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EFFECT OF FERTILITY LEVELS AND HERBICIDE MIXTURES ON YIELD AND YIELD ATTRIBUTES OF RAINFED MAIZE UNDER TEMPERATE CONDITIONS OF KASHMIR

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ABSTRACT

The present study was aimed to assess the response of rainfed maize to various fertility levels and weed management practices under temperate Kashmir conditions. The field experiment consisted of 3 fertility levels of NPK *viz*., 60:40:20, 75:50:30 and 90:60:40, $N:P_2O_5:K_2O$ kg ha^{-1}) and 4 weed management practices *viz*., no weeding, two hand weeding 20 and 50 days after sowing (DAS), atrazine @ 1.0 kg a.i. ha^{-1} (as pre-emergence) + one hand weeding 20 DAS, and atrazine @ 1.0 kg a.i. ha^{-1} (pre-emergence) + isoprotron @ 1.0 kg a.i. ha^{-1} (post-emergence). The results revealed that fertility levels of 90:60:40 and 75:50:30 (NPK) were at par and showed significant increase in cob length, cobs $plant^{-1}$, grains cob^{-1}, 100-seed weight, grain yield, biological yield and stover yield as against fertility level of 60:40:20 NPK. However, the number of rows cob^{-1} and cob diameter showed significant improvement with increase in fertility level. Increase in fertility level from 60:40:20 to 75:50:30 NPK significantly enhanced harvest index but further addition caused significant decrease. Weed management practices of atrazine as pre-emergence application + one hand weeding at 20 DAS was at par with atrazine as pre-emergence + isoprotron as post-emergence application treatment and both showed significant improvement in all yield contributing characters over no weeding and 2 hand-weedings at 20 and 50 days DAS. Both grain and stover yields were significantly higher with atrazine as pre-emergence application + 1 hand weeding at 20 DAS over hand weeding on 20 and 50 DAS and no weeding.

Key words: Fertility levels, grain yield, maize, weed management, yield attributes

INTRODUCTION

Maize (*Zea mays* L.) belongs to grass family *Gramineae* and is believed to have originated from Mexico or Central America and spread to West Africa with early European traders in 16th century (Revilla *et al*., 2003). It is the 3rd most important cereal crop in the world after rice and wheat and is produced under diverse environments. In industrialized countries maize is largely used as livestock feed and as a raw material for industrial products, while in developing countries it is mainly used for human consumption. Maize is consumed mainly as second-cycle produce in the form of meat, eggs and dairy products. It is an important source of proteins (10.4%), fat (4.5%), starch (71.8%), fiber (3%), vitamins and minerals like Ca, P, S and small amounts of Na (Anorvey, 2011). Its flour is considered good diet for heart patients due to its low gluten (protein) content (Hamayun, 2003).

Plant nutrition is a key input to increase the productivity of maize crop. Nitrogen, phosphorus and potassium are essential nutrients for plant growth and development. They play a fundamental role in metabolism and energy producing in plants and significantly increase grain yield. Nitrogen governs better utilization of potassium, phosphorus and other elements and constitutes 40-50% of plant cell protoplasm on dry weight basis and can be a limiting factor under stressed conditions. Leaf area index (LAI), leaf area duration, crop growth rate and crop photosynthetic rate decreases under nitrogen stress that led to decrease in kernel number and finally grain yield (Uhart and Andrade, 1995). Phosphorus helps in energy transfer reaction in plants and its deficiency restricts both top and root growth. With severe deficiency, the root system is poorly developed (Anonymous, 2000). It is indispensable for cell differentiation and development of tissue, which form the growing points of the plants. It plays major role in hastening crop maturity and ensures timely and uniform ripening of crop (Qasim *et al*., 2001). Potassium acts as macro-nutrient in plant growth and crop production (Marschner, 1986) and plays role in cell expansion, maintains turgor pressure, helps in osmo-regulation of plant cell, assists in opening and closing of stomata (Hsiao, 1973). More than 60 enzymes are activated by potassium (Tisdale *et al*., 1990) so it has promotive effect on growth, development and grain yield in maize (Kasana and Khan, 1976) and plays main role in resistance to drought stress (Davis *et al*., 1996).

