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Assessment of different crop nutrient management practices for yield improvement

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Abstract

Food security could only be attained with increasing crop productivity. One of the major crop productivity constraints is the unavailability of crop nutrients. Both macro and micro nutrient deficiencies have been reported in most of the soils, which could be provided through various nutrient management practices. Different nutrient application measures were studied for their impact on crop yield and yield-related parameters in a series of experiments, conducted at agricultural research farm, NWFP Agricultural University Peshawar, Pakistan from 2004 through 2007. FYM application was observed to improve crop growth and yield of different wheat cultivars. Nutrient seed priming resulted in better early growth of maize. At field level, nutrient seed priming improved performance of wheat. Similarly for maize crop, nutrient seed priming resulted in more number of cobs plot^{-1}, grains cob^{-1}, 1000-grain weight and biological yield of maize crop even at lower soil application. Soil application of P improved yield and yield components. Better results were obtained from combined use of priming and soil P application. Foliar application of macro and micro nutrients also produced better crop yield and yield components. Similarly, foliar application of micro nutrients (zinc and boron) improved yield over two years. Our results show that all of these crop nutrients management practices has a positive impact on crop performance and call for an integrated approach of crop nutrient management. Such integrated approach must be evaluated at farm level for their economic impact. Adoption of integrated crop nutrient management techniques could be more economical and environmental friendly to achieve higher yields and thus food security.

Introduction

Among several millennium goals, achievement of food security is one of the major one, achievement of which is mainly based on increasing crop productivity. However, crop productivity in developing world faces several constraints. One of the major crop productivity constraints in the third world is the unavailability of crop nutrients in appropriate amount and form to crops (Hussain *et al.* 2006). Plants require specific amount of certain nutrients in some specific form at appropriate times, for their growth and development. The roles of both macro and micronutrients are crucial in crop nutrition and thus important for achieving higher yields (Arif *et al.,* 2006). However, most of our soils are deficient in these nutrients (Jahiruddin *et al.* 1995), and must be supplemented through proper crop nutrients management. Crop nutrients could be provided through different nutrients application methods, including FYM and fertilizer application to soil, nutrients seed priming and foliar application of nutrients. Each of these application methods has its own advantages and limitations. For example, FYM application has been proven to improve crop growth by improving soil physical, chemical and biological properties (Mahmood *et al.,* 1997). However, availability of FYM in enough amount is always a concern. Similarly, soil application of fertilizers is considered to be the most effective and easily manageable way, in several cases (Graham and Ascher 1993). However, the use of fertilizer has several limitations mainly due to its expensiveness, adulteration and unavailability in market at (appropriate) affordable price and at critical time. Similarly, nutrients availability is influenced by soil chemical and physical properties. Plant roots are unable to absorb these nutrients adequately from dry topsoil (Graham *et al.,* 1992 and Foth and Ellis, 1996). Alternatively, the concept of nutrient seed priming and foliar application of nutrients was developed. Seed priming has been reported to result in vigorous early seedling growth and better stand establishment (Arif *et al.,* 2005 and Ali *et al.,* 2007). Foliar application of both macro and micro nutrients have been reported to crop productivity (Arif *et al.,* 2006, and Grewal *et al.,* 1997). To assess affectivity of these nutrient application methods, a series of experiments were conducted on crop nutrients management at Agricultural Research Farm, NWFP Agricultural University Peshawar, Pakistan from 2004 through 2007. Different nutrients application measures were studied for their impact on crop productivity.

Material and method

The study was conducted to assess affectivity of different nutrients nutrient application methods for their impact on crop productivity of wheat and maize. The paper presents reports results obtained from a series of experiments, conducted on crop nutrients management at agricultural research farm, NWFP Agricultural University Peshawar, Pakistan from 2004 through 2007. Crop nutrients management methods studied were soil nutrients application through fertilizers and FYM, nutrient seed priming and foliar application of macro and micro nutrients in separate experiments and in some combinations. The experimental site is located at 34^o N, 71.3^0 E with an altitude of 450 meters above sea level having silty-loam soil of pH 7.7- 8 and less than 1% organic

