



## Effects of irrigation intervals and nitrogen fertilizer levels on vegetative and reproductive yields of basil (*Ocimum basilicum* L.) under Birjand conditions

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### Abstract

In order to study the effect of irrigation and nitrogen fertilizer levels on yield of basil, an experiment was conducted as split plot based on randomized complete block design with three replications in Birjand (Moud region) in 2010. Main plot factor was two irrigation levels (7 and 14 days interval) and nitrogen fertilizer (as urea) was considered as sub plot factor in four levels (0, 50, 100 and 150 kg.ha<sup>-1</sup>). Results indicated that treatments affected on majority studied traits of basil. Seed yield was increased in 7 days irrigation interval by 18.4% in compared to 14 days irrigation interval. The highest seed yield was achieved in 100 and 150 kg.ha<sup>-1</sup> nitrogen fertilizers that were higher than control by 29.4 and 36.1%. Total biomass was 153.3 g.m<sup>-2</sup> in 7 days irrigation interval in compared to 133.8 g.m<sup>-2</sup> in 14 days irrigation treatment. The greatest total biomass was show in 150 kg.ha<sup>-1</sup> nitrogen fertilizer and the lowest was resulted from 0 and 50 kg ha<sup>-1</sup> nitrogen fertilizer levels. Ear number per plant was significantly affected by nitrogen fertilizer levels, but irrigation and fertilizer treatments had no significant effects on seed weight of basil. Increasing of irrigation intervals decreased the leaf yield of basil by 21.3%. Increasing of nitrogen application increased leaf and vegetative yields on basil.

**Keywords:** Leaf yield, Medicinal plant, Nutrition

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## Effects of biological fertilizer and vermicompost on vegetative yield and essential oil of basil (*Ocimum basilicum* L.) under Mashhad climatic conditions

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### Abstract

In order to study the effects of vermicompost and biological fertilizers on vegetative yield and essential oil of basil (*Ocimum basilicum* L.), an experiment was conducted based on a complete randomized block design with nine treatments and three replications at Mashhad during growing season of 2009-2010. The treatments were: 1) vermicompost, 2) Nitroxin (included: *Azotobacter* sp. and *Azospirillum* sp.), 3) biophosphorus (Included: *Pseudomonas* sp and *Bacillus* sp), 4) Vermicompost+ Nitroxin, 5) vermicompost+ biophosphorus, 6) Nitroxin+ biophosphorus, 7) vermicompost+ Nitroxin+ biophosphorus, 8) chemical fertilizer (N.P.K), 9) control (no fertilizer). Two harvests were cut at similar phenological stage during growing season. The results showed that at both cutting of basil, biological fertilizer combined with vermicompost were better compared to chemical fertilizer and control. In the first harvest, the highest fresh (11377.8 kg.ha<sup>-1</sup>) and dry yields (1895.6 kg.ha<sup>-1</sup>) obtained in vermicompost+ Nitroxin+ Biophosphorus treatment. Also, vermicompost+ Nitroxin and vermicompost+ biophosphorus produced the highest leaf dry yield (1164.7 and 1166.8 kg.ha<sup>-1</sup> respectively). In second cutting, the highest fresh yield (11333.3 kg.ha<sup>-1</sup>) obtained in vermicompost+ Nitroxin+ biophosphorus and the highest dry yield (2017.8 kg.ha<sup>-1</sup>) and leaf dry weight (1103.4 kg.ha<sup>-1</sup>) obtained in vermicompost+ Nitroxin treatments. In both cuttings, the highest essential oil percentage obtained in control. The results of this study showed that vermicompost and bio fertilizers alone or in combination had no effect on essential oil but increased vegetative yield.

**Keywords:** Biophosphorus, Dry yield, Nitroxin, Essential oil percentage, Sustainable agriculture

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## Effects of various organic and chemical fertilizers on growth indices of basil (*Ocimum basilicum* L.)

