Effect of different rates of zinc sulphate on hybrid maize grown alone and in combination with mungbean

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Abstract: Maize is grown for its grain and fodder purpose and mungbean for its protein rich seeds. In order to enhance per unit area yield, there is dire need of growing maize by using more economical techniques. Present study was conducted to evaluate the effect of different rates of zinc sulphate on hybrid maize grown alone and in combination with mungbean at Post Graduate Agricultural Research station, Jhung road, Faisalabad during March 2015. Maize hybrid (DK-6103) and NIAB mung-2006 were used as test crops. The experiment was in two factor factorial under randomized complete block design (RCBD) with plot size of 3.6 × 9 m. Single row hand drill and dibbler were used for sowing following intercropping pattern of sowing maize and mungbean. Results of study showed that $ZnSO_4$ @ 18 kg ha^{-1} increased grain yield, plant population per m^{-2} and oil contents in maize alone, maize protein contents, maize grain yield equivalent in maize + two rows of mungbean, no. of seeds/pod in maize + one row of mungbean and protein contents in mungbean alone. $ZnSO_4$ @ 12 kg ha^{-1} increased the no. of pods in mungbean alone. $ZnSO_4$ @ 6 kg ha^{-1} enhanced no. of plants per m^{-2}, grain yield and biological yield in mungbean alone. No zinc boosted grain weight per cob in maize + one row of mungbean and 1000-grain weight in maize + two rows of mungbean, biological yield in maize alone and 1000-grain weight of mungbean alone. Sole cropping of maize and intercropping of maize+ 2 rows of mungbean should be followed by using $ZnSO_4$ @ 18 kg ha^{-1}.
[Ahmad A and M Tahir. **Effect of different rates of zinc sulphate on hybrid maize grown alone and in combination with mungbean.** *Life Sci J* 2017;14(5):42-48]. ISSN: 1097-8135 (Print) / ISSN: 2372-613X (Online). http://www.lifesciencesite.com. 7. doi:10.7537/marslsj140517.07.

Keywords: maize, mungbean, zinc sulphate, intercropping, protein contents, oil contents

Introduction

Maize grain is used as raw material for making an array of products and also used for value addition. Its share in value addition to agriculture is 2.1 percent while in GDP is 0.4 percent. Area under maize has decreased to 1130 thousand hectares from 1168 thousand hectares in 2014-15. Due to which there was a decrease of 0.5%, i.e. the production has decreased from 4.944 million tons to 4.695 million tons. The decrease in production is due to decrease in area sown. There was an increase of 6.2 % in yield of mungbean as compare to the production of last year. This increase was due to increase in area sown [1]. Keeping in view this situation, Pakistan has to increase per unit area yield on dwindling land to crop ratio. Maize is a crop that is most susceptible to Zinc deficiency, due to the selection of high yielding cultivars, chemical fertilizer used are of high purity and intensive cropping system is usually followed. Zinc deficiency has become more prominent in last decade [2]. Zinc has been reported for increasing grain yield of maize in whole world [3, 4]. Mungbean is rich in amino acid like Lysine, which is usually deficient in cereals. Although it has a number of returns in terms of crop management and food value, the area and production of mungbean is not increasing as compare to other cereals. But in recent years there is a steady growth of area and production of mungbean [5]. Legumes are important source of protein, nutritive fiber and complex carbohydrates, and in whole world there is great concern about unconventional legumes [6]. It was found that the Intercrop system, help the crop plants to improve their growth, yield and production due to the efficient use of energy [7]. The intercropping also helps the crop plants to absorb nutrients from soil and use sunlight much efficiently [8,9]. The prescribed study was conducted to evaluate the effects g zinc sulphate on yield of maize and mungbean in inter cropping system.

