization amount. At -50 kPa-irrigation, yield was largest at RFST. Yield index at -80 kPa-irrigation was lower than 70 at no-fertilization but increased to 85 at RFST. Fertilization did not contribute to increasing yield under irrigation condition below -100 kPa. The RFST fertilization for red pepper in Korea was useful at higher than -100 kPa soil moisture potential. However, fertilizer application needed to be reduced at lower water than -100 kPa.

Media summary

The recommended fertilization with soil test for red pepper in Korea was useful at higher than -100 kPa soil moisture potential but it was needed to reduce the amount of fertilization at lower than -100 kPa.

Key words

Fertilizer response, drought, soil moisture potential

Introduction

Since the Korean Peninsula is located in the Asian monsoon belt, more than half of the annual precipitation falls during the summer season. Frequency of droughts reaches 80 to 90% in spring, and 50 to 70% in autumn, though the annual precipitation attains 1300 mm. Also, water has become scarce for agricultural production because more water has been allotted to increased domestic consumption in households and in-stream. Such conditions prevent plants from growing normally, and suppress availability of nutrients. On the contrary, excessive nutrients make water more scarce. Water and nutrients should be managed efficiently to increase yield even under drought.

Norum (1963) reported that water use efficiency (WUE) of wheat farming with fertilization was higher than that without fertilization. Moreover, he reported that more irrigation with fertilization reduced WUE while it increased yield. Eom (1983) presented that fertilization increased the uptake of N and K of soybean at high soil moisture potential. However, it became lower at recommended fertilization than at half recommendation rate at low soil moisture potential. Tanguilig et al (1987) and Ryu et al (1996) also reported that water stress affects leaf elongation and nutrient uptake of rice, maize, and soybean. A lot of researches were also conducted to find out the common effect of water and nutrient on yield response.

They have managed to achieve maximum yield, even to an optimum condition so as not to alleviate the drought damage.

This research studies the response of red pepper to fertilizer, and aims to improve nutrient management to increase yield even under several soil moisture deficit conditions.

Methods

This study was conducted in Suwon, Korea from 2002 to 2003. The pepper variety used in the experiment was Taeyang, and the soil was Bonryang series, a coarse loamy over sandy, mixed, mesic family of Typic Udifluvents. Rainfall was intercepted by transparent plastic to exclude the rainfall effect on soil moisture condition. Red pepper was transplanted with a planting distance of 50?50 cm. Irrigation started at three soil matric potential levels, -30, -50, and -80 kPa in 2002, and at four soil matric potential levels, -30, -50, -100, and -150 kPa, in 2003. Irrigation volume was determined by the difference between soil water content at -10 kPa, and at irrigation starting potential. Soil matric potential was measured at 20 cm soil depth using tensiometer (0~-80 kPa) and watermark (0~200 kPa), a standard by Irrometer, USA. Drip line was used and the irrigation rate was 3.6L hr^{-1} $dripper^{-1}$. The amount of fertilization was applied at four levels: recommended fertilization with soil test (RFST), RFST 50%, and 150% of RFST, and no-fertilization. Soils and plants were sampled once a month during the experiment, and nutrient content, and yield component were examined based on Analysis Method of Soil and Plant(NIAST, 2000) and Standard Examination Method of Agricultural Experiment (RDA, 1983).

Results

Yield at -30 kPa-irrigation and 150% RFST plot was the largest in both years, and yield index was by assumed to be 100. Figure 1 shows yield responses to fertilization at each irrigation level using yield index. At -30 kPa-irrigation plot, yield linearly increased with the amount of fertilization. At -50 kPa-irrigation plot, yield was the largest at RFST. Yield index at -80 kPa-irrigation was lower than 70 at no-fertilization but this increased to 85 at RFST. Fertilization amount did not increase yield under the soil moisture condition of lower than -100 kPa. Irrigation at lower moisture potential reduced yield, but reduced irrigation volume, and increased WUE. This was similar to the study of Aggelides et al.(1999) on lettuce where WUE was highest at -100 kPa irrigation, and the largest yield at -30 kPa irrigation.

WUE with different fertilization levels in the same soil moisture condition was dependent on yield since irrigation volume was similar, but yield was different from each other. Fertilization at -30 or -50 kPa irrigation levels was slightly effective since yield increased by about 10 of yield index. Since N, P, and K contents of plants did not have significant difference between fertilization levels at the same soil moisture condition, total nutrient uptake increased, and fertilizer efficiency decreased with yield. Especially, fertilizer efficiency of K was about 15% under 150% RFST, while that was over 60% under 50% RFST. It implies that natural supply of K became high. RFST was modified using the fertilizer response with soil moisture condition. Modified fertilization rate was estimated, assuming that re

presentative soil EC would be 1 dS m^{-1} and 1 dS m^{-1} would contribute to osmotic potential as -20 kPa. Figure 2 shows the yield under RFST, and the expected yield under modified fertilization method. RFST and modified fertilization has little difference till -100 kPa but it was expected to decrease yield by a maximum 20% yield index under water deficit condition below -100 kPa.