Weeds can be controlled by cultural, biological and chemical measures. Cultural methods are useful tools but are laborious, time consuming and expensive. Hand hoe-weeding timely done twice or thrice as well as the use of herbicides have been found effective in controlling weeds in maize (Chikoye *et al*., 2002). Considering the limitations in cultural methods of weed control, herbicide application appears an efficient way to manage weed infestation and helps to achieve speedy breakthrough by increasing maize production (Naveed *et al*., 2008). Weed control in maize through herbicide-use has received little attention and the farmers who apply some herbicides do not apply them adequately as per recommended rates due to high input costs (Aflakpui *et al*., 2005). Use of proper herbicides in appropriate dose and proper time of application are important for lucrative return on maize production (Fayad *et al*., 1998). As there are limitations of every weed control method, therefore an integrated weed management strategy is a considered viable option for sustainable agriculture. in view the above, the present study was aimed to determine the effect of various fertility levels and weed management practices on yield and yield attributes of rainfed maize under temperate conditions of Kashmir.

MATERIALS AND METHODS

The study was conducted during *kharif* 2012 and 2013 at Dryland (Kerawa) Agriculture Research Station, SKUAST-K, Budgam, Kashmir. The area lies between 34^{o} 0.8′ N latitude and 74^{o} 83′ E longitude at an altitude of 1587 m amsl. The mean maximum temperature ranged from 24.3 to 31.5^{o}C and minimum from 9.7 to 17.6^{o}C during 1^{st} cropping season and 21.22 to 32.2^{o}C and 8.2 to19.8^{o}C, respectively, during 2^{nd} cropping season. The total rainfall received during the entire cropping season of 2012 and 2013 was 383.70 mm and 426.10 mm, respectively (Anonymous, 2012; 2013). The experiment was laid out in a randomized block design on the same plot during both the years with treatments comprising of 3 fertility levels of NPK as 60:40:20, 75:50:30 and 90:60:40, $N:P_2O_5:K_2O$ kg ha^{-1} and 4 weed management practices i.e. no weeding, 2 hand weeding on 20 and 50 DAS, application of atrazine @ 1.0 kg a.i. ha^{-1} (pre-emergence) + 1 hand weeding on 20 DAS, and application of atrazine @1.0 kg a.i. ha^{-1} (pre-emergence) + isoprotron @ 1.0 kg a.i.ha^{-1} (post-emergence). Each treatment was replicated three times. Prior to sowing, the experimental field well pulverized and seed bed prepared for seed sowing. The maize variety “C6” was sown at a plant spacing of 75 x 20 cm. Nitrogen, phosphorus and potassium were applied in the form of urea, diammonium phosphate and muriate of potash. Full dose of phosphorus and potassium and 1/3rd of nitrogen was band placed as per the treatments just before seed sowing. Remaining nitrogen was top dressed in two equal splits at knee high and tasselling stages.

Yield attributes *viz.,* cob length, cobs plant^{-1}, grains cob^{-1}, cob diameter, row numbers cob^{-1}, 100-grain weight and cob number plant^{-1} were recorded from five randomly selected plants from each plot. After crop harvest, the cobs and stalk were sun-dried and weighed to obtain biological yield. The grains yield was recorded as kg plot^{-1}. After removal of cobs from stalks, the stalks were weighed to obtain stover yield. Harvest index (%) was determined by dividing grain weight per plot (at 15% moisture content) by total produce per plot and multiplying it by 100. The data obtained was statistically analyzed by using analysis of variance (Cochran and Cox, 1963).

RESULTS AND DISCUSSION

Fertility levels

The yield contributing character *viz*., cob length and diameter, number of cobs plant^{-1}, grain rows and number of grains cob^{-1} and 100-grain weight showed significant increase upto 75:50:30 NPK level, beyond which difference was unmarked (Table 1). Higher cob length and diameter obtained at 75:50:30 NPK level might be due to sufficient supply of nitrogen to the crop because nitrogen being as essential constituent of plant tissue is involved in cell division and cell elongation. Moreover, higher cob length and diameter values noticed at 75:50:30 NPK level means the production of more photosynthates leading to increase in grain number and weight of grains. Rasheed *et al.* (2003) and Onasanya *et al.* (2009) have reported that with the application of 75 kg N and 50 kg of P ha^{-1} the number of cobs plant^{-1}, number of grains cob^{-1}, 100-grain weight, leaf area index, dry matter, crop growth rate and grain yield in maize showed significant increase. Besides increase in 100-grain weight might be due to enhancement in source efficiency and sink capacity (Maqsood *et al.*, 2000).

