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Interaction of nutrient resource and crop diversity on resource use efficiency in different cropping systems

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Keywords: Absorption Efficiency, Intercropping, Monoculture, Nutrient, Use efficiency, Water

Introduction

Conventional operations in fields, soil and water management are not efficient and loss of and damage to the environment are considerable (Lal, 2000). Crop diversity and understanding the complex interactions between environmental and socioeconomic factors are approaches to make better use of limited resources (Tengberg et al., 1998). The most diverse ecosystems have a higher production under environment stress conditions compared with ecosystems with low diversity due to the better efficiency in the use of water, radiation and nutrients (Hulugalle & al, 1986; Walker & Ogindo, 2003).

Materials and Methods

In order to investigate the effects of crop diversity and nutrient source on resource use efficiency, a split plot experiment was conducted based on complete randomized blocks with 3 replications at the Agricultural Research Station, the Ferdowsi University of Mashhad, Iran, during 2006 and 2007. The treatments included manure and chemical fertilizers as the main plots and intercropping of 3 soybean varieties (Williams, Sahar and Gorgan3), intercropping of 3 Millet species (common millet, foxtail millet and pearl millet), intercropping of millet, soybean and sesame (*Sesamum indicum*) and intercropping of millet, sesame, fenugreek (*Trigonella foenum-graecum)* and ajowan (*Trachyspermum ammi)* as sub plots.

Results and Discussion

The results indicated that in the first year, intercropping of 3 Millet species and intercropping of millet, soybean and sesame showed the highest water use efficiency (WUE) based on biological yield. In the second year, intercropping of 3 millet species showed the highest WUE based on biological yield. The highest concentrations of nitrogen, phosphorous and potassium in crop tissues were observed in intercropping of 3 soybean varieties and intercropping of millet, soybean and sesame. In the first year, intercropping of 3 soybean varieties showed the highest nutrient use efficiency (NUE). In the second year, intercropping of 3 soybean varieties, intercropping of millet, soybean and sesame and intercropping of millet, sesame, fenugreek and ajowan showed the highest NUE. In the two years, intercropping of millet, soybean and sesame and intercropping of millet, sesame, fenugreek and ajowan showed the highest nitrogen and phosphorus absorption efficiency (NAE). Intercropping of millet, soybean and sesame showed the highest potassium uptake efficiency. In this study, nutrient resource did not have a significant effect on water and nutrient use efficiency.

The research results have indicated that often nitrogen amount and use efficiency in legume and non legume intercropping were higher than monocultures. This indicates the synergist effect in the intercroppings (Vandermeer, 1989; Szumigalski & Van Acker, 2006). In general, the different benefits of diversity and better use of available inputs are obtained by increasing the diversity of crops and proper selection of plants cultivated in intercropping systems and crop rotations in monoculture systems

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Effects of mycorrhiza inoculation and different irrigation levels on yield, yield components and essential oil contents of fennel (*Foeniculum vulgare* Mill.) and ajwain (*Trachyspermum ammi* L.)

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Keywords: Biofertilizer, Medicinal plant, Symbiosis

Introduction

Fertilizers are the key components which provide plant nutrients' needs in recent years (Omid Jangir & Sing, 1996; Kapoor et al., 2007). In many cases, using chemical fertilizers has different negative environmental effects such as soil, water and air pollution, which increase environmental hazardous and production costs (Jangir & Sing, 1996; Kapoor et al., 2007). Biological activities are markedly enhanced by microbial interactions in the rhizosphere of plants (Kapoor et al., 2007).

Many investigators have successfully used mycorrhiza to increase the availability of immobilized phosphate and thus minimize the use of mineral fertilizers. Arbuscular Mycorrhizal Fungi (AMF) can better enable a plant to withstand environmental stresses such as drought and salinity. AMF interacts with pathogens and other rhizosphere inhabitants which affect plant health and nutrition. More importantly, mycorrhizal fungi are capable of dissolving weakly soluble soil minerals, especially phosphate, by releasing acids or increasing CO_2 partial pressure (Gupta et al., 2002; Gosling et al., 2006; Kapoor et al., 2007). Therefore, they have the ability to enhance host plant uptake of relatively immobile nutrients particularly P, S and Zn.

Limited water supply is also another major environmental constraint in the productivity of crop and medicinal plants. Moisture deficiency induces various physiological and metabolic responses such as stomatal closure, decline in growth rate and photosynthesis (Flexas and Medrano, 2002). The results of Baher et al. (2002) showed that greater soil water stress decreased plant height and total fresh and dry weight of *Satureja hortensis*.

Materials and Methods

In order to study the effects of mycorrhiza inoculation and different irrigation levels on the growth, quantitative and qualitative yield of fennel (*Foeniculum vulgare* Mill.) and ajwain (*Trachyspermum ammi* L.), a field experiment was conducted as factorial based on randomized complete block design with three replications at the Agricultural Research Station, the Ferdowsi University of Mashhad, Iran during two growing seasons of 2009-2010 and 2010-2011. Mycorrhiza inoculation (with and without inoculation) and irrigation levels (1000, 2000 and 3000 $m^3.ha^{-1}$) were allocated to the first and the second factors, respectively. Several criteria such as yield components (including branch numbers per plant, umbel number per branch, umbellet number per umbel, seed number per umbellet and 1000-seed weight), biological yield, seed yield, harvest index, essential oil content and essential oil yield of fennel and ajwain were measured.