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### Abstract

In order to develop the high intensive agriculture, more chemical fertilizers are applied to the soil that resulting in soil degradation and environment deterioration. Application of organic manure is an important approach for maintaining and improving the soil fertility and increasing fertilizer use efficiency. Therefore, in order to evaluate the effect of organic manures and chemical fertilizer on growth indices and biological yield of basil (*Ocimum basilicum* L.), an experiment was conducted at Research Station, Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, during growing season of 2008-2009. A complete randomized block design with six treatments and three replications was used. The treatments were: cow manure, sheep manure, chicken manure, vermicompost, chemical NPK fertilizers and control (no fertilizer). The results showed that the use of organic fertilizers significantly increased seed and biological yield of basil compared with chemical fertilizer and control. The maximum and the minimum dry weights were observed at 105 days after planting, in sheep and cow manures, respectively. Gradually during the period of plant growth and development to reproduction phase percent of stem decreased and dry weight of inflorescence increased. The highest and the lowest leaf area index were observed at 90 days after planting, in cow manure and control, respectively, and then decreased in all treatments. The maximum crop growth rate in most of treatments at 90 days after planting was obtained, except the control which plant growth rate was lowest. Net assimilation rate (NAR) in most treatments increased until 75 days after planting and then declined. While the highest and the lowest NAR were observed at 75 days after planting in chicken manure and chemical treatment, respectively.

**Keywords:** Growth trend, Net assimilation rate, Organic fertilizers, Relative growth

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## Effects of organic and chemical fertilizer rates on nitrogen efficiency indices of isabgol (*Plantago ovata* Forsk.)

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### Abstract

Enhancing nitrogen use efficiency is one of the most important strategies for improving productivity in agriculture and reducing risk of environmental pollutions in sustainable agriculture. In order to study the effects of different levels of organic manure and chemical fertilizer on nitrogen uptake efficiency (NupE), nitrogen utilization efficiency (NutE) and nitrogen use efficiency (NUE) of isabgol (*Plantago ovata* Forsk.), a field experiment was performed based on a randomized complete block design with three replications at the Agricultural Research Station, College of Agriculture, Ferdowsi University of Mashhad, during growing season of 2011-2012. Treatments included three levels of nitrogen fertilizer (25, 50 and 75 kg.ha<sup>-1</sup>), three levels of cow manure (5, 10 and 15 t.ha<sup>-1</sup>), three levels of vermicompost (2, 4 and 6 t.ha<sup>-1</sup>) and control. Seed yield, biological yield and nitrogen content of biomass of isabgol were measured and then NupE, NutE and NUE based on seed yield and biological yield were calculated accordingly. The results showed that the different fertilizers had significant effects on all studied traits of isabgol. The highest seed yield and biological yield of isabgol were observed in 6 t.ha<sup>-1</sup> vermicompost with 98.2 and 54.8 g.m<sup>-2</sup>, respectively. By increasing fertilizer rate, nitrogen percentage and content of biomass were increased. The maximum NutE and NupE were achieved in control plots. Also, the highest and the lowest NupE of isabgol were obtained in 5 t.ha<sup>-1</sup> cow manure and 75 kg.ha<sup>-1</sup> N with 8.9 and 7.0 gN per g<sup>-1</sup> Ns, respectively. Organic manures improved NupE and NUE more than chemical fertilizer. So, organic manure application enhanced yield, NupE and NUE of isabgol compared to chemical fertilizer. So, it seems that organic input application could be considered as a sustainable approach for improving growth and yield of medicinal plants such as isabgol in agroecosystems that will increase nitrogen efficiency and reduce environmental pollutions due to slow release of nutrients.

**Keywords:** Medicinal plant, Nitrogen uptake ratio, Nitrogen use, Sustainable agriculture

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## 30 Years of agronomic research in Iran: I. Evaluation of trends, gaps and setting priorities

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### Abstract

During the last few decades scientific researches in different fields of agricultural sciences have been grown drastically. However, there is no published study, if any, on structural analysis of the national agricultural research system of Iran and setting priorities for the future. In the present study 2361 scientific papers published during the three decades in the domestic journals were surveyed to analyze the research structure, gaps and priorities. The papers were categorized based on crop species, temporal and spatial scale of experiments, subject and type of the researches and the results were subjected to the statistical analysis. Number of published papers followed a sigmoid growth further with a long lag period of 10 years and leveled off at 240 papers per year. Cereals and industrial crops had the highest frequency in the surveyed papers while forage, medicinal and pulse crops were the next abundant species, respectively. Annual experiments (83% of total papers) were the most frequent for all crops however, less than 10% of papers were the result of biannual experiments (> 2 years). In addition frequency of experiments conducted in research stations and protected environments (laboratory and greenhouse) were 58 and 30%, respectively indicating the small contribution of studies at regional/national scale. Management practices were the most prevalent topics among the papers (35% of total). However, sustainability of agroecosystems, agricultural climatology and crop modeling were less frequent subjects (<5% of total) and the other subjects covered 5-10% of total papers. Such a research gap was almost the same for all crop species. Overall, 64% of total papers were related to applied studies while contribution of strategic and basic studies was 10 and 1%, respectively. Based on the results it was concluded that despite quantitative growth of the published papers, national agricultural research system is not highly efficient. While applied researches and testing agronomic practices in short duration studies are widespread, long term strategic studies on the sustainability of production systems and conservation of resource base, impacts of climate change on national food security and protection of agrobiodiversity at national/regional scales are almost overlooked.