Material and methods

A study was conducted to evaluate the effects of different rates of zinc sulphate on hybrid maize grown alone and in combination with mungbean in research area of Postgraduate Agricultural Research Station (PARS) Jhung Road Faisalabad in March 2015. Hybrid maize (DK-6103) and AZRI mung-2006 were sown as test crops. Experiment was sown in randomized complete block design (RCBD) with factorial arrangements have net plot size of 3.6 m ×9 m. Factor A was comprised of intercropping techniques (maize alone, mungbean alone, maize + one row of mungbean, maize + two rows of mungbean) and factor B was $ZnSO_4$ levels (0, 6, 12, 18 kg ha^{-1}). Row to row distance was kept 30 cm, while P × P distance for maize was 22.5cm and in mungbean P × P was 10cm. The parameters taken were grain weight per cob (g), 1000-grain weight (g), plant population (m^{-2}), grain yield (kg ha^{-1}), biological yield (kg ha^{-1}), oil contents, protein contents and maize grain yield equivalent in maize and no. of seeds per pod, no. of pods, plant population (m^{-2}), 1000-grain weight (g), grain yield (kg ha^{-1}), biological yield (kg ha^{-1}) and protein contents of mungbean. Data was statistically analyzed by using Fisher's analysis of variance technique [10].

Results

Grain weight per cob

Grain weight per cob is an important yield contributing factor, which directly influences the grain yield of maize crop. Data from Table 1 showed that both the factors and its interaction had significantly influenced the grain weight per cob. Maximum grain weight per cob (113.23 g) was obtained where maize was grown with two rows of mungbean and no zinc sulphate was used. And lowest grain weight per cob (78.15 g) was obtained in maize alone and zinc sulphate was applied @ 12 kg $ha^{-1.}$

1000-grain weight

Magnitude of seed development can be expressed through 1000-grain weight, as it plays a vital role in determining quality and potential yield of crop. 1000-grain weight is generally a genetically and environmentally controlled factor. Data regarding 1000-grain weight are presented in Table 1, which showed that during growing season of crop, both treatments made a significant effect on the parameter under study and the interaction of the both treatments was also significant. Maximum 1000-grain weight (281.36 g) was observed in treatment, where maize was grown with two rows of mungbean and no zinc sulphate was applied. On the contrary, lowest 1000-grain weight (236.66 g) was observed in the treatment where maize was grown with two rows of mungbean and zinc sulphate was applied @ 6 kg ha^{-1}.

Table 1. Mean performance of maize grown alone and in combination with mungbean under different levels of $ZnSO_4$

Treatment	Grain weight per cob (g)	1000-grain weight (g)	Plant population (m^{-2})	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Oil contents (%)	Protein contents (%)
M_1Z_0	87.70 e	242.67 h	14.54 c	8459 d	28459 b	4.22 e	8.32 g
M_1Z_1	94.55 d	250.01 g	14.65 b	9940 b	27160 c	4.42 c	8.67 f
M_1Z_2	78.15 g	238.63 i	14.58 c	8583 c	25550 d	4.61 b	9.07 de
M_1Z_3	102.80 bc	266.36 c	14.72 a	10734 a	32640 a	4.71 a	9.37 c
M_3Z_0	113.23 a	250.33 g	7.39 e	6340 f	14764 g	3.82 h	9.06 de
M_3Z_1	88.77 e	252.67 f	7.29 fg	4920 j	11174 i	4.12 f	9.05 de
M_3Z_2	85.38 f	267.66 b	7.25 g	4683 k	12712 h	4.42 c	9.27 cd
M_3Z_3	84.70 f	258.00 d	7.39 e	6199 h	18301 e	4.59 b	9.55 bc
M_4Z_0	104.29 b	281.36 a	7.43 e	6210 g	16446 f	3.69 i	8.95 ef
M_4Z_1	89.08 e	236.66 j	7.25 g	4548 l	13651 h	3.80 h	9.42 bc
M_4Z_2	84.66 f	255.36 e	7.33 f	5770 i	15310 g	4.05 g	9.69 b
M_4Z_3	100.96 c	238.33 i	7.50 d	6437 e	17707 e	4.29 d	10.12 a

($P < 0.05$)

Plant population m^{-2} at harvest

Plant population per unit area is an important yield contributing factor which contributes towards the final yield of the crop. Data from Table 1 showed that intercropping, zinc sulphate levels and its interaction had significantly influenced the plant population m^{-2}. Highest plant population m^{-2} (14.72) was presented by maize alone where zinc sulphate was applied @ 18 kg ha^{-1}. And lowest plant population (7.25) was obtained in maize grown with two rows of mungbean and zinc sulphate was applied @ 6 kg ha^{-1}.