Results and Discussion

Results indicated that the simple effects of mycorrhiza inoculation and irrigation levels on the biological and seed yields, harvest index (HI), yield components, essential oil content and essential oil yield of fennel and ajwain were significant ($p\leq 0.01$). The maximum biological yield of fennel (5.3 $g.m^{-2}$) and ajwain (4.3 $g.m^{-2}$) were observed in mycorrhiza inoculation. Mycorrhiza inoculation enhanced seed yield of fennel and ajwain up to 46% and 97% compared with control, respectively. The highest essential oil content of fennel (4.2%) and ajwain (3.0%) were obtained in mycorrhiza inoculation. The highest and the lowest seed yield of fennel and ajwain were observed in 3000 $m^3.ha^{-1}$ (1.6 and 0.9 $g.m^{-2}$) and 1000 $m^3.ha^{-1}$ (1.4 and 0.7 $g.m^{-2}$) irrigation levels, respectively. The maximum essential oil content of fennel and ajwain were obtained in 3000 $m^3.ha^{-1}$ (4.0% and 3.4%) and the

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minimum were for 1000 $m^3.ha^{-1}$ (3.2% and 2.9%). Interaction effects among mycorrhiza inoculation and different irrigation levels on the biological yield, HI and some yield components of fennel (such as branch number per plant, umbel numbel per branch, umbellet number per umbel and seed number per umbellet) and ajwain (such as umbellet number per umbel, seed number per umbellet and 1000 seed weight) scale fern number, seed number and 1000 seed weight of ajwain were significant ($p \leq 0.05$). Inoculation with mycorrhiza, enhanced root development and resulted in the availability of moisture and nutrients, particularly phosphorus. On the other hand, these fertilizers are the cause of production of many growth regulators for the plant. The higher irrigation levels increased photosynthesis and dry matter production due to vegetative growth and photosynthesis area of the plants.

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Evaluation of competition, yield quantity and quality of soybean (*Glycine max* L.) Merrill.) and calendula (*Calendula officinalis* L.) in intercropping systems

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Keywords: Aggressivity, Competitive ratio, Planting pattern, Relative crowding coefficient

Introduction

With the continuous growth of world population, degradation and ecological imbalance throughout the world, there is a need to increase agricultural production and environmental protection measures. In this respect, efforts to supply nutrients to the environment are at the head of the programs. One of the ways to approach this goal is the use of intercropping systems (Najafi & Mohammadi, 2005). Suitable performance in intercropping systems may be achieved by selecting genotypes possessing traits consistent with and appropriate for establishing minimum and maximum synergy and competition employing proper agronomic practices such as density and planting pattern (Mutungamiri et al., 2001). In this context, selected plants should be less competitive in terms of environmental impact. The purpose of this study was to investigate the effect of different planting patterns on the competition between the two species of calendula and soybean and to evaluate the yield and quality of an intercropping system compared with a mono-cropping system.

Materials and Methods

In order to evaluate the competition between soybean and calendula, a field experiment was conducted based on randomized complete block design with 7 treatments and 3 replications in the research farm of the Faculty of Agriculture, the University of Tabriz in 2009. The treatments included pure stands for both species, 1:1, 2:2, 4:2, 4:4 and 6:4 for soybean and calendula number of rows per strip, respectively. Before planting, soybean seeds were inoculated with *Bradyrhyzobium japonicum*. Before harvesting, the number of pods per plant, seeds per plant, 1000- grain weight, grain yield, percentage of oil and protein of soybean grain were measured in 10 randomly selected plants. The number of flowers per plant, dry inflorescence weight and dry petal weight of Calendula were recorded. The harvest of flowers of calendula began on July 30 and harvesting was done every 15 days in six steps. It was continued to mid-October. Total dry petals and sepals of 6 withdrawals flower per plot were considered as inflorescence dry weight. The land equivalent ratio (LER), actual yield loss (AYL), relative crowding coefficient (RCC), aggressivity (A) and competitive ratio (CR) were determined at the end of the growing season. For statistical analysis, analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) were performed using MSTAT-C.

Results and Discussion

The results showed that the effect of planting pattern on the number of pods per plant, seeds per plant, 1000-grain weight, grain yield of soybean, percentage of oil and protein contents of soybean was not significant. The effect of planting pattern on inflorescence dry weight and dry petal weight of calendula was significant. Row and strip intercropping 6:4 produced greater dry inflorescence weight and dry petal weight than calendula monoculture. The highest petal and inflorescence yield was achieved by 1:1 (87.63, 30.75) and 6:4 (41.75, 22.68) intercrops, respectively. The effect of planting pattern on the number of flowers per plant was significant at 1% level. The number of flowers per plant for row intercropping and strip intercropping of 1:1 and 6:4 were greater than calendula monoculture. The highest flowers per plant was achieved by 1:1 and 6:4 intercrops, respectively. The land equivalent ratio was greatest for 6:4 and 1:1 intercrops equal 1.34 and 1.13, respectively and the lowest land equivalent ratio was achieved by 2:2 intercrops. The actual yield loss value of all treatments were positive that indicated increased yield. In row intercropping and strip intercropping 4:4 and 2:2 competitive ratio of calendula (1.13, 1.25, 2.06) was>0 and the competitive ratio of soybean (1.07, 1.2) was>1 that show that