The seed yield increased significantly upto fertility level of 75:50:30 NPK, beyond which the differences remained insignificant (Table 2). The yield components *viz*., cobs plant^{-1}, grains cob^{-1} and grain weight increased significantly upto 75:50:30 NPK level; thereby revealing that the combined effect of these components caused yield increase as yield is equivalent to the product of cobs plant^{-1}, grains cob^{-1} and grain weight. Similar effect of fertilizers on maize yield and its components has been reported by Maqsood *et al.* (2000). The higher uptake of nutrients by the crop resulted in healthy plants meaning more production of photosynthates leading to higher dry matter production in terms of grain and stover/biological yield. Since nitrogen is involved in cell division and enlongation, phosphorus directly governs the energy relations of plant, thereby the higher uptake of these nutrients accounted for higher grain and stover yield. These findings are in conformity with those of Abdullah *et al.* (2007) and Ghaffar *et al.* (2012). The harvest index showed significant improvement with increase in fertility level of 60:40:20 to 75:50:30 (NPK) but significantly decrease with increase in fertility level from 75:50:30 to 90:60:40 (NPK). Highest harvest index was noticed in treatment 75:50:30 (NPK) which suggested that the capacity of photosynthates to translocate from source to economic part (grain) was higher with 75:50:30 NPK fertilization. Bakht *et al*. (2007) and Onasanya *et al.* (2009) also reported an increase in harvest index with application of N, P and NPK.

Weed management practices

Cob length and diameter, cobs plant^{-1}, grain rows, number of grains plant^{-1} and 100-seed weight (Table 1) recorded in treatments atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + hand

Table 1: Yield contributing characters of maize as affected by fertility levels and weed management practices

Treatments	Cob length (cm)	Cobs plant^{-1} (No.)	Grains cob^{-1} (No.)	Cob diameter (cm)	Rows cob^{-1} (No.)	100-grain weight (g)	Biological yield	Harvest index (%)
Fertility levels (2012)								
60:40:20, NPK	11.49	1.06	318.9	1.73	14.29	19.81	108.35	39.44
75:50:30, NPK	13.96	1.12	332.9	2.09	16.31	20.66	115.16	40.31
90:60:40, NPK	14.23	1.12	334.9	2.14	17.10	20.71	117.27	40.07
SE(m) ±	0.10	0.01	1.84	0.09	0.25	0.27	1.89	0.03
$CD_{0.05}$	0.31	ns	5.67	0.28	0.75	0.85	5.83	0.09
Weed management (2012)								
No weeding	11.83	1.06	312.0	1.58	12.83	18.70	101.88	39.31
Two hand weedings	12.91	1.10	327.4	1.93	15.94	20.02	110.40	39.59
Atrazine [1.0 kg ha^{-1}] pre-emergence + 1 hand weeding	14.11	1.12	340.5	2.23	18.63	22.27	122.69	40.71
Atrazine [1.0 kg ha^{-1}] pre-emergence + isoprotron [1.0 kg ha^{-1}] post-emergence	14.06	1.11	337.5	2.21	16.19	21.26	119.40	40.66
SE(m) ±	0.06	0.02	1.86	0.09	0.26	0.29	2.06	0.04
$CD_{0.05}$	0.20	ns	5.74	0.28	0.78	0.92	6.36	0.14
Fertility levels (2013)								
60:40:20, NPK	14.49	1.08	330.4	1.84	14.88	19.83	109.45	40.26
75:50:30, NPK	15.85	1.13	336.8	2.17	16.48	21.58	117.06	41.00
90:60:40, NPK	16.19	1.14	340.0	2.25	17.22	21.83	119.07	40.55
SE(m) ±	0.27	0.01	1.68	0.04	0.23	0.31	2.09	0.05
$CD_{0.05}$	0.84	0.02	5.18	0.13	0.67	0.97	6.43	0.15
Weed management (2013)								
No weeding	14.05	1.09	319.2	1.78	13.92	18.59	103.58	40.03
Two hand weeding	15.09	1.11	335.2	2.06	16.11	20.29	112.12	40.24
Atrazine [1.0 kg ha^{-1}] pre-emergence + 1 hand weeding	16.45	1.13	346.4	2.31	17.92	22.38	124.25	41.13
Atrazine [1.0 kg ha^{-1}] pre-emergence + isoprotron [1.0 kg kg ha^{-1}] post-emergence	16.21	1.13	343.2	2.20	16.80	22.07	120.82	41.03
SE(m) ±	0.30	0.01	2.05	0.05	0.24	0.32	2.33	0.05
$CD_{0.05}$	0.94	0.03	6.34	0.15	0.69	1.01	7.20	0.16