Table 1. Characteristics of soil used.

year	pH	EC (dS m^{-1})	OM (g kg^{-1})	Texture	Soil moisture characteristics(w/w, %)				
					10 kPa	30 kPa	50 kPa	100 kPa	200 kPa

2002	6.0	2.0	11.8	SL	22.3	17.7	15.5	13.1	10.9
2003	6.3	2.5	12.1						

Table 2. Irrigation amount and water use efficiency under recommended fertilization with soil test(2002~2003)

2002	Irrigation volume (mm)	Yield index	Water use efficiency (kg MT^{-1})	2003	Irrigation volume (mm)	Yield index	Water use efficiency (kg MT^{-1})
-30 kPa	508	96.0	3.70	-30 kPa	508	99.4	1.98
-50 kPa	435	97.3	4.38	-50 kPa	355	97.5	2.94
-80 kPa	308	94.1	5.97	-100 kPa	162	68.3	4.51
				-150 kPa	159	60.7	4.10

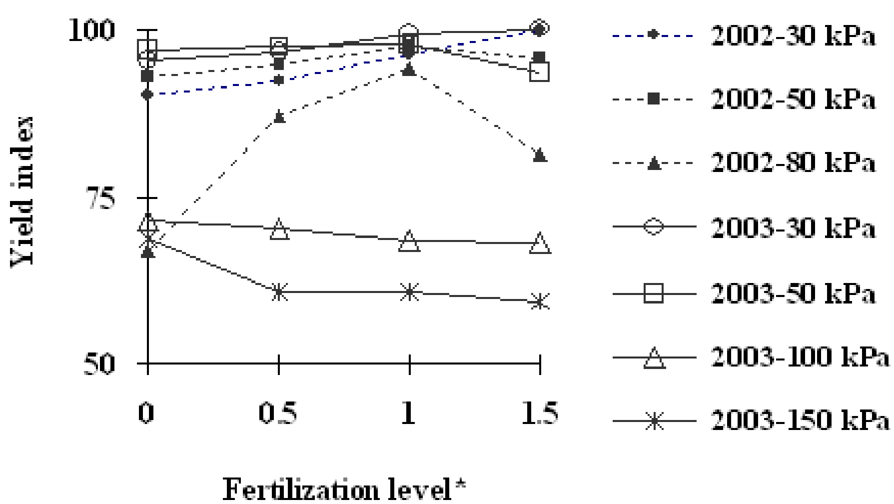

Figure 1. Yield responses to irrigation and application level

*** Fertilization level means the times of recommended fertilization rate with soil test**

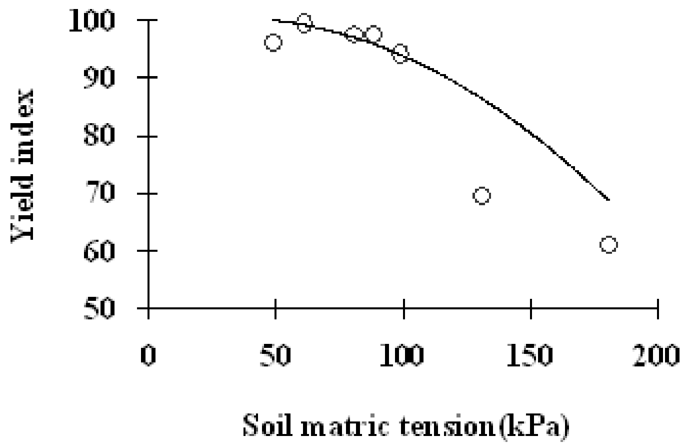

Figure 2. Prediction curve of yield change with a shortage of soil moisture under recommended fertilization with soil test(RFST)(circle) and modified RFST considering soil moisture (line).

*** Assuming that soil electrical conductivity would be 1.0 dS m^{-1}.**

Conclusion

Yield increased gradually with the fertilization amount under wet condition but fertilizer efficiency decreased. Fertilization rate for maximum yield became smaller as soil moisture got low. The RFST was useful at higher than -100 kPa soil moisture potential equivalent to 1 dS m^{-1} of soil EC but it needed to reduce the amount of fertilization at lower than -100 kPa. Modified fertilization under dry condition was expected to be helpful for alleviating yield reduction.

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