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yield advantage was greater than mono-cropping system. The relative crowding coefficient (RCC) of calendula (0.46, 0.46, 0.76) was greater than that of soybean that proves the competitive advantage of calendula against soybean. In strip intercropping, 6:4 and 4:2 aggressivity of soybean (0.98, 1.43) was>0, that indicates the relative yield of soybean is greater than calendula. The negative aggressivity of calendula (0.93, 1.19) in this treatment shows that the relative yield of calendula is less than soybean. In row intercropping and strip intercropping 4:4 and 2:2 competitive ratio of calendula (1.13, 1.25, 2.06) was>0 and competitive ratio of soybean (1.07, 1.2) was >1 that shows that yield advantage was greater than mono-cropping system.

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Evaluation of seed yield and competition indices of corn (*Zea mays* L.) intercropped with different bean (*Phaseolus* spp.) cultivars

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Keywords: Aggressivity, Grain yield, Land equivalent ratio, Relative crowding coefficient

Introduction

Intercropping of legumes with cereals is one of the old practical multi-cropping techniques to increase crop yields and to improve land use efficiency (Thobatsi, 2009; Poggio, 2005). Hence, competition among mixtures is thought to be the major aspect affecting yield as compared with solitary cropping. Species selection, seeding ratios and competition capability within mixtures can affect the growth and yield of the species used in intercropping systems (Agegnehu et al., 2006; Banik et al., 2006). Some competition indices such as land equivalent ratio, aggressivity, relative crowding coefficient and competitive ratio have been proposed to describe competition and economic advantages of intercropping systems (Dhima et al., 2007). Therefore, the objective of this study was to compare the productivity of corn intercropped with different bean cultivars compared with sole cultures and to examine the competitive relationships of corn and bean cultivars in intercrops.

Materials and Methods

A field experiment was carried out in randomized complete block design with three replicates at the Sari Agricultural Sciences and Natural Resources University (latitude 36°N, longitude 53°E and altitude of 25m below sea level, GARMIN, GPSmap) during 2010. The experimental treatments were mono-cropping of corn, white bean, bush bean, red bean, pinto bean, and intercropping of corn with bean types in 50:50 planting ratio. The plot size was 3.0 m × 6.0 m (providing 5.3 plants/ m^2 for solitary treatment). Experimental plots of pure corn and mixed crops received the 300 kg/ha of urea, 100 kg/ha of potassium sulfate and triple super phosphate and the pure bean cultivars plots received 100 kg/ha of urea, potassium sulfate and triple super phosphate all applied at planting. The experiment was planted on May 1 in 2010 and was harvested on September 20 in 2010. Grain yield was determined by harvesting each crop separately from the mixtures in the two middle rows. The land equivalent ratio (LER), aggressivity (A), relative crowding coefficient (K) and competitive ratio (CR) were calculated by using the following formula:

$$LER= Y_c/Y_{cc}+ Y_b/Y_{bb}$$

where Y_{cc} and Y_{bb} are the yields of corn and bean cultivars as sole crops, respectively and Y_c and Y_b are the yields of corn and bean cultivars as intercrops, respectively;

$$K_{corn}=(Y_c \times Z_b)/(Y_{cc} - Y_c) \times Z_c \text{ and } K_{bean} =(Y_b \times Z_c)/(Y_{bb}-Y_b) \times Z_b$$

where Z_c and Z_b are the proportions of corn and bean cultivars in the mixture, respectively;

$$A_{corn}= (Y_c/Y_{cc} \times Z_c)-(Y_b/Y_{bb} \times Z_b) \text{ and } A_{bean}= (Y_b/Y_{bb} \times Z_b)-(Y_c/Y_{cc} \times Z_c);$$

$$CR_{corn}= (LER_c/LER_b) \times (Z_b/Z_c) \text{ and } CR_{bean}= (LER_b/LER_c) \times (Z_c/Z_b)$$

For statistical analysis, analysis of variance (ANOVA) and least significant difference (LSD) were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC, USA).

Results and Discussion

In the present experiment, intercropping the corn-bush bean and corn-pinto bean had the highest economical yields (5718.4 and 5687.1 kg/ha, respectively) and land equivalent ratios (LER=1.13 and 1.21, respectively). Among different crops, the highest relative crowding coefficients were related to red bean (K= 1.85), pinto bean (K= 2.41) and sword bean (K= 2.80). The most aggressivity value, however, belonged to pinto bean intercropped

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with corn (A= -0.02). Also, both the red bean and pinto bean (CR=0.75 and CR=0.98, respectively) had the maximum competitive ratios. Furthermore, the most corn relative crowding coefficient (K=1.15) belonged to corn and sword bean intercropping. The maximum corn aggressivity value was observed in corn intercropped with white bean (A=+0.60) and bush bean (A=+0.69). In conclusion, according to competition indices, intercropping of 50% corn +50 % red bean and pinto bean plants were superior as compared with other combinations.