**Keywords:** National agricultural research system, Research priorities, Research scale, Research subject

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## 30 Years of agronomic research in Iran: II. Evaluation of research ethics

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### Abstract

During the last three decades publication of papers in different fields of agronomic sciences have been increased drastically in Iran. However, there is growing warnings about research misconducts. To get a quantitative insight into the commitment to the research ethics, 1269 papers published during the last 3 decades in the refereed domestic journals were surveyed using human tools. The frequency of different type of misconducts were calculated and compared statistically. The results indicated that overlap in title, the target crop, experimental factors (treatments) and the measured traits was occurred with frequency of 26% among the surveyed papers which was categorized as unauthorized adoption of ideas. Falsification and fabrication was distinguished based on the coefficient of variation (CV), probability of type I error and discrepancy between the results of ANOVA and regression analysis. This type of misconducts had frequency of 6%. However, plagiarism had a significantly higher frequency and was detected in up to 12% of the papers. The frequency of all type of misconducts was significantly higher in the papers where the corresponding authors were students compared to the papers published by scientific staffs of universities/research institutes. Overall research misconducts were distinguished in 16% of papers and were most frequent in the 1380 decade compared to 60's and 70's. It seems that lack of awareness about the principles of research ethics is the main cause of the prevalence of the observed misconducts. Therefore, development of a national code of ethics is of high priority for the national agricultural research system in the country.

**Keywords:** Agronomic sciences, Plagiarism, Professional ethics, Research ethics

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## Effect of green manure crops and nitrogen fertilizer levels on dry matter remobilization efficiency in wheat (*Triticum aestivum* L.) internodes

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### Abstract

In order to evaluate the effect of nitrogen rates and green manure crops on dry matter mobilization and mobilization efficiency indices of wheat (*Triticum aestivum* L.) a field experiment was conducted in Agricultural Faculty of Shahid Chamran University, Ahvaz during growing season of 2010-2011. The experimental design was split-plot based on randomized complete block with three replications. Main plot included four nitrogen rates (i.e. 0, 50, 100 and 150 kgN.ha<sup>-1</sup>) and sub-plot included six green manure crops containing millet (*Pennisetum* sp.), amaranth (*Amaranthus* sp.), sesbania (*Sesbania* sp.), cowpea (*Vigna unguiculata* L.), mung bean (*Vigna radiata* L.) and fallow. This experiment was done at two stages. First, planting and turn down of green manure crops and then planting of wheat. The results showed that the maximum weight and specific weight of all stem internodes obtained from 0 to 20 days after wheat anthesis. Then, this trend decreased from 20 to 50 days after wheat anthesis due to remobilization of dry matter to grain. Mobilized dry matter was more in control (0 kg.N.h<sup>-1</sup>) than in high N application for peduncle (219 vs. 181 mg) and penultimate (203 vs. 165 mg), while, was less in the lower internodes (403 vs. 407 mg). Generally, with increasing of nitrogen levels, dry matter mobilization efficiency was decreased by. So, the effect of green manure crops not limited only by soil properties, while influences the relationship between physiological sources and sink.

**Keywords:** Extent, Peduncle, Penultimate, Specific rate, Specific weight

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## Effects of sowing time and plant density on yield and essential oil production of medicinal plant, peppermint (*Mentha piperita* L.)