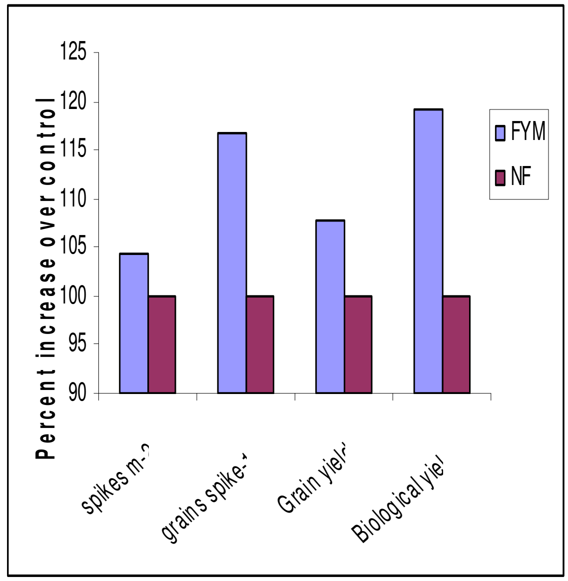

Fig 1. Effect of FYM application on number of spikes m^{-2}, number of grains $spike^{-1}$, grain yield and Biological yield of wheat, during 2004-05

matter. The affectivity of FYM application was assessed using three wheat cultivars (Uqab-2000, Bakkhar-2001 and Saleem-2000), during winter 2004-05, in RCB design with split plot arrangement. The effect of seed priming on a wheat cultivar Saleem-2000 was studied, during 2004-05, through priming seed in water, 0.3% Zn, 0.2% P and 0.3% Zn+0.2%P solutions for 12 hours. The effect of foliar application of macro and micronutrients on yield and yield components of wheat, another experiment was conducted during winter 2005-06. Nutrient solution having N, P and K at100 g mL^{-1} and Fe, Zn, Cu, B, Mn and Mo at 0.8 g mL^{-1}, was applied at 100 mL ha^{-1}. Three treatments i.e., single spray, two sprays and three sprays, along with water application as control were studied on wheat cultivar Saleem2000, with basal dose of N and P at 50:30 kg ha^{-1}. First foliar application of nutrients was made at tillering stage, 2nd second at jointing stage and 3rd third boot stage. To assess the impact of foliar application of zinc and boron on wheat cultivar Saleem-2000, an experiment was conducted during 2005-06 and 2006-07. Solutions for foliar application were prepared using zinc sulphate for zinc and boric acid for boron at 20g L^{-1} and 30 g L^{-1}, respectively. Water spray application and no spray application were considered as control.

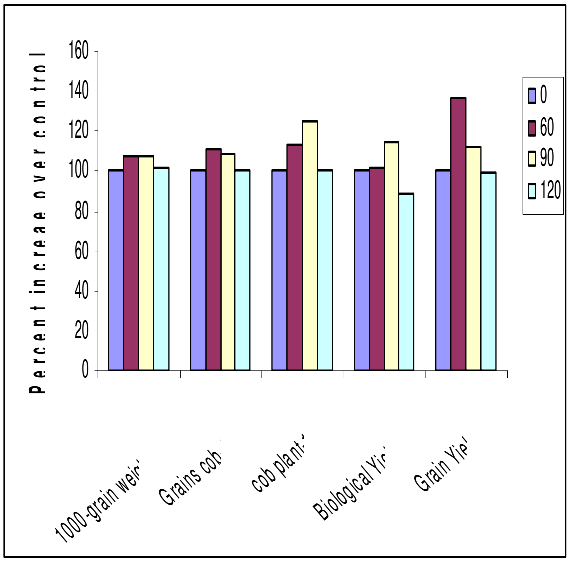

Fig 2.Effect of soil application (60, 90 and 120 kg ha^{-1}) on number of yield and yield components of maize, during spring, 2005.

Data was collected on grain yield and yield contributing traits. The effect of nutrient seedling priming on early growth of maize was studied during spring maize season, 2005. Similarly, the effect of four levels of phosphorus doses (0, 60, 90 and 120 kg ha^{-1}) was studied during spring maize season, 2005. A detailed study was then conducted to assess the effect of nutrient seed priming on yield and yield components of maize variety 'Azam', at different levels of soil P application, during summer 2005, using priming in distilled water, 1% P, 2% P, 1%P+2% Zn, 2% P+2% Zn and NPK solutions for 12 hours. The sources for zinc and phosphorus were zinc sulphate and potassium dihydrophosphate, respectively. Four levels of phosphorus doses (0, 60, 90 and 120 kg ha^{-1}) were also included in the experiment. Data was collected on grain yield and yield contributing traits. The data from each experiment was were statistically analyzed, using ANOVA technique appropriate for the respective design. Means were separated through LSD test, when differences were significant. Here we reported the affectivity of each nutrients nutrient management technique through comparison with check, for the traits, having significant differences.

Result and discussion

The effectivity of nutrient application methods were assessed from a series of experiments, conducted at agricultural Research Farm, NWFP Agricultural University Peshawar, Pakistan from 2004 through 2007. Results obtained from these experiments are reported as an increase through comparison with control, for traits having significant variations for treatments applied.