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Effect of application of bio-fertilizers and organic manure on yield and morphological index of roselle (*Hibiscus sabdariffa* L.)

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Keywords: Biological phosphorus, Biological yield, Biosulfur, Economical yield, Nitroxin

Introduction

Since excessive use of fertilizers causes changes in soil pH and salt augmentation, it reduces soil fertility and bacterial activity (Pokorna, 1984), while use of manure increases soil microorganisms activity and results in the production of carbon dioxide, ammonium nitrate and simple acids in the soil (Patel & Patel, 1988). Bio-fertilizers that are beneficial microorganisms cause nitrogen fixation, release of phosphate ions, potassium, iron, etc., and will help the plants in the absorption of elements (Wu et al., 2005). Since the production process of medicinal plants is going to improve the quality, quantity and safety of their active substances, healthy nutrition plants by using bio-fertilizer and organic manure, are more compatible with this process. In this study, the effects of the application of organic fertilizers on yield and morphological index of roselle was studied.

Materials and Methods

The experiment was conducted as split plot based on a randomized complete block design with three replications at the Agricultural Research Center of Zabol University, Iran during the growing season of 2011-2012. The treatments included three manure levels; 0, 10 and 20 $t.h^{-1}$ and eight levels of bio-fertilizer such as control, nitroxin, bio-sulfur, biological phosphorus, nitroxin+ bio-sulfur, nitroxin+ biological phosphorus, bio-sulfur+ biological phosphorus, nitroxin+ bio-sulfur+ biological phosphorus. Different levels of manure and bio-fertilizer inoculations were considered as main plots and subplots, respectively. Adding manure to the soil and seeds of roselle inoculation treatment was performed with bio-fertilizers before planting. Traits including plant height, stem diameter, number of lateral branches, number of fruits, economical yield, biological yield, harvest index and morphological index of roselle were measured at the end of the growing season (November) when the fruits were at physiological maturity. The former measurements were statistically analyzed using SAS program version 1.1. Means were compared by using Duncan multiple range test at 0.05 level.

Results and Discussion

Based on the results, levels of manure and bio-fertilizers and their interactions on biological traits were significant. The results showed that 10 $t.h^{-1}$ manure+ nitroxin consumption increased plant height and stem diameter by 24 percent compared with control (168.5 vs. 135.4 cm and 13.3 vs. 10.7 mm, respectively). The same results have been reported for fennel by Azzaz et al. (2009). 10 $t.h^{-1}$ manure+ nitroxin treatment increased the number of fruits by 111 percent compared with the control treatment (36 vs. 17 fruits per square meter). The highest number of lateral branches (8.3) was obtained in 10 $t.h^{-1}$ manure+ nitroxin treatment that shows an increase of 66 percent when compared with the control treatment (5.1). The highest economical yield (1.29$t.ha^{-1}$) was shown in 10 $t.h^{-1}$ manure+ nitroxin treatment that indicates more than 300 percent increase in economical yield compared with the control treatment (0.3$t.ha^{-1}$). The highest Biological yield (17.4$t.ha^{-1}$) and harvest index (7.6 %) were obtained in 10 $t.h^{-1}$ manure+ nitroxin treatment. Farm yard manure is the most important source of energy and nutrients through improved physical, chemical and biological soil properties to increase the yield (Fallahi et al., 2009). Also use of bio-fertilizer includes nitroxin that can produce vitamins, drivers of growth and root growth can accelerate the absorption of water and nutrients, and improve the number of branches of flowers, fruit and their biological yield. These features increase the economical yield which is positively related to growth. These results are in agreement with the results of researchers (Sanches Govin et al., 2005). The results showed that the combined use of manure and bio-fertilizer, rather than taking them individually plays an

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effective role in increasing economic performance and growth characteristics of roselle.

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Evaluating soybean (*Glycine max* L. Merrill) growth parameters in response to plant growth promoting fungi under Mazandaran's climate conditions

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Keywords: Mycorrhiza, Phosphorus, Plant growth-promoting fungi, Soybean, *Trichoderma*

Introduction

In recent years, integrated farming systems have been developed based on reduced inputs of chemical fertilizers. Many researchers believe that using fungal bio-fertilizers is an environmentally-friendly approach, as it can help to enhance the crop growth and promote organic farming production (Bulluck *et al*., 2002; Chacon *et al*., 2007; Leck *et al*., 2008; Martinez-Medina *et al*., 2011). The network of arbuscular mycorrhizal fungi's (AMF) mycelium connects to the roots and increases the soil volume, which can be more efficient in phosphate uptake than a non-mycorrhizal root (Yedidia *et al*., 2004; Meghvansi *et al*., 2008; Neumnn and George, 2009).

Fungal genus *Trichoderma* (T) is cosmopolitan in soils and the ecological adaptability of *Trichoderma* species is evident by its widespread distribution including under different environmental conditions and on various substrates (Zheng and Shetty., 2000; Harman, 2005; Yadav *et al*., 2009; Powlson *et al*., 2011; Medine *et al*., 2011). In addition, a synergistic effect of some saprophytic fungi on AMF colonization has been confirmed (Gosling *et al*., 2006; Meghvansi *et al*., 2008; Ene and Alexandru, 2008; Martinez and Johnson, 2010; Martinez-Medina *et al*., 2011; Hemashenpagam *et al*., 2011). Meghvansi *et al.* (2008) reported that some *Trichoderma* strains may influence AMF spore germination and activity.

