International Research Journal of Applied and Basic Sciences

ISSN 2251-838X / Vole, 3 (9):1867-1873
Science Explorer Publications

Effect of pre-sowing seed treatment and spraying of bio-organic nutrient on yield and yield components of maize (*Zea mays* L.)

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Abstract

To study effect of bio-organic nutrients on maize (SC 704) this experiment was done with eleven treatments based on a Randomized Complete Block design in three replications. Treatments consist of Humax, Marmarin, Biomix, Nitroxin, Distil water and Control that applied separately as pre-sowing seed treatment and foliar application. Row number per ear, ear diameter, number of grain per ear, 1000-grain weight, seed yield, biomass yield and harvest index of corn plants in both pre-sowing seed treatment and spraying methods have significant differences compared to mean control value. Maximum (4.76 cm) and minimum (4.1 cm) ear diameter was obtained in plants that treated with Humax as pre-sowing seed treatment and control plants, respectively. Results showed that the plants treated with Humax in foliar application and pre-sowing seed treatment had a maximum row number per ear and the control plants had the minimum of it. Application of Humax in both methods causes the highest number of grain per ear and the lowest belonging to the control. Plants treated with Humax showed the increase in 1000-grain weight in both pre-sowing seed treatment and foliar application method. The highest grain yield observed in plants treated with Nitroxin at pre-sowing seed treatment method and the lowest mean value of it obtained by control. The highest (30554 kg/ha) mean value of biomass yield was obtained from the plants that sprayed with Humax fertilizer. Generally, application of Humax as with pre-sowing seed treatment and foliar application lead to increase in yield and yield components of maize.

Keywords: Biomix, Foliar application, Humax, Marmarin, Nitroxin

Introduction

However, maize grain yield potential is twice as high as compared to other cereal crops (Tollenaar and Lee 2002), But actual harvested yields are low (Jones and Benton, 2003). Maize actual yield affected by many things that insufficient nutrients decrease 10-22% of maize yield (Subedi and Ma, 2009).

Germination is the first step in the plant growing, which is one of the critical stages in the life cycle of plants and is a key process in germinating seed treatment (De villiers et al., 1994). Germination ability of seeds in unfavorable conditions, the more chance of establishment of the plant and will lead to higher density, which is resulting in increased performance (Baalbaki et al., 1999). Rapid and uniform field emergence is two essential prerequisites to increase yield, quality, and ultimately profits in crops. Uniformity and percentage of seedling emergence of direct-seeded crops have a major impact on final yield and quality. Slow emergence results in smaller plants and seedlings, which are more vulnerable to soil-borne diseases (Tzortzakis, 2009). Over the past two decades seed enhancement through seed priming has led to great improvements in a grower's ability to routinely achieve this goal in both the field and greenhouse (Tzortzakis, 2009). Nowadays, various seed priming techniques have been developed that enhanced seedling vigor (Ashraf and Foolad, 2005). The beneficial effects of priming have also been demonstrated for many field crops such as wheat, sugar beet, maize, soybean and sunflower (Parera and Cantliffe, 1994; Singh, 1995; Sadeghian and Yavari, 2004). Some bacterial species mostly associated with the plant rhizosphere, have been tested as pre-sowing seed treatment and found to be beneficial for plant growth and yield (Esitken et al., 2010). For example, it was reported that the Plant growth promoting rhizobacteria (PGPR) can stimulate growth and increase yield in apricot (Esitken et al., 2003).