FYM application:

The effectivity of FYM application assessed using three wheat cultivars (Uqab-2000, Bakkhar-2001 and Saleem-2000), during winter 2004-05 showed that application of FYM enhanced number of grains $spike^{-1}$, spike m^{-2} and grain yield over control (Fig. 1). FYM application has been reported to improve crop growth by improving soil physical, chemical and biological properties (Mahmood *et al.,* 1997). This improved soil condition will provide a favorable environment for seedling development and subsequent growth. FYM application improved soil profile water content and root and leaf growth (Aggarwal *et al,* 1995). Here we observed that this organic source had improved crop growth and yield of different wheat cultivars (cultivar was data not shown). Previously, Yadav and Poonia (1996) have also reported better yield for FYM application.

Soil application of fertilize:

The impact of soil P application was studied during spring maize season, 2005 (Fig. 2). All levels of P application (60 kg ha^{-1}, 90 kg ha^{-1} and120 kg ha^{-1}) resulted in increase in number of cobs $plot^{-1}$, number of grains cob^{-1}, thousand-grain weight and grain yield as compared to control (0 kg ha^{-1}). P dose of 60 kg ha^{-1} resulted in maximum increase in number of grains cob^{-1}, thousand-grain weight and grain yield. Phosphorus, being primary essential nutrient, has prime importance in crop nutrition. It is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP (Khalil and Jan, 2003). Thus fertilizer application makes this nutrient available to crop plants and result in better

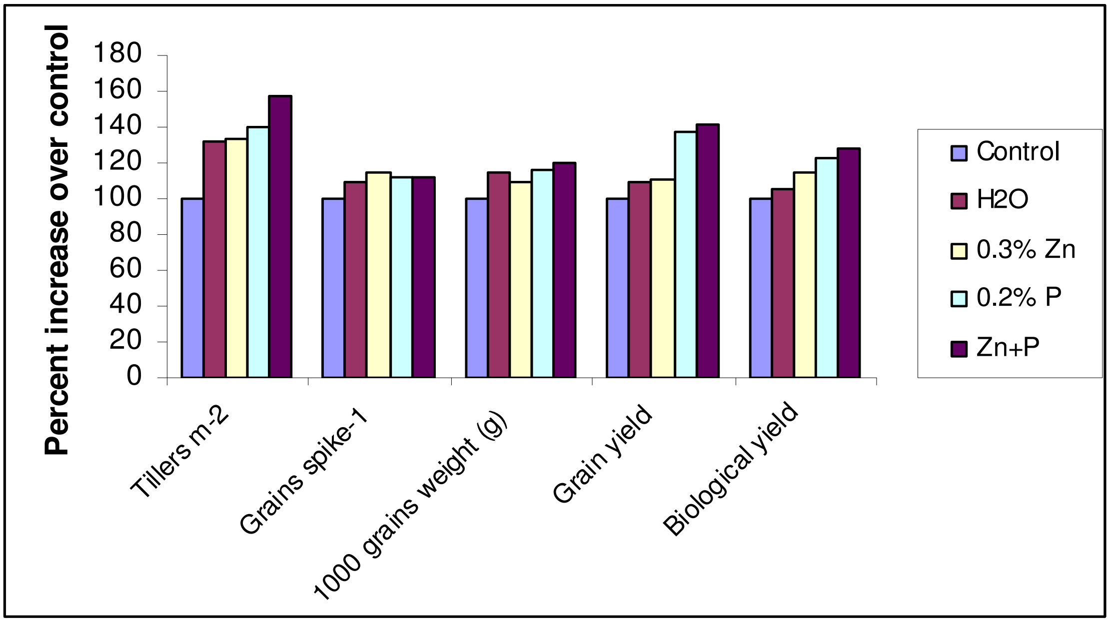

Fig3 . Effect of nutrients seed priming on number of spikes m^{-2}, number of grains $spike^{-1}$, grain yield and Biological yield of wheat, during 2004-05.

growth and development. These results are in agreement with those of Niazi *et al.* (1990) and Khan *et al.* (2000) who also reported increased grain yield for P application.

Nutrients seed priming

The effect of priming seed in water, 0.2% Zn, 0.3% P and 0.3% P+ 0.2% Zn was evaluated for yield and yield components, during 2004-05. An increase was observed in number of plants m^{-2}, number of tillers m^{-2}, number of grains $spike^{-1}$, thousand grain weight, grain yield and biological yield for primed seed as compared to control (Fig. 3). Nutrient seed priming makes the seed rapidly imbibe and revive the seed metabolism, resulting in a higher germination rate and a reduction in the inherent physiological heterogeneity in germination (Rowse, 1995). The resulting improved stand established can reportedly increase drought tolerance, reduce pest damage and ultimately increase crop yield (Harris *et al.* 1999). These results are in line with that of Harris *et al.* (2000) who reported higher grain yield for seed priming as compared with control.