In recent years, increase in soybean cultivation in Iran has improved the rural economy and socio-economic status of Iranian farmers. Therefore, this study was designed to evaluate the response of soybean seedling growth to inoculation of AMF (both *G. intraradices* and *G. mosseae*) and the beneficial fungus of *Trichoderma harzianum* under conventional and low input phosphate conditions.

Materials and Methods

A field study was conducted at the research farm of the Genetics and Agricultural Biotechnology Institute of Tabarestan, the Sari Agricultural Sciences and Natural Resources University (SANRU) during the 2011-2012 growing season. This site is located at latitude 36°N, longitude 53°E and altitude of 25m below sea level (GARMIN, GPSmap). A factorial experiment was used based on a randomized complete block design with three replicates. Treatments were two factors of fungi inoculation with six levels (*T. harzianum* and AMF genus Glumus: *G. mosseae*, *G. intraradices*, and co-inoculation of *T. harzianum* + *G. mosseae*, *T. harzianum* + *G. intraradices* and non-inoculated control) and phosphorus amounts at three levels (conventional P: 140 kg ha^{-1} and reduced levels of $P_{0\%}$: 0 and $P_{50\%}$: 70 $kgha^{-1)}$. The data were analyzed by using GLM procedures included in the SAS statistical package version 9.1.

Results and Discussion

Results of combined analysis showed that the inoculation of *T. harzianum* and *G. mosseae* increased SPAD value up to 17% and 16% at the reduced (70 $kg.ha^{-1}$) and the conventional (140 $kg.ha^{-1}$) phosphorus dosages as compared with the control, respectively. Using these inoculants plus either reduced or conventional phosphorous dosages had a more remarkable effect on chlorophyll *a* than those plots without phosphorous application. Co-inoculation of *Trichoderma* and *mycorrhizae* fungi in the reduced phosphorous dosage did not have a significant effect on the plant dry weight and chlorophyll *a* content than the conventional phosphorous dosage. In the present study, the effectiveness of these fungi on soybean growth was remarkable in the reduced phosphorous

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dosage (70 kg ha^{-1}) than the non-application of phosphorous. However, these fungi did not show any efficiency in the conventional phosphorous dosage.

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نشریه بوم شناسی کشاورزی
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Yield gap analysis of Chickpea (*Cicer arietinum* L.) under semi-arid conditions: a simulation study

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Keywords: Actual yield, Benchmarking, Modelling, Potential yield

Introduction

Chickpea is the most important legume in West Asia and North Africa especially under rainfed conditions (Silim et al., 1993). Chickpea yield is at low levels in major producing countries (Millan et al., 2006), indicating a need to increase crop yield via crop genetic improvement and enhanced crop management. Genetic and management constraints can be analyzed by using crop simulation models. Crop models are very useful tools to evaluate the potential yield and environment constraints, genetics and management factors (Lobell et al., 2009). The yield gap (Yg) is the difference between Yp (irrigated crops), or Yw (rainfed crops) and actual yields (Ya). Any improvement of crop management practices requires that the potential yield and its difference with actual yield be determined and ultimately evaluate the determinants of yield gap (Lobell et al., 2009). Assessment of potential yield and yield gaps can help in identifying the yield limiting factors and it helps us develop suitable strategies to improve the productivity of any crop (Naab et al., 2004). In this study, yield potential and yield gap across the major chickpea-growing regions of the Khorasan Razavi province in Iran were quantified by using the SSM-chickpea model and actual yield and its variability within farmers' fields were evaluated. This study tries to determine the potential yield capacity and chickpea yield gap.

Materials and Methods

For model parameterization, a field experiment was conducted in a randomized complete design with 4 replications in the research field of the Ferdowsi University of Mashhad. The Chickpea cultivar ILC482 was used in this experiment.

The Chickpea model of Soltani and Sinclair (2011) was used in this study. The simulations started from the sowing date and ended at maturity. Finally, the simulated results of LAI, aboveground biomass and grain yield were examined by the root mean square error (RMSE). RMSE was calculated as shown in Eq.1 (Wallach & Goffinet, 1987):

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(Pi - Oi)^2}{n}} \quad (1)$$

Where Oi is the observed data, Pi is the simulated data and n is the total number of observations.

The study was performed at nine regions in the Khorasan Razavi province located in the Northeast of Iran, under two water conditions, i.e. potential and water limited. Irrigated and rainfed actual yields were based on statistical data at regional level for the period of 2002–2012, which were collected from the Agricultural Jihad of the Khorasan Razavi province (Anonymous, 2012). These yields were averaged out for calculating the actual yield for each region for which simulations were carried out.