Intensive farming practices, that warrant high yield and quality, require extensive use of chemical fertilizers, which are costly and create environmental problems. In fact, the danger of fixation and/or leaching of the synthetic fertilizers are harmful for soil and environment (Naeem et al., 2006). Therefore, recently emphasis has been shifted to replace or changes the chemical fertilizers application (Sudhakar et al., 2000). Thus, it is necessary to supply the plant requirement to nutrient through proper procedure. One of the best methods is foliar application. Foliar feeding is a technique of feeding plants by applying liquid fertilizer directly to their leaves. Foliar application of fertilizer is a convenient and effective method of nutrient application for many crops. Nutrients applied to the foliage are generally absorbed more rapidly than when applied to the soil (Garcia and Hanway, 1976). The organic manure provides a good source of nutrients and can serve as alternative practice to mineral fertilizers for plants (Wong et al., 1999).The humic substances have multiple effects that can greatly benefit plant growth (Cimrin and Yilmaz, 2005; Sangeetha et al., 2006). The positive effects of the humic substances were also observed on the studies such as dry matter yield increases on corn and oat seedling (Lee and Bartlett, 1976; Albuzio et al., 1994). Yield increases on radish and green bean seedlings (Singhvi, 1989; Russo and Berlyn, 1992) have been well documented.

Uses of bio-fertilizers containing beneficial microorganisms instead of synthetic chemicals are known to improve plant growth through supply of plant nutrients and may help to sustain environmental health and soil productivity (O'Connell, 1992). Nitroxin (including bacteria such as *Azotobacter choroccum* and *Azospirillum lipoferoum*) is one of the important biological fertilizers that used as seeding methods. Effective use of this type of bio-fertilizers cause to better germination of seeds. Beneficial effect of application of Azotobacter in mulberry leaf production was established and demonstrated by Das et al., (1996) and Gangwar and Thengavelu (1992). Advantages of foliar application of bacterial biofertlizer on mulberry leaf production was also reported by Sudhakar et al., (2000).

Use of bio- organic fertilizers will be more effective in the reproductive stage, the reproductive phase in plants is the result of grain production, it forms the most important part of plant life, performance and seed quality mainly depends on this stage (Perkasem et al., 1993).

Different bio-organic substance can be applied in soil and as a foliar spray or pre-sowing seed treatment. There is little information available on the effect of bio-organic application as a pre-sowing seed and foliar treatment on maize. Thus, the main objective of the present study was to investigate the effect of pre sowing Seed treatment and foliar application of Bio-organic nutrition on yield attributes of maize.

Materials of Methods

This field experiment was conducted based on completely Randomized Block Design with three replications in the experimental field, of Urmia University (37° 39´ N and 44° 58´ E, altitude 1365 m, Urmia-Iran) in 2011. Soil texture was a silty clay whit a pH 7.12 and phosphorus 7.5 ppm. The treatments consist of four bio-organic nutrients; distil water and control that applied separately as pre-sowing seed treatment and foliar application as follows:

1-Humax (Humax®, JH Biotech, Inc., Ventura, CA) contains of 12 % humic acid, 3 % folic acid, and 3 % K2O. Humax were applied by foliar application according to factory recommendations (5 g per lit).

2-Marmarin , contains Organic Matter 20-22 %, Growth regulator (Cytokinin) 400 ppm and Total Amino Acid 6.5 % (w/v) that produce by IFTC Co., in fact, Marmarin is the natural growth stimulator extracted from the Seaweed *Ascophyllum nodosum*, which contains more than 60 macro and micro elements in addition to natural growth regulators, organic acids and sugars. According to factory recommendations it applies 1.5-2.5 lit /ha×3 times according to growth stage.

3-Biomix® that manufactured by Manvert Co., contain micronutrients of boron 0.7% w/w , copper 0.3% w/w, iron 7.8% w/w , manganese 3.7% w/w , molybdenum 0.2% w/w, zinc 0.7% w/w that copper, iron, manganese and zinc are EDTA chelated. Biomix were applied by foliar application according to factory recommendations.

4-Nitroxin (Nature Biotechnology Co. (NBICO), Iran, supplied these bacteria) that including bacteria such as *Azotobacter choroccum* and *Azospirillum lipoferoum*). The Nitroxin biofertilizer was applied in this study for seed inoculation and foliar application of maize. Seed inoculation with Nitroxin involved placement of the seeds in bacterial suspensions at 109 CFU ml-1 for 30 min before planting (Ozturk et al., 2003).