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### Abstract

In order to investigate the effects of two sowing time (middle of May and early June) and four plant density (8, 12, 16 and 20 plants.m<sup>-2</sup>) on yield and essential oil content of peppermint at two cutting stages, an experiment was conducted at the Research Farm of the Faculty of Agriculture, University of Tabriz during growing season of 2003-2004. These treatments were performed as factorial based of randomized complete block design with three replications. The result of the first cutting showed that plant sowing at the early June and eight plants.m<sup>-2</sup> densities had the highest leaf (4.47%) and plant (2.92%) essential oil percentage, but these factors and their interaction effects did not effect on the essential oil yield. In the second cutting, the highest plant essential oil was observed in plant sowing at early June and 12 plants/m<sup>2</sup> densities. The highest essential oil yield in second cutting produced in middle of May sowing time. The results of two cutting stages showed that the fresh and dry yield decreased by delaying in sowing time.

**Keywords:** First cutting, Leaf essential oil percentage, Plant essential oil percentage, Second cutting

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## Effect of mycorrhizal inoculation on seedlings establishment and morphological parameters of alfalfa (*Medicago sativa* L.) in rangeland of Bahar Kish Quchan

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### Abstract

Plant establishment is the most critical stage in biological renovation of rangelands. The processes which normally fails, due to the harsh conditions in the arid and semiarid environments. New technologies may be used to overcome this problem. The purpose of the present study was to investigate the possibility of enhancing seedling establishment and growth rate of alfalfa (*Medicago sativa* L.) under natural habitats by inoculation with mycorrhiza species. Seeds of alfalfa were sown under greenhouse for 20 days and inculcated with two species of *Glomus intraradices* and *G. mosseae*. After 30 days seedlings were transplanted the rangeland as sub plots as split plot based on RCBD (Randomized complete block design) were evaluated with three replication. Root colonization percent with *G. mosseae* was 62/7 % and with of *G. intraradices* was 72%. Mycorrhozal inoculation increased establishment of alfalfa at the early and late growth stages, with stronger effects of *G. intraradices* than *G. mosseae*. Furthermore leaf and root dry matter, total dry matter and the shoot/root, was increased as a result of *G. intraradices*, compared with *G. mosseae* inoculation. In conclusions, *G. intraradices* can be used as a biological fertilizer for establishment of alfalfa in semiarid rangeland of Bahar Kish, Quchan.

**Keywords:** Biofertilizer, Colonization, Seedling transplantation

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## Effect of silicon application on physiological characteristics and growth of wheat (*Triticum aestivum* L.) under drought stress condition

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### Abstract

In order to investigate the effect of silicon application on some physiological characteristics and growth of Wheat (*Triticum aestivum* L.) under late drought stress condition, an experiment was conducted at the Agriculture and Natural Resources University of Ramin, Khuzestan during year 2012. The experiment was conducted in the open environment as factorial randomized complete block design with three levels of drought stress (irrigation after 25, 50 and 75% depletion of available water content) as the first factor and four levels of silicon (0, 10, 20 and 30 mg Si.kg<sup>-1</sup> soil) as the second factor with three replications. The results showed that drought stress imposed a negative significant effect on all traits. The drought stress led to increased electrolyte leakage and proline content, cuticular wax, leaf silicon concentration, superoxide dismutase activity (SOD) and grain potassium were decreased. The severe drought stress has most effect on electrolyte leakage (up to 53%). The application of silicon except the shoot/root parameter, on all characters have been affected so that application of 30 mg Si.kg<sup>-1</sup> soil led to decrease electrolyte leakage up to 22.5% and increased SOD activity, proline content, cuticular wax grain K and flag leaf Si concentration, 25, 12.8, 21, 17 and 30% compared to control, respectively. In general, the results showed a positive effect of silicon on wheat plant under stress conditions that were higher than no stress condition.

**Keywords:** Electrolyte leakage, Silicon k concentration, Superoxide dismutase activity

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## Evaluating of irrigation levels on weed diversity on corn (*Zea mays* L.) field

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### Abstract

In order to study the different levels of irrigation on diversity, density and compound of weed species in corn field, experiment was conducted at Agricultural Research Station, Ferdowsi University of Mashhad during growing season of 2008-2009. The experiment was with four levels of irrigation (6130, 7290, 8800 and 12330 m<sup>3</sup>) and four levels of weed control (complete control, broad-leaves control, grasses control and without control). Weed sampling was done at four stages including first, middle and end of critical period weed control and harvest then all species counted species separate. The results showed that in different levels of irrigation the weed species were different. At the first time of critical period, the most diversity was in 8800 and 7290 m<sup>3</sup> and the minimum diversity was in 12330 and 6130 m<sup>3</sup> irrigation levels. At the harvest time, the most diversity was in 12330 and 6130 and 8800 m<sup>3</sup> irrigation levels and least diversity within different indexes were in 7290, 8800 and 6130 m<sup>3</sup> irrigation levels, respectively. Stability index changed at different levels of irrigation. In addition, maximum when the irrigation level was in minimum level, however, highest level of irrigation caused the maximum unstability of species but levels of irrigation had no significant on dominance index.