Yield gaps

Yield gaps were defined as:

YGMM= Simulated potential yield - simulated water limited yield

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YGMI= Simulated potential yield - irrigated actual yield
YGMR= Simulated water limited yield - rainfed actual yield

Results and Discussion

The results suggest that the Khorasan Razavi province with low actual Chickpea yields has a high probability of large yield gaps and large potentials to increase current yields. The model simulations showed that the average potential yield of Chickpea for the regions was 2251 kg ha^{-1}, while the water limited yield was 1026 kg ha^{-1} indicating a 54% reduction in yield due to adverse soil moisture conditions. The average irrigated and rainfed actual yield were also 64% and 79% less than the simulated potential and water limited yields, respectively. Across all study locations, the potential yields were less variable than water limited and actual yields, and were correlated with solar radiation during the season (R^2= 0.63, $P<0.05$). Generally, YGMI and YGMM showed an increasing trend from the North (including Neishabur, Mashhad, Quchan and Daregaz regions) to the South of this province (Torbat- Jam and Gonabad). In comparison with other yield gaps, the quantity of YGMR was very low because both limited simulated water and average rainfed actual yields were low in these regions. Furthermore, YGMR was more or less unaffected by the amount of rainfall received in these regions.

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نشریه بوم شناسی کشاورزی
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Effect of different irrigation regimes and nitrogen levels on fruit production, oil quality, water use efficiency and agronomic nitrogen use efficiency of pumpkin (*Cucurbita pepo* L.)

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Keywords: Linoleic acid, Medicinal plants, Oleic acid, Plant nutrition, Water management

Introduction

Oilseed pumpkin (*Cucurbita pepo* L.) is a medicinal plant, and it seeds as well as some other parts of it are being utilized in treating an array of human diseases in Iran. Plant yield and its components are considered in plant production and the effect of water stress depends on plant type, harvested product, irrigation intervals and time of stress (Ali & Shui, 2009). Drought is one of the most common and important environmental stresses that may limit agricultural production worldwide. Despite the negative effects on yield, drought stress can enhance other stresses, to the especially nutrient deficit stress in plant (Kumbhar et al., 2007). Among food elements, nitrogen plays a very crucial role in the production power of crops and its deficit is one of the most important limiting factors to crop yield. Nutrient absorption is reduced under water deficiency conditions which causes proper proportion generation between water supply and fertilizer consumption that can reduce excessive consumption of nitrogen and this does not have any positive effect on seed yield in such conditions. Considering the plant's significance in the health products industry on the one hand, and the countrywide drought stresses and a lack of information on mineral nutrition of the oil seed pumpkin on the other hand, the aim of the present paper was to study the impact of different irrigation regimes and nitrogen levels on percentage of seed fatty acids, yield, water and nitrogen use efficiency of pumpkin.

Materials and Methods

Field experiment was carried out as split plot based on complete randomized block design with three replications at the Bu-Ali Sina University in the growing season of 2013. Irrigation (320, 420, 600 and 900 mm ha^{-1}) was set as the main plots and nitrogen fertilizer (0, 130, 260, 390 and 520 kg urea ha^{-1}) was allocated in subplots. A furrow irrigation system was used for crop irrigation and irrigation treatments were applied after full establishment of the plants. Nitrogen fertilizer was applied at three stages of planting, flowering and fruiting. The evaluation traits included oleic acid, linoleic acid, fruit and seed yield, water use efficiency (WUE) and agronomic nitrogen use efficiency (ANUE). After physiological maturity, 1 m^2 from each experimental unit was harvested to determine fruit and seed yields. Seed yield was calculated with 14% moisture at the harvest time. Seed fatty acids were determined using gas chromatography (GC). The WUE (kg mm^{-1} water) was calculated for fruit and seed yield. Agronomic nitrogen efficiency (ANE) was calculated as the ratio of (Grain yield F – Grain yield control) to N applied, where F equals fertilizer treatments (El-Gizawy, 2009). SAS procedures and programs were used for analysis of variance (ANOVA) calculations. The significance of the treatment's effect was determined using F-test and to determine the significance of the difference between the means of the two treatments. Least significant differences (LSD) were estimated at the 5% probability level.

Results and Discussion

Our findings indicated that the effects of irrigation and nitrogen on all traits were significant ($p<0.01$). Also, interaction of irrigation × nitrogen had a significant effect on all traits except WUE and ANUE. The highest values of linoleic fatty acid, fruit yield, seed yield and agronomic nitrogen use efficiency were achieved with the consumption of 600 mm water ha^{-1} and application of 390 kg urea ha^{-1}. The lowest fruit and seed yield were obtained with the consumption of 320 mm water ha^{-1} and non-application of urea. The highest water use

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efficiency for fruit and seed yield; 56.61 and 1.10 kg mm^{-1}, were obtained at 600 mm irrigation water ha^{-1}. Between nitrogen levels, maximum and minimum WUE for fruit and seed yield, were achieved at treatments of 390 and 0 kg urea ha^{-1}, respectively. Also, maximum agronomic nitrogen efficiency belonged to 390 kg urea. It seems that water and nitrogen limitation during the growth period of the plants caused a decrease in fruit number per plant, seed number in fruit and seed weight through interruption in fertilization and reduction in plant growth period. The WUE was obviously reduced due to an increase in water consumption at irrigation level of 900, and a decrease in yield at irrigation level of 320 mm water ha^{-1}, respectively. With increasing N rates up to 390 kg U ha^{-1}, WUE increased due to an increase in fruit and seed yield. Generally, based on the results of this research and by considering water and nitrogen use efficiency, irrigation of pumpkin plants with 600 mm water ha^{-1} and consumption of 390 kg urea ha^{-1} are identified as suitable treatments.