Maize grain yield

Maize grain yield is an important component of final grain yield of the crop. Final yield is obtained by using different yield components. By using different rates of zinc sulphate and intercropping, significant maize grain yield was obtained as shown in Table 1. Both the factors and interaction significantly affected the maize grain yield. Maximum maize grain yield (10734 kg ha^{-1}) was obtained in maize alone by using zinc sulphate @ 18 kg ha^{-1}. While lowest grain yield (4048 kg ha^{-1}) was recorded when maize was grown with 2 rows of mungbean.

Biological yield

Biological yield is an important indicator of plant growth. Total dry matter of a crop determines the final biological yield of the crop. If a crop translocate assimilates efficiently, then the total dry matter content increases and hence biological yield increases. Both the factors intercropping and zinc sulphate levels have significantly influenced the biological yield of maize crop. And its interaction was also found to be significant. From the Table 1 it was obvious that highest biological yield (32640.00 kg ha^{-1}) was found where sole maize was grown with zinc application @ 18 kg ha^{-1}. While minimum biological yield (11170.00 kg ha^{-1}) was in maize intercropped with one row of mungbean and zinc was applied @ 6 kg ha^{-1}.

Oil Contents

Data from Table 1 showed that both factors intercropping and zinc sulphate levels have significant influence on oil contents of maize. Maximum oil contents (4.71%) were found in maize alone where zinc sulphate was applied @ 18 kg ha^{-1}. While lowest oil contents (3.69%) were found where maize was grown with one row of mungbean and no zinc sulphate was applied.

Protein contents

It was revealed from data Table 1 that intercropping, soil application of zinc sulphate and its interaction has a significant effect on protein contents (%) of maize crop. Highest protein contents (10.12%) were obtained in maize grown with two rows of mungbean and zinc sulphate was applied @ 18 kg ha^{-1}. While lowest protein contents (8.32%) were found where maize alone was grown and no zinc sulphate was applied.

Mungbean

Number of seeds per pod

Results concerning the effect of intercropping and zinc sulphate levels on number of seeds per pod are presented in Tables 2. It was obvious that effect of zinc sulphate was found non-significant while intercropping and interaction were found to be significant. Maximum number of seeds per pod (8.00) was found in mungbean alone and zinc was applied @ 6 kg ha^{-1}. And it was significantly similar to treatments like M_2Z_3 (mungbean alone + $ZnSO_4$ @ 12 kg ha^{-1}) and M_3Z_3 (Maize+ one row of mungbean and $ZnSO_4$ @ 18 kg ha^{-1}. While minimum number of seeds per pod (6.00) was found in two rows of mungbean intercropped with maize and zinc sulphate was applied @ 6 kg ha^{-1}.

Number of pods per plant

It is one of vital parameters which contribute towards the final yield of crop. Data from Tables 2 showed that intercropping had a significant effect on number of pods per plant while effect of zinc sulphate showed a non-significant behavior. Maximum number of pods per plant (24.67) was found in mungbean alone and zinc sulphate was applied @ 12 kg ha^{-1}. While minimum number of pods per plant (17.00) was present in intercropping of two rows of mungbean and maize.

1000-grain weight

Grain weight has a full bearing on the final yield of mungbean crop. It is an important component of yield contributing factors. Data regarding 1000-grain weight in Table 2 showed that there was a significant difference among both factors and its interaction. Highest 1000-grain weight (44.00 g) was obtained where mungbean was grown alone and no zinc sulphate was applied. While lowest 1000-grain weight (38.70 g) was obtained where maize was grown with two rows of mungbean and zinc sulphate was applied @ 6 kg ha^{-1}.

Plant Population

It is an important yield contributing factor. Optimum plant population per unit area ensures satisfactory crop yield per unit area. Among many other yield contributing factors, plant population is most important one due to its contribution in final yield of the crop. Data regarding plant population is presented in Tables 2. It was evident that both factors had a significant effect on plant population of crop. Maximum plant population (20.34) was present in treatment where mungbean alone was grown and zinc was applied @ 6 kg ha^{-1}. It was significantly at par to M_2Z_3 (mungbean alone with zinc sulphate application @ 18 kg ha^{-1}. Minimum plant population (8.34) was in one row of mungbean intercropped with one row of maize and no zinc was applied.