5-Distil water (that sprayed on plant the same as other treatments).

6-Control (no pre-sowing seed treatment and no foliar application).

In pre-sowing seed treatments, the maize seed were washed thoroughly with double distilled water and Seed inoculation with Nitroxin involved placement of the seeds in bacterial suspensions at 10^9 CFU ml^{-1} for 30 min before planting (Ozturk et al., 2003). For the other Organic fertilizer (Humax, Marmarin and Biomax), seeds soaked in various above pre-treatment solutions for 10h. Also in the foliar application method, Humax, Marmarin, Biomix, Nitroxin and distil water were sprayed according to factory recommendations on the shoots of the maize plant at vegetable growth, tassel initiation and end of tasseling stages using hand operated compressed air sprayer. Control was maintained using no pre-sowing seed treatment and no foliar application.

Treated maize seeds were planted in the field that the size of each plots was 6×3.75 m with distance of 75×20cm was set between the rows. Irrigation schedule was performed in 7 days intervals immediately after planting. Weeds were controlled by hand when needed.

The maize variety was SC 704. For all treatments, nitrogen fertilizer (as urea) on the basis of 100 kg ha^{-1}; phosphorus fertilizer (as phosphate ammonium), 150 kg ha^{-1} was applied. Pesticides, for controlling pests, diseases, and weeds during the growing season's herbicides, and fungicides were not used. Weeds were managed by hand weeding throughout the growing season.

Agronomic traits of maize such as row number per cob, grain number in row, ear length, ear diameter, were measured at harvest time in 10 plants. At physiological maturity, three central rows in each plot were harvested (1 m^2); the ears were de-husked, dried and threshed. Grain weight was recorded and then converted into kg ha^{-1}. Plants in 1 m^2 of each plot were harvested and then weighed to note biomass yield. Two hundred dry kernels from each plot were weighed to determine the 1000-kernel weight. Harvest index was calculated by the following formula:

Harvest index (%) = (seed yield /biomass yield) × 100

Data analysis of variance was done by SAS 9.1 software. The means differences among the treatments were compared by LSD Multiple Comparison Test at 0.05 level of probability.

Results and Discussion

Results showed that row number per ear, ear diameter, number of grain per ear, 1000-grain weight, seed yield, biomass yield and harvest index of corn plants in both pre-sowing seed treatment and spraying methods have significant differences compared to mean control value (Table 1).

Ear length is one of the important factors contributing to grain yield. Mean comparing of the ear length (Table 2) showed that the lowest (18.93 cm) ear length was related to control treatment, and the plants that sprayed with Nitroxin had the highest (22.5 cm) ear length which was statistically equal with other bio-organic fertilizer (Humax, Biomix and Marmarin) in both method applications (Table 2). The increase in ear length may be attributed to the availability of more nitrogen and other nutrients from bio-organic fertilizer for plant development at least up to ear formation. These results suggested that adequate supply of nutrients from both bio-organic fertilizer sources for proper ear development in maize. This result is in accordance with those of Sims et al., (1995).

Maximum (4.76 cm) and minimum (4.1 cm) ear diameter was obtained in plants that treated with Humax as pre-sowing seed treatment and control plants, respectively (Table 2) . According to the mean comparison in plant treated with all bio-organic nutrients, it shows that in both pre-sowing seed treatment and foliar application methods were almost identical increase in ear diameter in comparison of control treatment (Table 2). Based on ear diameter means, it is revealed that application of bio-organic and water as pre-sowing seed treatment was effectiveness than foliar application method (Table 2).

Row number per ear is one of the very important agronomic traits, related to maize yield (Liu et al., 2010). Results showed that the plants treated with Humax in foliar application and pre-sowing seed treatment had a maximum row number per ear and the control plants had the minimum of it (Fig 1).