**Keywords:** Minhinik index, Simpson index, Shanon index, Stability

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## Introduction of an index for drought evaluation using principle components analysis

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### Abstract

Isfahan province is located in the center of Iran and has arid and semi-arid climate. In recent years, water shortage has increased in this region and has affected crop production. Wheat is one of the most important crops of the province. In the present research, an index (DEI) has been developed for drought evaluation using long term climatic data through application of principle components analysis (PCA). The counties of the province were classified and evaluated according to drought intensity. In addition to DEI for quantifying drought, Aridity index (AI) was also calculated at different time scales in each county. The climatic and grain yield data were collected from the Iranian Meteorological Organization and Isfahan Agricultural Organization, respectively. In order to remove the positive effects of genetic improvement and progress in agronomic management on long-term wheat grain yield, double exponential smoothing technique was used. According to DEI, Isfahan, Shahreza, Golpaygan and Natanz had semi-arid climate and Ardestan, Koorobiabanak, Kashan and Naein could be classified as arid, while according to AI studied counties had arid climate. AI had the greatest amount only in Golpaygan while DEI had the greatest value in Isfahan, Shahreza, Golpaygan, Kashan and Natanz. PCA results showed that maximum temperature (coefficient of 3.51) followed by mean wind speed (coefficient of 2.27) were the main climatic variable influencing counties weather. Calculated drought indices showed poor correlation with wheat yield, indicating that other meteorological indices should still be examined to capture wheat yield variability in this province.

**Keywords:** Aridity index, Wheat, Double exponential smoothing

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## Evaluation of different intercropping patterns of cumin (*Cuminum cyminum* L.) and lentil (*Lens culinaris* L.) in double crop

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### Abstract

In order to evaluate the comparison of different intercropping patterns of cumin (*Cuminum cyminum* L.) with lentil (*Lens culinaris* L.) in double crop, a field experiment was conducted based on a randomized complete block design with three replications and eight treatment at the farm located in West Azerbaijan province - city Nagadeh, Iran during growing season of 2011-2012. Treatments included intra-row intercropping (50% cumin + 50% lentil), row intercropping (one row of lentil + one row of cumin) and strip intercropping (two rows of lentil + one row of cumin, three rows of lentil + one row of cumin, four rows of lentil + two rows of cumin, six rows of lentil + two rows of cumin and pure lentil and cumin). Intercropping patterns had significant effect on all of mentioned traits. Results showed that the highest and the lowest economic yield of lentil were achieved in monoculture with 600 and 1600 kg.ha<sup>-1</sup> and six rows of lentil + two rows of cumin with 273 and 676 kg.ha<sup>-1</sup>, respectively. Grain yield and biological yield were no significant differences at monoculture with row intercropping and intra-row intercropping. But with increasing strip widths of grain yield and biological yield decreased by 50 and 54 %, respectively. The essential oil percentage of all treatments was higher than monoculture. The highest essential oil yield was obtained of intra-row intercropping (20 kg.ha<sup>-1</sup>). Results indicated that maximum (1.8) and minimum (0.94) LER values were obtained of row intercropping and strip intercropping (six rows of lentil + two rows of cumin), respectively. By changing row intercropping patterns to strip intercropping, LER was decreased due to complementary and facilitative effects in intercropping.