Two hand weeding done 20 and 50 DAS

weeding 20 DAS and atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron @ 1.0 kg a.i. ha^{-1} post emergence as well as in unweeded treatment were significantly higher than weed control treatment and unweeded treatment. Reduced weed competition due to application of atrazine as pre-emergence allowed the crop stand growth better and utilize available nutrients especially nitrogen which is because of its cell division and cell elongation role improved cob length and diameter as well as the number of cobs plant^{-1}. Higher number of grains cob^{-1} could be attributed to better translocation of metabolites for seed development. Decrease in number of grains in hand weeding 20 and 50 days after sowing and no weeding treatments was due to increase in weed competition (Bibi, 2010). Patel *et al*. (2006) from Gujarat reported that pre-emergence application of atrazine at 0.50 kg a.i ha^{-1} in combination with pendimethalin at 0.25 kg a.i ha^{-1} gave significantly lower density of both monocot and dicot weeds as well as higher 100-seed weight and grain yield of maize as compared to other treatments.

Table 2: Seed and stover yield (q ha^{-1}) of maize as affected by fertility levels and weed management practices

Treatments	Seed		Stover	
	2012	2013	2012	2013
Fertility levels (N:P:K kg ha^{-1})				
60:40:20, NPK	44.60	45.68	67.75	67.78
75:50:30, NPK	46.58	47.99	68.59	69.07
90:60:40, NPK	46.99	48.28	70.27	70.79
SE(m) $\pm$	0.19	0.17	0.73	0.59
$CD_{0.05}$	0.59	0.53	1.85	1.04
Weed management				
No weeding	40.83	42.27	63.05	63.31
Two hand weeding	44.89	46.32	68.51	68.80
Atrazine [1.0 kg ha^{-1}] pre-emergence + 1 hand weeding	49.54	50.69	72.14	72.56
Atrazine [1.0 kg ha^{-1}] pre-emerge-nce + isoprotron [1.0 kg ha^{-1}] post-emergence	48.96	49.99	71.45	71.83
SE(m) $\pm$	0.24	0.26	0.75	0.65
$CD_{0.05}$	0.74	0.82	1.94	1.21