Number of grain per ear is an important yield determining factor in maize (Cheema et al., 2010). As shown in Table 2, the highest mean value of number of grain per ear obtained in the seed treatment method. Application of Humax in both methods causes the highest number of grain per ear and the lowest belonging to the control where no bio-organic fertilizer was applied. These results are similar to the finding of Zhang et al., (1998) who reported that precise application of manure and mineral fertilizer to maize crop can be as effective as commercial nitrogen fertilizer for yield response. Among the bio-organic fertilizer application in both methods of pre-sowing seed treatment and foliar application, plants that treated with Biomix had the lowest number of grain per ear (Table 2).

However mean comparison showed that the 1000-grain weight in both method application of bio-organic fertilizer (except application of Marmarin as foliar application) was statistically equal with other bio-organic fertilizer (Table 2). But, plants treated with Humax showed the increase in 1000-grain weight in both pre-sowing seed treatment and foliar application method. The lowest of 1000-grain weight (258.3 g) was recorded in plot where no fertilizer was applied (Control) (Table 2). The increase in 1000-grain weight over that of control was mainly due to balanced supply of food nutrients from both bio-organic fertilizers throughout development of maize plant. These results are in accordance with the reporting of Ma et al.,

(1999) and Garg and Bahla (2008). The final grain yield is a function of combined effect of the individual yield components under applied inputs and 1000-grain weight is important one of them (Cheema et al., 2010).

Grain yield is a function of interaction among various yield components that are affected differentially by the growing conditions and crop management practices (Cheema et al., 2010). Although mean comparison of grain yield showed that in both methods application of bio-organic fertilizer was statistically equal with other bio-organic fertilizer (Fig 2). But, Results showed that the highest grain yield observed in plants treated with Nitroxin at pre-sowing seed treatment method and the lowest mean value of it obtained by control, water and Marmarin respectively. While in the foliar application method the highest obtained grain yield belonging to plants treated with Humax and the lowest mean belonging to control and plant treated with water and Marmarin respectively. These results are in accordance with the finding of Boateng et al., (2006) who reported that organic manure significantly increased the grain yield of maize.

In this research biomass yield was significantly affected by the different levels of bio-organic fertilizer treatments (Table 1). Data recorded in Table 2 showed that the highest (30554 kg/ha) mean value of biomass yield was obtained from the plants that sprayed with Humax fertilizer, however it was statistically equal to application of Humax, Marmarin and Nitroxin as pre-sowing seed treatment and Biomix and Nitroxin in foliar application method (Table 2). Significantly lowest biomass yield (20081 kg/ha) was recorded from plot where neither bio-organic fertilizer applied (control) (Table 2).

The comparison of treatments means (Table 2) showed that the highest harvest index belonging to the plants treated with water and the lowest of it, belonging to control and after control belonging to plants that treated with Marmarin. The decrease in biomass yield of plants that treated with water caused the increase in harvest index of maize that sprayed with water than other bio-organic fertilizer (Table 2).

Generally, The results of this study showed that application of Humax and Nitoxin as pre-sowing seed treatment and foliar application were the best treatments due to given higher yield and yield component in maize. In fact, these treatments improved grain yield in maize via increased number of seed per pod and thousand seed weight.