**Keywords:** Essential oil, Land equivalent ratio, Replacement intercropping, Row intercropping, Strip intercropping

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## Evaluation of relation between weed population and nitrogen use efficiency in wheat as affected by integrated fertilizer management

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### Abstract

In order to evaluation of relation between weed dynamic and utilization of nitrogen in weed as influence of integrated fertilizer management in different weed densities, a field experiment was carried out in experimental farm of Agricultural Faculty of Shahid Chamran university of ahvaz at 2011-2012 growing season. Experimental design was based on a split-plot with three replications. Main plot was 5 integrated fertilizer managements and sub plot was 3 weed densities. Our results showed that the treatment 75% chemical fertilizer whit Biological fertilizer in lower weed density had the highest weed density and dry weight. Narrow leaf and broad leaf weeds was dominant species in 100% chemical fertilizer and 100% biological fertilizer Treatments, respective. Also, weed diversely was reduced by reduction. So, Treatment 100% biological fertilizer had the highest weed density nitrogen fertilizer utilization efficiency was increased by reduction of nitrogen chemical fertilizer. In addition, all nitrogen useefficiency. Indices were more affected by nitrogen chemical fertilizer, than weed density. Based on our results,increasing dependence to biological fertilizer, will reduce is the compatibility of wheat plant, in early growth period, which caused increasing in density and decreasing of weed at the wheat growth period.

**Keywords:** Biological fertilizer, Competition, Wild mustard

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## Effect of water depth and temperature on germination characteristics of rice and barnyard grass in the laboratory conditions

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### Abstract

Response of seed germination of a crop to different environmental conditions is one of the most important determination factors to indicate its ability in competition with weeds. In order to evaluate the effects of water depth and temperature on the germination of different varieties of rice and barnyard grass, an experiment was conducted in the Seed Laboratory, Faculty of Agriculture, Ferdowsi University of Mashhad, as a factorial design based on a Complete Randomized Blocks in four replications of 25 seeds. First factor was water depth in six levels (0, 2, 4, 6, 8, and 10 cm), second factor was temperature in seven levels (10, 15, 20, 25, 30, 35 and 40 °C), and third one was different cultivars (Khazar, Hashemi and Domsiah) and barnyard grass. According to the results the best germination characteristics of all rice varieties and barnyard grass obtained at 30 °C. With increasing temperature up to 30°C germination increased. However, temperatures above 30°C reduced the germination. Increasing water depth lead to reduce the speed and percentage of germination in all varieties, But the effect of water depth on the germination of rice varieties was lower than the barnyard grass.

**Keywords:** Competition, Germination, Oxygen, Temperature, Weed

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## Effect of plant growth promoting rhizobacteria (PGPR) application, nitrogen and zinc sulphate fertilizer on yield and nitrogen uptake in rapeseed (*Brassica napus* L.)

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### Abstract

In order to study the effects of simultaneous application of  $ZnSO_4$  and biological fertilizer, *Azotobacter chroococcum* and *Azospirillum brasilense*, on grain yield and nitrogen uptake efficiency in rapeseed (*Brassica napus* L.), cv. Hyola308, a field experiment was conducted as split plot factorial based on randomized complete block design at research field of Faculty of Agricultural Sciences, University of Guilan, Iran, during growing season of 2007-2008. Results showed that urea fertilizer,  $ZnSO_4$  fertilizer and biological fertilizer had significant effects on nitrogen uptake and accumulation. Maximum grain yield ( $2568 \text{ kg} \cdot \text{ha}^{-1}$ ) were obtained in  $150 \text{ kgN} + ZnSO_4 + \text{bio}$  treatment. Maximum accumulation of nitrogen in rosette stage (4.9%) and nitrogen content of grain (3.6%) was obtained in  $150 \text{ kg N} \cdot \text{ha}^{-1} \text{N} + ZnSO_4 + \text{bio}$ . Maximum Nitrogen uptake efficiency and nitrogen use efficiency ( $0.86$  and  $29.56 \text{ kg} \cdot \text{kg}^{-1}$ , respectively) were obtained in  $50 \text{ kgN} \cdot \text{ha}^{-1} \text{N} + ZnSO_4 + \text{bio}$ . In regard to significant effects of  $ZnSO_4$  and biological fertilizer with lower N rate and high nitrogen uptake efficiency of rapeseed, it seems that the ability of uptake and use of nitrogen fertilizers was greater for seed formation in the presence of  $ZnSO_4$  and biological fertilizer in rapeseed, cv. Hyola308. The most important of mechanisms of PGPRs is increase the bioavailability of mineral nutrients with biological nitrogen fixation and soluble phosphorus and potassium that lead to economize nitrogen fertilizer in rapeseed production and minimizing environmental pollution risk.

**Key words:** *Azotobacter*, *Azospirillum*, Nitrogen uptake efficiency, Nitrogen use efficiency

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