The lowest grain yield was noticed in unweeded treatments (Table 2) which could be attributed to greater renewal of nutrients and moisture by weeds. A severe crop weed competition resulted in poor source and sink development with poor yield components. The results are in agreement with Sinha *et al*. (2003) and Kolage *et al*. (2004). Among weed control treatments atrazine use @1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS; followed by atrazine use @ 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron @ 1.0 kg a.i. ha^{-1} post emergence gave maximum grain yield which could be attributed to the improvement in yield components *viz*., higher number of cobs plant^{-1}, grains cob^{-1} and 100-grain weight. This improvement, in turn, was due to higher dry matter production and distribution in different parts (Kamble *et al*., 2005). This implies that with effective weed control, more plant nutrients are made available to the crop for enhanced leaf area formation that increases solar radiation interception thereby favouring better utilization of photosynthesis for higher grain yield. Both stover and biological yield were significantly higher in atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS and atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron @ 1.0 kg a.i. ha^{-1} post emergence treatments (Table 2). Higher biological and stover yield appears due to higher plant height, more number of functional leaves and higher dry matter production. Harvest index, a ratio of yield biomass to the total biomass at harvest (Worku and Zelleke, 2007), was lowest in no weeding treatment which could be attributed to higher partitioning of assimilates to vegetative biomass at the expense of sink (grains). Significantly higher harvest index was observed in atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS treatment, though it was at par with treatment atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron @ 1.0 kg a.i. ha^{-1} post emergence. This could be attributed to adequate suppression of weed growth and more availability of plant nutrients to maize crop which favoured better utilization of photo-assimilates for grain yield formation. Earlier Subhan *et al*. (2007) found that pre-emergence application of atrazine produced taller plants with longer cobs containing higher number of grains, higher grain and stover yield and harvest index as compared to no weeding treatment. Similarly, Riaz *et al*. (2007) obtained 34% increase in maize grain yield with integrated weed management i.e. atrazine use at 2-3 leaf stage of weeds + hand weeding at 50 DAS over no weeding treatment. This treatment also gave highest net benefit as compared to other treatments with lowest in no weeding. Khan *et al*. (2012) have reported that atrazine treated plots produced higher cob length and grain yield, while the lowest values of these parameters were recorded in control plots i.e. no weeding treatment. This clearly indicated the recognized fact that the weeds suppress the growth of the crop affecting all its yield components and yield as they compete with the main crop for nutrients, light and moisture.

REFERENCES

Abdullah, 2007. *Effect of Planting Methods and Herbicides on Yield and Yield Components of Maize.* M.Sc (Hons) thesis, Agricultural University of Peshawar, Peshawar, Pakistan.

Aflakpui, G.K.S., Abdulai, M.S., Berchie, J.N., Ennin, S. and Sallah, P.Y.K. 2005. *Maize Production*. MoFA Food Development Project. Amayen Press, Kumasi, Ghana.

Anonymous. 2000. *Fertilizers and Their Use.* FAO, International Fertilizer Industry Association, Rome, Italy.

Anonymous. 2012. *Meteorological Report.* Division of Agronomy, SK University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir.

Anonymous. 2013. *Meteorological Report*. Division of Agronomy, SK University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir.

Anorvey, V.Y. 2011. *The Efficacy of Lumax 537.5 se for Weed Control in Maize for Maximum Economic Returns.* M.Phil. thesis, University of Education, College of Agriculture Education, Winneba, Ghana.

Bakht, J., Siddique, M.F., Shafi, M., Akbar, H., Tariq, M., Khan, N., Zubair, M. and Yousef, M. 2007. Effect of planting methods and nitrogen levels on the yield and yield components of maize. *Sarhad Journal of Agriculture,* **23**: 553-559.

Bibi, Z., Khan, N., Akram, M., Khan, Q., Khan, M.J., Batool, S. and Makhdum, K. 2010. Integrating cultivars with reduced herbicides rates for weed management in maize. *Pakistan Journal of Botany,* **42**: 1923-1929.

Chikoye, D., Manyong, V. M., Carsky, R. J., Ekeleme, F., Gbehounou, G. and Ahanchede, A. 2002. Response of spear grass (*Imperata cylindrica*) to cover crops integrated with hand weeding and chemical control in maize and cassava. *Crop Protection,* **21**: 145-156.

Cochran, W.G. and Cox, G.M. 1967. *Experimental Designs.* John Wiley & Sons Inc., New York, USA.

Davis, J.G., Walker, M.E., Parker, M.B. and Mullinix, B. 1996. Long term phosphorus and potassium application to corn on coastal plain soils. *Journal of Production Agriculture,* **9**: 88-94.

Fayad, T.B., Sabry, S.R.S. and Aboul, E.S.H. 1998. Effect of herbicides on weed density, wheat grains yield, and yield component. **In:** *Conference on Weed Biology and Control*. 14-16 March, 1998, Stuttgart Hohenheim, Germany.

Ghaffar, A., Ehsanullah, N., Akbar, S.H., Khan, K., Jabran, R.Q., Hashmi, A., Iqbal and Ali, M.A. 2012. Effect of trench spacing and micronutrients on growth and yield of sugarcane (*Saccharum officinarum* L.). *Australian Journal of Crop Science,* **6**: 1-9.

Hamayun, M. 2003. Effect of spacing and weed free periods on the productivity of maize (*Zea mays* L.). *Pakistan Journal of Weed Science and Research,* **9**: 179-184.