Grain yield

Seed yield is an important function of collective effects of no. of seeds per pods, no. of pods per plants, plant population and 1000-seed weight, and these parameters are affected by genetic makeup agronomic practices and prevailing environmental conditions. Seed yield is an important one parameter through which effect of treatment can be determined. Data from Table 2 showed the significant effects zinc sulphate and intercropping on seed yield of mungbean. Highest seed yield (988.85 kg ha^{-1}) was obtained where sole mungbean was grown and zinc sulphate was applied @ 6 kg ha^{-1}. While lowest yield (434.64 kg ha^{-1}) was obtained where two rows of mungbean were intercropped with maize.

Biological yield

For determining the activity of photosynthesis, crop biological yield is an important parameter. Through biological yield of crop it can be determined that how much amount is converted into vegetative portion of the crop. Outcome in the form of biological yield as effected by different zinc sulphate levels and intercropping strategies is illustrated in Tables 2. It was evident that maximum biological yield (4822.20 kg ha^{-1}) were obtained where mungbean alone was grown and zinc sulphate was supplied @ 6 kg ha^{-1}. While lowest biological yield (1121.30 kg ha^{-1}) was obtained in intercropping of one line of mungbean with maize.

Protein Contents

It is an important yield characteristic. Data regarding protein contents is depicted in Tables 2. It was obvious that both intercropping and zinc sulphate has significantly enhanced the protein contents of mungbean. The interaction of both factors was also significant. Maximum protein contents (24.65%) were present in mungbean alone and zinc sulphate was applied @ 18 kg ha^{-1}. And lowest protein contents

(22.00%) were present in treatment where maize was intercropped with 2 rows of mungbean and no zinc sulphate was applied.

Table 2. Mean performance of mungbean grown alone and in combination with maize using different levels of $ZnSO_4$

Treatment	No. of seeds per pod	No. of pods per plant	1000-grain weight (g)	Plant population (m^{-2})	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein contents (%)
M_2Z_0	7.34 ab	20.34 cdef	44.00 a	19.00 b	873.76 c	3490.70 c	23.00 g
M_2Z_1	8.00 a	22.67 b	42.00 cd	20.34 a	988.85 a	4822.20 a	23.92 c
M_2Z_2	8.00 a	24.67 a	39.84 efg	17.34 c	759.71 d	3398.30 c	24.50 b
M_2Z_3	7.00 abc	21.34 bcd	43.94 ab	20.00 a	918.93 b	4492.60 b	24.65 a
M_3Z_0	7.00 abc	20.00 def	43.00 abc	8.34 g	474.04 h	1526.80 de	22.17 j
M_3Z_1	7.34 ab	17.84 gh	42.64 bc	10.00 e	520.14 g	1500.40 def	22.90 h
M_3Z_2	6.00 c	19.00 fg	40.27 ef	10.34 e	436.36 k	1471.30 ef	23.29 e
M_3Z_3	8.00 a	18.00 gh	41.00 de	9.34 f	440.57 j	1121.30 i	23.64 d
M_4Z_0	7.00 abc	21.67 bc	42.94 abc	11.34 d	558.71 f	1400.60 fg	22.00 k
M_4Z_1	6.00 c	20.94 cde	38.70 g	9.00 f	434.64 k	1243.50 h	22.25 i
M_4Z_2	6.67 bc	17.00 h	39.11 fg	10.34 e	445.44 i	1305.30 gh	22.87 h
M_4Z_3	7.00 abc	19.68 ef	42.64 bc	10.00 e	575.37 e	1597.20 d	23.20 f

($P<0.05$)

Competitive functions

Maize grain yield equivalent

For assessing the superiority of intercropping system over sole cropping, MGYE is an important tool. MGYE is the seed yield of maize crop and seed yield of intercrop converted into maize seed yield equivalent.

MGYE of maize intercropped with one row of mungbean influenced by different zinc sulphate levels.

Data from Table 3 regarding MGYE of maize intercropped with one row of mungbean showed a negative sign when compared to control treatment. Lowest percentage (-21.61 %) was shown by maize grown with one row of mungbean and zinc sulphate was applied @ 12 kg ha^{-1}.

MGYE of maize intercropped with two rows of mungbean influenced by different zinc sulphate levels

From the table 4 regarding MGYE presented that there was a negative relationship among treatments when compared to control treatment except one treatment which showed some type of compatibility. Highest percentage (+1.06%) increase over control treatment was found where maize was grown with two rows of mungbean and zinc sulphate was applied @ 18 kg ha^{-1}. While lowest percentage (-23.03%) was found where maize was intercropped with two rows of mungbean and zinc sulphate was applied @ 6 kg ha^{-1}.