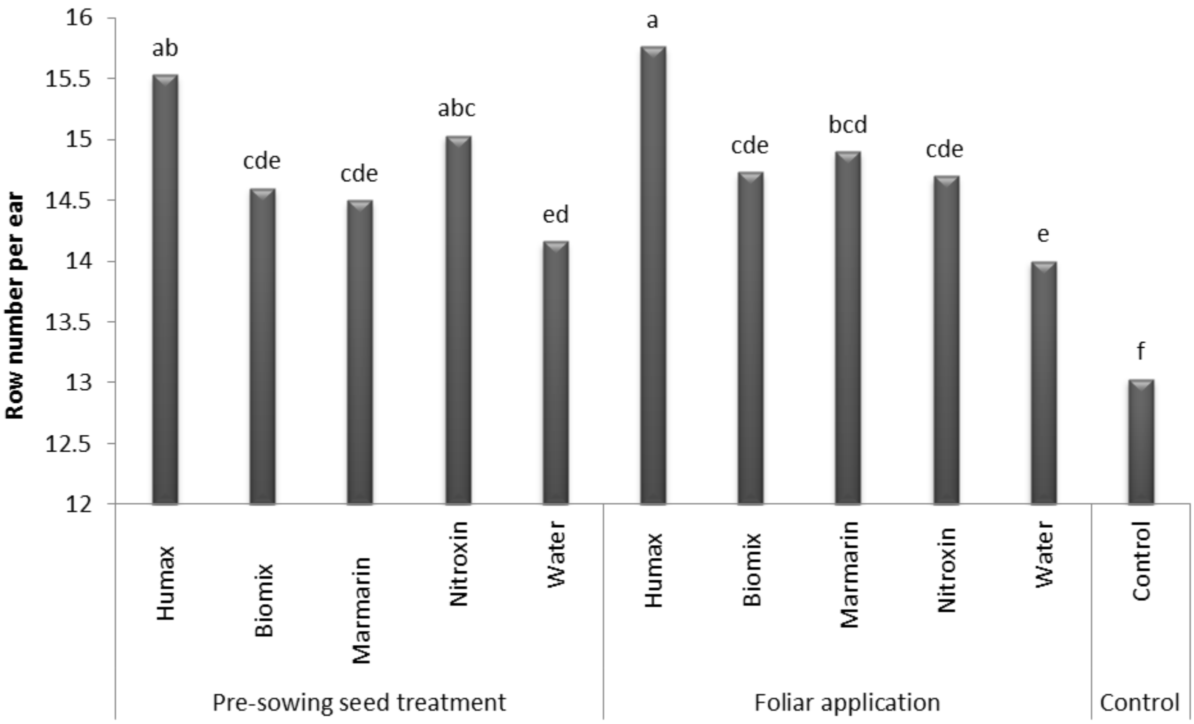

Figure1. Means comparison of row number per ear of maize affected by pre-sowing seed treatments and spraying of bio-organic nutrients. The same letters in each column shows non-significant differences.

Table 1. Analysis of variance for yield and yield components of maize affected by pre-sowing seed treatment and spraying of bio-organic fertilizers.

		Mean square							
Source of variation	Df †	Row number per ear	Ear length	Ear diameter	Number of grain per ear	1000-grain weight	Grain yield	Biomass yield	Harvest index
Replication	2	0.63	0.23	0.002	3821.3	2.38	6712950	73963098	53.84
Treatment	10	1.66**	3.21^{ns}	0.108**	13844.6**	31.65**	8233650*	36418212**	49.89^{ns}
Error	20	0.207	1.45	0.019	3229.6	4.76	2563128	6674859	34.29
Coefficient of variation (%)		3.11	5.72	3.05	7.91	6.62	12.3	9.8	11.79

Ns,* and **, Non-Significant and Significant at 5% and 1% probability level, respectively

† Df: Degrees of freedom

Table 2. Mean comparison of yield and yield components of maize affected by pre-sowing seed treatment and spraying of bio-organic fertilizers.