Hsiao, T.C. 1973. Plant response to water stress. *Annual Review of Plant Physiology,* **24**: 519-570.

Kamble, T.C., Kakade, S.U., Nemade, S.U., Pawar, R.V. and Apotikar, V.A. 2005. A integrated weed management in hybrid maize. *Crop Research (Hisar),* **29**: 396-400.

Kasana, N.A. and Khan, M.A. 1976. Studies on the relative efficiency of various complex fertilizers and mixture of straight fertilizer on yield of maize. *Agriculture Journal*, **14**: 127-135.

Khan, N.W., Khan, N. and Khan, I.A. 2012. Integration of nitrogen fertilizer and herbicides for Efficient weed management in maize crop. *Sarhad Journal of Agriculture,* **28**: 457-463.

Kolage, A.K., Shinde, S.H. and Bhilare, R.L. 2004. Weed management in *kharif* maize. *Journal of Maharashtra Agricultural Universities,* **29**: 110-111.

Maqsood, M., Ali, R., Nawaz, N. and Yousaf, N. 2000. The effect of NPK application in different proportions on the growth and yield of spring maize. *Pakistan Journal of Biological Science,* **3**: 356-357.

Marschner, H. 1986. *Mineral Nutrition of Higher Plants.* Academic Press, San Diego, USA.

Naveed, M. Ahmad, R., Nadeem, M.A., Nadeem, S.M., Shahzard, K. and Anjum, M.A. 2008. Effect of new post-emergence herbicide application in combination with urea on growth, yield and weed control in maize (*Zea mays* L.). *Journal of Agricultural Research*, **46**: 186-192.

Onasanya, R.O., Aiyelari, O.P., Onasanya, A., Oikeh, S., Nwilene, F.E. and Oyelakin, O.O. 2009. Growth and yield response of maize (*Zea mays* L.) to different rates of nitrogen and phosphorus fertilizers in Southern Nigeria. *World Journal of Agricultural Sciences,* **5**: 400-407.

Patel, V.J., Upadhyay, P.N., Patel, J.B. and Patel, B.D. 2006. Evaluation of herbicide mixtures for weed control in maize (*Zea mays* L.) under middle Gujarat conditions. *The Journal of Agricultural Sciences*, **2**: 15-20.

Qasim, M., Himayrull, H. and Subha, M. 2001. Effect of increasing levels of phosphorus and seed rate on the economic yield of maize. *Journal of Biological Science*, **1**: 40-42.

Rasheed, M., Hussain, A. and Tariq Mahmood, T. 2003. Growth analysis of hybrid maize as influenced by planting techniques and nutrient management. *International Journal of Agricultural Biology,* **5**: 169-171.

Revilla, P., Soengas, P., Cartea, M.E., Malvar, R.A. and Ordas, A. 2003. Isoenzyme variability among European maize populations and the introduction of maize in Europe. *Maydica*, **48**: 141-152.

Riaz, M., Jamil, M. and Mahmood, T.Z. 2007. Yield and yield components of maize as affected by various weed control methods under rain-fed conditions of Pakistan. *International Journal of Agriculture and Biology,* **9**:152-155.

Sinha, S.P., Prasad, S.M., Singh, S.J. and Sinha, K.K. 2003. Integrated weed management in winter maize (*Zea mays*) in north Bihar. *Indian Journal of Weed Science*, **35**: 273-274.

Subhan, F., Din, N., Azim, A. and Shah, Z. 2007. Response of maize crop to various herbicides. *Pakistan Journal of Weed Sciences Research,* **13**: 9-15.

Tisdale, S.L., Nelson, W.L. and Beaton, J.D. 1990. *Soil Fertility and Fertilizers*. McMillan Publishing Co., New York, USA.

Uhart, S.A. and Andrade, F.H. 1995. Nitrogen deficiency in maize. I. Effects on crop growth, development, dry matter partitioning, and kernel set. *Crop Science*, **35**: 1376-1383.

Worku, M. and Zelleke, H. 2007. Advances in improving harvest index and grain yield of maize in Ethiopia. *East African Journal of Science,* **1**: 112-119.