Table 3. MGYE of maize intercropped with one row of mungbean influenced by different zinc sulphate levels.

Treatments	Description	MGYE	% increase over control
M_1Z_0	M_1 (Maize alone) Z_0 (No zinc application)	8459.02	-
M_3Z_0	M_3 (Maize + 1 row of mungbean) Z_0 (No zinc application)	8094.16	-3.64
M_3Z_1	M_3 (Maize + 1 row of mungbean) Z_1 ($ZnSO_4$ @ 6kg ha^{-1})	6844.99	-16.14
M_3Z_2	M_3 (Maize + 1 row of mungbean) Z_2 ($ZnSO_4$ @ 12 kg ha^{-1})	6297.55	-21.61
M_3Z_3	M_3 (Maize + 1 row of mungbean) Z_3 ($ZnSO_4$ @ 18 kg ha^{-1})	7828.88	-6.30

Table 4. MGYE of maize intercropped with two rows of mungbean influenced by different zinc sulphate levels.

Treatments	Description	MGYE	% increase over control
M_1Z_0	M_1 (Maize alone) Z_0 (No zinc application)	8459.02	-
M_4Z_0	M_4 (Maize + 2 rows of mungbean) Z_0 (No zinc application)	8276.79	-1.82
M_4Z_1	M_4 (Maize + 2 rows of mungbean) Z_1 ($ZnSO_4$ @ 6kg ha^{-1})	6155.73	-23.03
M_4Z_2	M_4 (Maize + 2 rows of mungbean) Z_2 ($ZnSO_4$ @ 12 kg ha^{-1})	7417.85	-10.41
M_4Z_3	M_4 (Maize + 2 rows of mungbean) Z_3 ($ZnSO_4$ @ 18 kg ha^{-1})	8565.56	+1.06

Discussion

Increase in grain weight per cob might be due to proper nutrition and zinc fertilization. Zinc plays an important role in cellular functions and in regulation & activation of several enzymes. These enzymes might have increased the growth and yield related parameters of the crop. It was concluded that cereal-legume intercropping increased the grain weight per cob [11]. Increment in 1000-grain weight might be due to improvement in growth parameters like leaf area index, leaf area duration, net assimilation rate, dry matter accumulation and crop growth rate.

Maize grown in 90 cm apart double row strip increased the 1000-grain weight of maize [12]. Contradictory results were reported that organic/inorganic fertilizers application in maize improved 1000-grain weight [13]. Application of zinc sulphate might have increased the plant population m^{-2}. It was found that establishment of the ideal plant population density is a crucial point for obtaining maximum profits when growing different species together [14]. Increase in maize grain yield might be due to soil application of zinc sulphate. Due to decrease in pH, availability of zinc is increased. There might be an increase in dry matter accumulation and improvement in growth parameters of crop. Zinc concentration increased the grain yield of maize [15]. Maximum maize grain yield can be obtained through seed priming by using P and Zn @ 2% and 2%, respectively [16].

Increase in biological yield might be due to zinc sulphate fertilization and no intercrop competition. Zinc application increases the dry matter content and biological yield (kg ha^{-1}) of maize crop [17]. Oil contents might be influenced by intercropping, and zinc is closely related with oil contents of maize. Zinc application at highest rate also increased the oil contents. It was reported that increment in grain oil contents might be due to more number of grains, more grain yield, net assimilation rates and proper amount of nutrition at proper time [18]. Protein contents might have increased because there is big correlation between Zn and protein contents of seed. As N is an integral part of amino acid, so due to biological nitrogen fixation and high rates of zinc sulphate, protein contents of seed had increased. Combined application of Zinc as priming (2%) and as foliar spray (2%) has significantly increased the protein contents of maize crop by 43.61% and 36.57%, respectively [19].