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The study of environmental impact quotient (EIQ) of pesticides used in wheat and barley farms in Mashhad

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Keywords: Consumer and leaching component, Ecological component, Farm worker component, Fungicide, Herbicide, Pesticide

Introduction

The environmental impact quotient (EIQ) developed by Kovach et al. (1992) is used an effort to fill an important gap; i.e. the need to provide farmers and others with easy-to-use information about the adverse effects of pesticides. It represents a method for calculating the environmental impacts of pesticides, and the values obtained from these calculations can be used to compare different pesticides and pest management programs with each other to ultimately determine which program or pesticide is likely to have the lowest environmental impact.

The EIQ value for a particular active ingredient is calculated according to a formula that includes parameters for toxicity (dermal, chronic, bird, bee, fish, and beneficial arthropod), soil half-life, systemicity, leaching potential, and plant surface half-life. Each of these parameters is given a rating of 1, 3 or 5 to reflect its potential of causing harm. Six of these ratings are based on measured or known properties and the other five are based on judgments according to their potentially low, moderate or severe impact. Since the EIQ value is mainly a hazard indicator, additional calculations are required to obtain an indication of the pesticide risk. To account for exposure, an equation called the Field Use EIQ has been developed. This rating is calculated by multiplying the EIQ value for a specific chemical from the tables by the percent active ingredient in the formulation and its dosage rate used per hectare (usually in liters or kilograms of the formulated product).

EIQ is used in different studies to compare the environmental effects of different pesticides and/or different production systems (Avila et al., 2011; Doris et al., 2011; Gallivan et al., 2001; Macharia et al., 2009). The aim of this study was to evaluate management strategies in using pesticides in wheat and barley farms in the city of Mashhad located in the Khorasan Razavi province in Iran.

Materials and Methods

Data related to pesticides (insecticides, herbicides and fungicides) used in wheat and barley in the city of Mashhad located in the Khorasan Razavi province were gathered through face to face filling questionnaires by the users. The indices measured in this study include Environmental Impact Quotient (EIQ) and its components (farm worker, consumer, leaching and ecology) and Field Use Rate - EIQ (FUR-EIQ). EIQ is calculated based on the work of Kovach et al. (1992). The formula is:

$$EIQ=\{C[(DT\times5)+(DT\times P)]+[(C\times((S+P)/2)\times SY)+(L)]+[(F\times R)+(D\times((S+P)/2)\times3)+(Z\times P\times3)+(B\times P\times5)]\}/3$$

In this formula: DT: Dermal Toxicity; C: long term health effects; SY: mode of action; F: fish toxicity; L: leaching potential; R: surface runoff potential; D: bird toxicity; S: soil residue half-life; Z: bee toxicity; B: beneficial arthropod toxicity; P: plant surface half-life.

EIQ field use rating was calculated by multiplying the EIQ value for a specific chemical from the table by the percent active ingredient in the formulation and the rate of its dosage used per hectare:

EIQ Field Use Rating = EIQ × % active ingredient × Rate

Results and Discussion

A large degree of variation was observed in the amount of EIQ and its components. The results showed that

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in wheat cultivation, Carbendazim had the most effect on the farm worker component and Diazinon had the least effect on this component. The most risk of the consumer and leaching component in wheat fields were shown in fungicides. The fungicide Carbendazim had the most effect on the consumer and leaching component. The least effect on consumer and leaching component were obtained in Deltamethrin. Replacement of Carbendazim with Iprodione, Thiram and Carboxin which are used for disinfection of seeds will improve the consumer and leaching component.

In terms of ecology, the Diazinon component had the most dangerous environmental risk in wheat fields. In this section, pesticides were more importance than fungicides. The use of Deltamethrin to control *Eurygaster integriceps* in wheat, is not recommended and it should be replaced by Trichlorfon because of the risk of ecological destruction. Such ecological destruction is not much different among the various fungicides.

The maximum and minimum amount of EIQ among the pesticides used in wheat farms in Mashhad were obtained in Diazinon and Deltamethrin, respectively. 2, 4- D and Fenoxaprop ethyl had the lowest and highest EIQ indices among the herbicides used in wheat farms. The lowest FUR-EIQ index in wheat fields was observed for the application of herbicides. The maximum value of this index was shown in the usage of fungicides. The highest value of the EIQ-FUR related to the Carbendazim fungicide. Due to low consumption of Detamethrin, it had the small value of this index. Considering EIQ-FUR, the use of Deltamethrin is considered to be more appropriate than Trichlorfon. Use of Iprdion for the disinfection of seeds, and Tribenuron-methyl for the elimination of weeds in wheat fields are the best choices since they had the lowest FUR-EIQ index.

In barley cultivation, Carbendazim and Diazinon had the most and the least effects on farm worker component, respectively. In the consumer and leaching component, the most and the least effects were to the observed in Carbendazim as a fungicide and in the Deltamethrin as an insecticide, respectively. In terms of ecology, the Diazinon and Tribenuron-methyl components had the most and the least effect respectively. In this respect, the fungicides used for seed treatment did not show much difference.