Bio-organic fertilizer		Ear length (cm)	Ear diameter (cm)	Number of grain per ear	1000-grain weight (g)	Biomass yield (kg/ha)	Harvest index (%)
Pre-sowing seed treatment	Humax	21.83 abc	4.76 a	804.43 a	368 a	29167 ab	51.77 abc
	Biomix	21.53 abc	4.6 abc	687.87 cd	337.6 abc	25285 bc	51.34 abc
	Marmarin	22.06 ab	4.43 c	765.33 abc	346.6 ab	27084 ab	49.36 abc
	Nitroxin	21.43 abc	4.7 ab	788.83 ab	352.3 ab	29837 a	48.77 abc
	Water	20.2 bcd	4.4 bc	652.53 de	304 cd	22661 cd	55.82 ab
Mean		21.41	4.578	739.798	341. 7	26806.8	51.422
Foliar application	Humax	20.83 abcd	4.7 ab	781.13 abc	360.6 ab	30554 a	47.57 abc
	Biomix	20.86 abcd	4.5 bc	706.8 bcd	342 ab	28442 ab	45.98 bc
	Marmarin	21.4 abc	4.46 bc	710.53 abcd	323.6 bcd	25383 bc	49.25 abc
	Nitroxin	22.5 a	4.63 abc	723.4 abcd	338 abc	29057 ab	45.1 c
	Water	19.96 cd	4.4 c	706.33 bcd	294.3 ed	22300 cd	56.88 a
Mean		19.96	4.4	706.33	331.7	27147.2	48.95
Control	Control	18.93 d	4.1 d	570.03 e	258.3 e	20081 d	44.25 c

The same letters in each column shows non-significant differences.

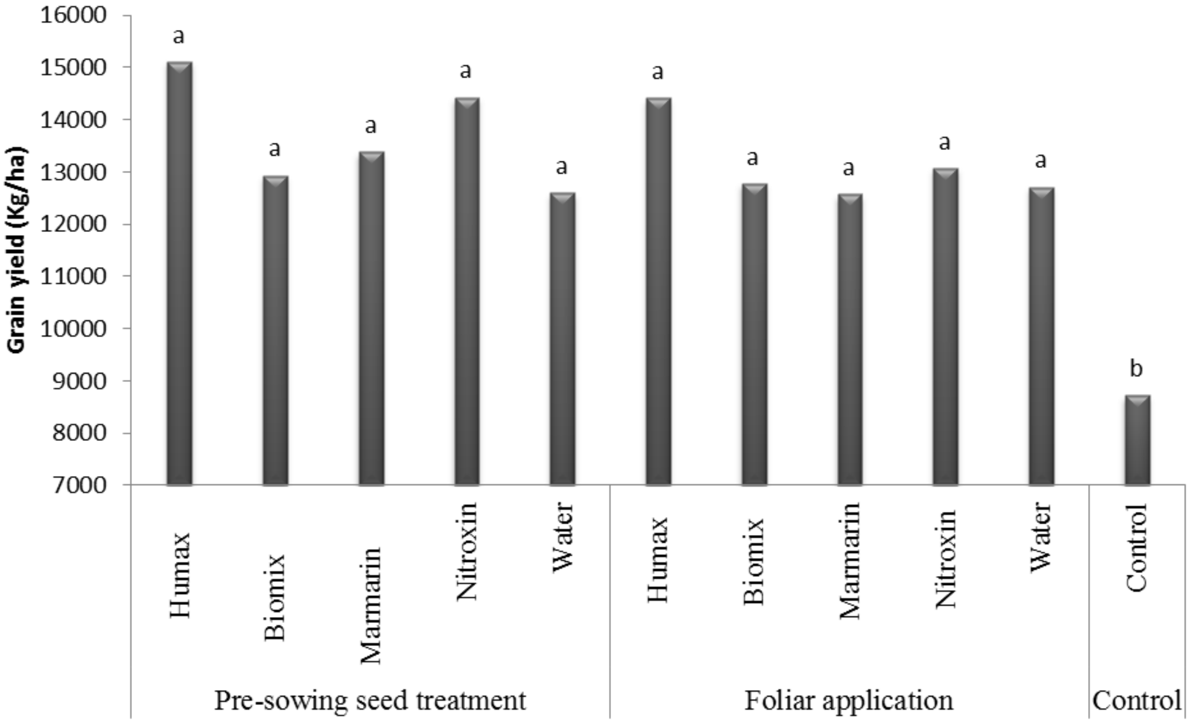

Figure 2. Means comparison of grain yield of maize affected by pre-sowing seed treatments and spraying of bio-organic nutrients. The same letters in each column shows non-significant differences.

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