Mungbean

Increase in number of seeds per pod may be due to zinc fertilization, as zinc improves the translocation of assimilates and hence the yield in the form of seed per pod. It was concluded that zinc application had increased the no. of seeds per pod [20]. Increase in number of pods per plant might be due to proper zinc fertilization and no competition with maize. Results were presented that increase in number of pods per plant increased the final grain yield of the crop [14]. Increase in plant population might be due to proper maintenance, zinc sulphate application and thinning of crop. Thinning of crop improves the growth of crop. Increase in 1000-grain weight might be due to more leaf area and no competition effect. Results were concluded that sole growing of mungbean instead of intercropping, increased the 1000-grain weight, no. of pods per plant, no. of seed per pod and single pod weight [21-23]. Increase in biological yield might be due to sole cropping, more photosynthetic activity under no competition which resulted in more assimilates translocation and more favorable environmental conditions. Results were narrated that in chick pea optimum dose of zinc sulphate increased the no. of pods per plant, seed yield and vegetative growth of mungbean crop [24]. Highest seed yields might be due to no competition effects and zinc sulphate application while low yield might be due to competition effects. It was revealed that zinc sulphate increased the no. of pods per plant which ultimately increased the seed yield of mungbean crop [25]. Zn application might have increased the N availability which in return increased the protein contents of mungbean. Results were presented that zinc has a significant impact in increasing protein contents of mungbean [26-30].

Competitive functions

Maize grain yield equivalent

Increase in MGYE might be due to highest level of zinc and its compatibility with two rows of mungbean. Zinc increased the net photosynthesis of crop which resulted in increased productivity of the crop. As positive value of MGYE shows some benefits while negative value indicates the drawback of treatment or experiment.

References

1. Govt. of Pakistan. 2015. Economic survey of Pakistan 2014-2015. Ministry of food, agriculture and livestock (federal bureau of statistics), Islamabad, Pakistan. pp: 29-30.
2. Fageria, N.K., C. Baligar, R.B. Clark. 2002. Micronutrients in crop production. Advances in Agronomy. 77: 185– 268.
3. Harris, D., A. Rashid, G. Miraj, M. Arif and H. Shah 2007. Priming seeds with zinc sulphate solution increases yields of maize on zinc-deficient soils. Field Crops Res. 102: 119-127.
4. Hossain, M.A., Jahiruddin, M., Islam, M.R., Mian, M.H., 2008. The requirement of zinc for improvement of crop yield and mineral nutrition in the maize-mungbean-rice system. Plant and Soil 306, 13–22.
5. Afzal, M.A., M.A. Bakr, A. Hamid, M.M. Haque and M.S. Akhtar. 2004. Mung bean in Bangladesh. Lentil Black gram and Mung bean Development Pilot Project. Pulses Research Centre, BARI, Gazipur- 1701. 23: 60.
6. Sarwar, S., M.S. Sadiq., M. Saleem and G. Abbas. 2004. Selection criteria in F_3 and F_4 populations of mung bean. Pak. J. Bot. 36: 297-310.
7. Matusso, J.M.M., J.N. Mugwe and M. Mucheru-Muna. 2012. Potential role of cereal-legume intercropping systems in integrated soil fertility management in smallholder farming systems of sub-Saharan Africa Research Application Summary. Third RUFORUM Biennial Meeting 24-28 September 2012, Entebbe, Uganda.
8. Sullivan, P. 2003. Intercropping principles and production practices. Appropriate Technology Transfer for Rural Areas Publication. Retrieved from http://www.attra.ncat.org.
9. Sanginga, N. and P.L. Woomer. 2009. Integrated soil fertility management in Africa: Principles, Practices and Development Process. (Eds.). Tropical Soil Biology and Fertility. Institute of the International Centre for Tropical Agriculture. Nairobi.
10. Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and procedures of statistics. A Biometrical Approach 3rd Ed. McGraw Hill Book Co. Inc. New York, p. 400-428, 1997.
11. Olufemi, O.R. Pitan and J.A. Odebiyi. 2001. The effect of intercropping with maize on the level of infestation and damage by pod-sucking bugs in cowpea. Crop Protection. 20: 367-372.
12. Ehsanullah, M. Javed, R. Ahmad and A. Tariq. 2011. Bio-economic assessment of maize-mash intercropping system. Crop and environ. 2: 41-46.
13. Rehman, S., H.A. Bukhsh and M. Ishaqu. 2008. Comparative performance and profitability of two corn hybrids with organic and inorganic fertilizers. Pak. J. Agric. Sci. 45: 8-12.
14. Morgado, L.B. and R.W. Willey. 2008. Optimum plant population for maize-bean intercropping system in the Brazilian semi-arid region. Sci. Agric. 65: 474-480.
15. Kanwal, S., Rahmatullah, A.M. Ranjha and R. Ahmad. 2010. Zinc partitioning in maize grain after soil fertilization with zinc sulfate. Int. J. Agric. Biol. 12: 299-302.
16. Ali, S., A.R. Khan, G. Mairaj, M. Arif, M. Fida and S. Bibi. 2008. Assessment of different crop nutrient management practices for yield improvement. Aust. J. Crop. Sci. 2: 150-157.
17. Zeb, T. and M. Arif. 2008. Effect of zinc application methods on yield and yield components of maize [abstract]. Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan.
18. Huang, B., W.Z. Sun, Y.Z. Hao, J. Hu, R. Yang, Z. Zou, F. Ding, and J. Su. 2007. Temporal and spatial variability of soil organic matter and total N in an agricultural ecosystem as affected by farming practice. Geoderma. 139: 336-345.
19. Mohsin, A.U., A.U.H. Ahmad, M. Farooq and S. Ullah. 2014. Influence of zinc application through seed treatment and foliar spray on growth, productivity and grain quality of hybrid maize. The J. Anim. & Plant Sci. 24: 1494-1503.
20. Nadergoli, M.S., M. Yarnia and F.R. Khoei. 2011. Effect of zinc and manganese and their application method on yield and yield components of common bean (*Phaseolus vulgaris* L. CV. Khomein). Middle-East J. Sci. Res. 8: 859-865.
21. Tabib, M.F.A.I., M.A. Karim, M.M. Haque, Q.A. Khaliq and A.R.M. Solaiman. 2014. Effect of planting arrangements on productivity of cotton