The maximum EIQ among the pesticides used in barley fields in Mashhad was observed in Carbendazim. Iprdion used for the disinfection of seeds had the lowest EIQ. Considering the herbicides 2, 4- D and Fenoxaprop ethyl had the lowest and highest values of EIQ, respectively.

The evaluation of FUR-EIQ in barley fields in Mashhad showed that cyproconazole was the best fungicide used for seed disinfection and it is a good alternative for Carbendazim. Carbendazim was assessed as the most dangerous environmental pesticide. Considering the pesticides dosage and FUR-EIQ, Deltamethrin was found to be a suitable insecticide against *Eurygaster integriceps* and Tribenuron-methyl was found to be a less dangerous herbicide.

The results showed that in wheat and barley farms in Mashhad, the biggest danger in farm worker consumer and leaching components was Carbendazim fungicide. Diazinon pesticide had the lowest risk in the farm laborer component. The lowest risk in consumer and leaching component related to the Deltamethrin pesticide. In terms of the ecology components, the most environmental degradation was created by the Diazinon pesticide. Carbendazim is the most dangerous pesticide. Based on the measurements of FUR-EIQ, the fungicides had the highest risk and the herbicides had the lowest risk.

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نشریه بوم شناسی کشاورزی
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Effects of nitrogen, zinc and water salinity levels on yield, quality indices and nutrient uptake in canola (*Brassica napus* L.) Okapi variety

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Keywords: Cl, Glucosinolate, Na, Oil percentage

Introduction

In general, canola is a salt sensitive crop especially at germination and seedling establishment stages. Hence, saline soil or saline water can affect canola yield potential through salt stress induction (Francois, 1994; Hashemi et al., 2010). Soil and water salinity are two of the major problems of agriculture in the arid and semi-arid regions of the world, especially in Iran (Ashraf & McNeilly, 2004; Rameeh et al., 2004). On the other hand, reasonable canola production depends on nutrient supply and any increase in quantitative and qualitative yields is highly correlated with the availability of nutrients, especially nitrogen and Zinc (Chamorro et al., 2002; Bahmanyar & Kazemi Poshtmasari, 2010).

Since Zn deficiency is one of the most widespread micronutrient deficiencies in Iran as a result of calcareous soil, it is important to apply zinc fertilizers to increase crop yield and improve crop quality in such conditions (Hacisalihoglu & Kochian, 2003; Khoshgoftar et al., 2006). On the other hand, N and Zn fertilization differ from normal to saline soils. Therefore, the objective of this study was to investigate the effects of different rates of N and Zn on quantitative and qualitative traits of canola irrigated with saline and ultra saline water.

Materials and Methods

In order to investigate the effects of nitrogen and zinc levels and water salinity on yield quality characteristics and nutrient uptake in canola (*Brassica napus* L. cv. Okapi), a field experiment was conducted in the Agriculture Research Center of East Azerbaijan, Iran from 2009 to 2010. The experiment was arranged by using a completely randomized block design based on factorial fashion with three replications. The experimental treatments included different nitrogen levels (0, 50 and 100 $kg.ha^{-1}$), different zinc levels (0, 5 and 10 $kg.ha^{-1}$) and different irrigation salinity levels (8 and 16 $dS.m^{-1}$), respectively.

Each plot was 8 m long and consisted of six rows, 0.5 m apart. Between the blocks and the plots, a 1 m wide alley was kept to eliminate all influences of the treatments on each other. Full amounts of potassium and phosphorus fertilizers and one third of the N fertilizer were applied at seed sowing time. The rest of the N fertilizers were used at the rosette and flowering stages.

At the physiological maturity stage, seed yield and yield components in each plot were estimated by harvesting 8 plants at random. The oil percentage and glucosinolate content were measured using succulent and HPLC methods, respectively. In addition, N, phosphorous, potassium, calcium, magnesium, sodium and chlorine were measured in the canola seeds.

The results were subjected to statistical analysis using the SAS software. The analysis of variance (ANOVA) was carried out as a combined analysis. Mean values were compared by using Duncan's multiple range test.

Results and Discussion

Based on the results, nitrogen and zinc applications showed a significant influence on increasing plant height, number of pods per plant and seed yield of canola. However, such traits of canola decreased as a result of increasing water salinity levels (from 8 to 16 $dS.m^{-1}$). Irrigation salinity at rate of 16 $dS.m^{-1}$ showed a significant effect on increasing glucosinolate percentage in seeds up to 9.5% (from 27.49% to 30.11%).

Glucosinolate which is a toxic organic component is considered as an undesirable qualitative trait in canola seeds (Francois 1994; Kim et al. 2002; Bybordi and Malakouti 2003), although the mechanism by which salinity affects glucosinolate content is not clearly known. It seems that water or temperature stresses during crop growth

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cause glucosinolate accumulation in seeds and consequently affect meal quality. Soil or water salinity is not an exception and can decrease oil or meal quality during the process.

Increasing salinity levels caused a decrease in N, P, K and Ca uptake and caused a significant enhancement of Na and Cl accumulation in the seeds. Totally, it seems that nutrient supply, especially nitrogen, can be considered as an effective approach to diminish the negative effects of salinity stress.

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