Foliar application of macro and micronutrients

The effect of foliar application of macro and micronutrient solution on yield and yield components of wheat was assessed during 2005-06. First foliar application of nutrients was made at tillering stage, 2^{nd} second at jointing stage and 3rd third at boot stage. Significant increase was recorded in number of spikes m^{-2}, grains $spike^{-1}$, thousand grain weight, biological yield and grain yield for foliar application of nutrients as compared to control treatments. Three foliar applications of nutrients resulted in maximum number of spikes m^{-2}, grains $spike^{-1}$, thousand grains weight and biological yield. Maximum grain yield was recorded for two foliar sprays which was statistically similar to that of the three foliar sprays. Similarly, Modhaihsh (1997) and Suhog *et al.* (1988) reported increased grain yield for application of

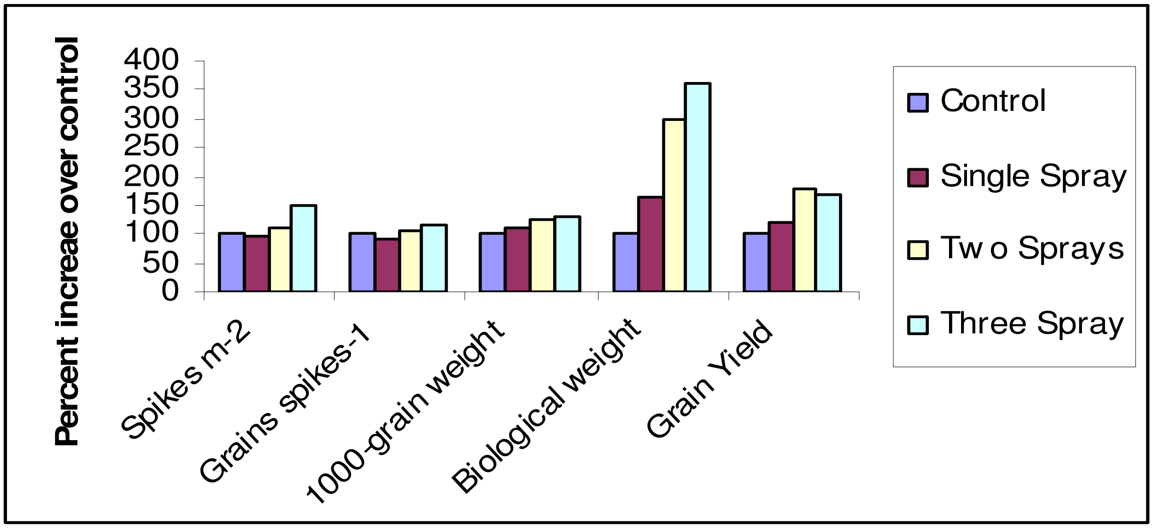

Fig4. Effect of foliar application of macro and micronutrients on yield and yield components of wheat, during 2005

micronutrients individually and in different combinations. A similar pattern of results were was obtained from an experiment on foliar application of Zn zinc and boron, conducted during 2005-06 and 2006-07.

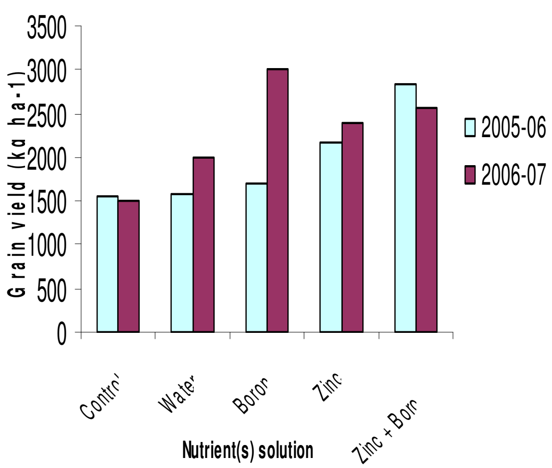

Fig5. Effect of foliar application of zinc and boron on Grain yield, during 2005-06 and 2006-07.

Inspection of the data on grain yield revealed significant increase in grain yield for foliar application of nutrients (Fig 5). Maximum increase in grain yield was produced by three sprays of nutrients and two foliar applications of nutrients, as compared to control.