+ mungbean intercropping systems. Bangladesh Agron. J. 17: 11-22.

22. Mahmood, Z., Afzal, M., Ahmad, M., Munir, MA., Ali, MI., Sharif, MN., and Maqbool, R. (2016). Genetic analysis for morphological traits of *Euphorbia helioscopia*. *Bulletin of Biological and Allied Sciences Research*, 1:5.
23. Ali, MI., Mahmood, Z., Ahmad, M., Afzal, M., Munir, MA., Sharif, MN., and Shakeel, A. (2016). Genetic variability in *Cirsium arvensei* under different environmental conditions. *Bulletin of Biological and Allied Sciences Research*, 1:3.
24. Valenciano, J.B., J.A. Boto and V. Marcelo. 2010. Response of chick pea (*Cicer arietinum* L.) yield to zinc boron and molybdenum application under pot conditions. Spanish J. Agri. Res. 8: 797-807.
25. Munir, MA., Ahmad, M., Ali, MI., Mahmood, Z., Afzal, M., Sharif, MN., and Aslam, M. (2016). Correlation and regression analysis of morphological traits in *Rumex dentatus*. *Bulletin of Biological and Allied Sciences Research,* 1:2.
26. Ahmad, M., Munir, MA., Mahmood, Z., Ali, MI., Afzal, M., Sharif, MN., and Khan, TM. (2016). Multivariate analysis for morphological traits of *Convulvularis arvensis*. *Bulletin of Biological and Allied Sciences Research,* 1:4.
27. Srivastava, A.K., P.N. Tripathi, A.K. Singh and R. Singh. 2006. Effect of *Rhizobium* inoculation, sulphur, and zinc levels on growth, yield, nutrient uptake and quality of summer green gram (*Phaseolus radiatus* L.). Int. J. Agri. Sci. 2: 190-192.
28. Ahmad, A. T., Muhammad (2017). Role of Zinc Sulphate for Maize (Zea mays L.) and Mungbean (Vigna radiata L. Wilczek) yield improvement: A review. *Bulletin of Biological and Allied Sciences Research* 2, 1-17.
29. Mustafa, H. S. B., Tariq M, Ahsan U, Amjad S, Abdul NB, Muhammad N and Rahat A (2017). Role of seed priming to enhance growth and development of crop plants against biotic and abiotic stresses *Bulletin of Biological and Allied Sciences Research* 2, 1-11.
30. Afzal, M., Ali, MI., Munir, MA., Ahmad, M., Mahmood, Z., Sharif, MN., and Aslam, M. (2016). Genetic association among morphological traits of *Lepidium draba*. *Bulletin of Biological and Allied Sciences Research*, 1:1.

5/8/2017