This increase may be mainly due to the additional availability of nutrients as foliar sprays. Alston (1997) and Gooding and Devies (1992) have also reported increased grain yield for foliar application of different nutrients, individually or in combination.

Similarly, foliar spray of different micronutrients has been reported to be equally or more effective as soil application by different researchers (Modaihsh, 1997 and Torun *et. al.,* 2001) suggesting that foliar sprays could be used effectively to overcome the problem of micronutrients deficiency in subsoil.

Nutrients seed priming at different levels of P doses

Inspection of the data on grain yield revealed a significant effect for nutrient priming, P doses and

Table 1. Effect of seed priming on grain and biological yield of maize at different levels of P doses, during spring 2005.

		P fertilizer dose (kg ha^{-1})				
	Priming level	**0**	**60**	**90**	**120**	**mean**
Grain Yield	**1% P**	2222.2	1822.2	1511.1	1644.4	1800.0 bc
	2% P	2111.1	3200	2533.3	2222.2	2516.7 a
	1% P + 2% Zn	1555.6	3066.7	1955.6	1911.1	2122.2 b
	2% P + 2% Zn	1911.1	3377.8	2888.9	2400	2644.4 a
	NPK	2133.3	2400	2666.7	933.3	2033.3 bc
	Water	2044.4	1777.8	1555.6	2222.2	1900.0 bc
	Control	1155.6	2355.6	1666.7	1644.4	1705.6 c
	Mean	1876.2 b	2571.4 a	2111.1 b	1854.0 b	
Biological Yield	**1% P**	9333.3	9288.9	12000	8000	9655.6 b
	2% P	14000	13422.2	13111.1	10888.9	12855.6 a
	1% P + 2% Zn	12000	8666.7	13777.8	8222.2	10666.7 b
	2% P + 2% Zn	7555.6	11111.1	12000	8444.4	9777.8 b
	NPK	8444.4	12000	13111.1	7555.6	10277.8 b
	Water	11777.8	9777.8	10444.4	11555.6	10888.9 b
	Control	10666.7	10444.4	10222.2	10444.4	10444.4 b
	Mean	10539.7 b	10673.0 b	12095.2 a	9301.6 c	

Grain yield: Lsd values for priming, P levels and P x priming are 368.5, 278.6 and 737.0:Biological yield: Lsd-values for priming, P levels and P x Priming are 1287, 972.9 and 2574, respectively.

interaction of both factors on grain and biological yield (Table I). Seed primed in 2% P + 2% Zn had a in maximum increase in grain yield followed by 2% P. Previously, Harris *et al.* (2000) have reported higher grain yield for seed priming. Similarly, P dose 60 kg ha^{-1} produced maximum grain yield as compared to control which produced least grain yield and other P levels,. This can be due to improved growth and better nutrition, which results in higher yields. These results are in agreement with those of Rajput *et al.* (1989) and Khan *et al.* (2000) who also reported increased grain yield for P application. Similarly, inspection of interaction effect showed that seed primed in 2% P + 2% Zn along with 60 kg ha^{-1} P produced highest grain yield followed by 2% P with 60 kg ha^{-1} P, while dry seed without P produced lowest grain yield. Seed primed with no P application produced grain yield which is almost equal to or greater than those with P application but no priming. Thus, seed priming can be used to supplement P application as well as in combination with P application to achieve higher yields. A similar pattern was observed for biological yield, showing increase in biological yield due to priming and P application. The inspection of interaction data revealed that seed primed with no P application produced biological yield more than that of dry seed with P application but without priming. Thus priming can be used to supplement P application and can be used in combination with P application to achieve higher yields. Nutrient priming has been shown to improve crop stand establishment, which is reported to improve drought tolerance, reduce pest damage and increase crop yield (Harris *et al.* 1999, Mussa *et al.,* 1999, Harris *et al.* 2000). Previously, both P application (Manchandra *et al*., 1982) and nutrient priming (Rashid *et al.,* 2000) has been reported to increase biomass production. These results are in agreement with Chhipa *et* al, (1993) and Ghosh *et al.,* (1997), who reported higher grain yield for priming as compared with control.

Conclusion

All of the tested nutrient management practices produced significant increase in crop yield. Organic sources (like FYM), nutrient seed priming soil application, and foliar application of nutrients resulted in better crop yield and yield components. These results reveal the importance of all of these crop nutrients management practices and call for an integrated approach of crop nutrients management, which would be more economical and environmental friendly to achieve higher yields and thus food security. On-farm experiments are needed to assess the economic impact of nutrient management practices in an integrated manner.

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