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Evaluation of Fertility Levels and Herbicide Mixtures for Yield and Yield Attributes of Rainfed Maize under Temperate Conditions of Kashmir Valley

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A B S T R A C T

Present study was undertaken to assess the response of rainfed maize to various fertility levels and weed management practices. A field trial was undertaken in 2012 and 2013 at Experimental Farm, D(K)ARS, SKUAST-Kashmir, (J&K). The experiment consisted of 3 fertility levels (F_1=60:40:20, F_2=75:50:30 and F_3=90:60:40, N:P_2O_5:K_2O kgha^{-1}) and 4 weed management practices (W_0=no weeding, W_1=hand weeding 20 and 50 DAS, W_2=atrazine @1.0 kg a.i.ha^{-1} (pre-emergence) + hand weeding 20 DAS and W_3=atrazine @1.0 kga.i.ha^{-1} (pre-emergence) + isoprotron @1.0 kg a.i.ha^{-1} (post-emergence). The results revealed that fertility levels F_3 and F_2, at par with one another recorded significant increase in cob length, cobs plant^{-1}, grains cob^{-1}, 100-seed weight, grain yield, biological yield and stover yield as against F_1, however, number of rows cob^{-1}, cob diameter showed significant improvement with increase in fertility level from F_1 to F_3. Further, increase in fertility level from F_1 to F_2markedly enhanced the harvest index significantly but with further addition of fertility level it decreased significantly. Weed management practices W_2 being at par with W_3 recorded significant improvement in all yield contributing characters over W_1 and W_0. Both grain and stover yields were also significantly higher with W_2 over W_1 and W_0, however, it was at par with W_3.

Introduction

Maize (*Zea mays* L.), belonging to the grass family *Gramineae*, is believed to have originated from Mexico or Central America and spread to West Africa with early European traders in the 16th century (Revilla *et al.*, 2003). It is the third most important cereal 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 to be a 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 the grain yield. Nitrogen governs better utilization of potassium, phosphorus and other elements and constitutes 40-50 per cent of protoplasm of plant cell on dry weight basis and can be a limiting factor under such 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 the crop (Qasim *et al.*, 2001). Potassium acts as macro-nutrient in plant growth and crop production (Marschner, 1986). It plays role in cell expansion and maintains turgor pressure. It 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). Promotive effect has been observed on growth, development and grain yield in maize (Kasana and Khan, 1976). It also plays an important role in resistance to drought stress as well as K absorption (Davis *et al.*, 1996).

Weeds can be controlled by cultural, biological and chemical measures. Although, cultural methods are still useful tools they are laborious, time consuming and expensive, especially when labour problem is becoming severe day by day. Hand hoe weeding when done timely twice or thrice, or the use of herbicides have controlled weeds effectively in maize (Chikoye *et al.*, 2002). Considering the limitations of cultural methods of weed control, chemical weed control is an important alternative. Herbicide application is an efficient way to check weed infestation that helps achieve speedy breakthrough for increasing maize production (Naveed *et al.*, 2008). Weed control in maize through the use of herbicides has received little attention and the farmers who apply some herbicides do not apply adequate amounts of the recommended rates, citing the high cost of the input (Aflakpui *et al.*, 2005). Proper selection of herbicides, proper time of application and proper dose of herbicides are the important consideration for lucrative return on maize production (Fayad *et al.*, 1998). As there are limitations of every weed control method therefore integrated weed management is a good option for sustainable agriculture.

Keeping in view the above points, the present study was undertaken to determine the effect of fertility levels and weed management practices on yield and yield attributes of rainfed maize.

Materials and Methods

The investigation 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 17.60 ^{o}C during first cropping season and 21.22 to 32.2 ^{o}C and 8.2 to19.8^{o}C during second cropping season. The total rainfall received during the entire growing season of 2010-11 and 2011-12 amounted to 383.70 mm and 426.10 mm, respectively (Anonymous, 2011 and 2012). The experiment was laid out in a randomized block design with combination of 3 fertility levels (viz., F_1 =60:40:20, F_2 =75:50:30 and F_3 =90:60:40, $N:P_2O_5:K_2O$ kg ha^{-1}) and 4 weed management practices (viz. W_0 =no weeding, W_1 =hand weeding 20 and 50 days after sowing, W_2 =atrazine @ 1.0 kg a.i. ha^{-1} (pre-emergence) + hand weeding 20 days after sowing and W_3 =atrazine @1.0 kg a.i. ha^{-1} (pre-emergence) + isoprotron @ 1.0 kg a.i.ha^{-1} (post-emergence) with 3 replications.

Prior to sowing, the field site was three times ploughed approximately 30 cm deep using a cultivator to destroy all types of the growing vegetation and then planking was done to prepare fine seed bed for sowing the seed. The maize variety "C6" was sown at a spacing of 75 cm x 20 cm between rows and plants. Nitrogen, phosphorus and potassium were applied through urea, diammonium phosphate and muriate of potash, respectively. Full dose of phosphorus and potassium and 1/3rd of nitrogen were 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, no. of rows cob^{-1}, and 100-grain weight and number of cobs $plant^{-1}$ were recorded from five randomly selected plants from each plot. After harvesting the crop, cobs and stalks were properly sun dried and bundled. The bundle weight of each net plot was recorded and expressed as biological yield. The grain yield of each net plot was thoroughly cleaned and sun dried. The yield from each plot was recorded separately as kg $plot^{-1}$ and then converted in q ha^{-1}. After removal of the cobs from stalks in each net plot, the stalks were weighed to determine the stover yield in q ha^{-1}. Harvest index (%) was determined by dividing the weight of grains per plot at 15 per cent moisture content by total produce per plot and multiplying by 100.

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

The data obtained in respect of various observations were statistically analyzed by the method described by Cochran and Cox (1963). The significance of "F" and "t" was tested at 5 per cent level of significance.

Results and Discussion

Fertility levels

The investigation revealed that yield contributing character viz., cob length and diameter, number of cobs per plant, grain rows and number of grains per cob and 100-grain weight increased significantly upto F_2 (75:50:30) level beyond which difference was unmarked (Table 1). Higher cob length and diameter obtained at F_2 (75:50:30) 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 F_2 (75:50:30) 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 also reported that with application of 75 kg N and 50 kg of P ha^{-1} significantly increased the number of cobs per plant, number of grains per cob, 100-grain weight, leaf area index, dry matter, crop growth rate and grain yield of maize. Besides increase in 100-grain weight might be due to enhancement in source efficiency as well as sink capacity (Maqsood *et al.*, 2000).

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

Treatments	Cob length (cm)	Cobs plant^{-1}	Grains cob^{-1}(no.)	Cob diameter (cm)	No. of rows cob^{-1}	100-grain weight (g)	Biological yield (g)	Harvest index (%)
Fertility levels (2012)								
F_1 (60:40:20)	11.49	1.06	318.94	1.73	14.29	19.81	108.35	39.44
F_2 (75:50:30)	13.96	1.12	332.94	2.09	16.31	20.66	115.16	40.31
F_3 (90:60:40)	14.23	1.12	334.94	2.14	17.10	20.71	117.27	40.07
SE(m) $\pm$	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)								
W_0(no weeding)	11.83	1.06	312.00	1.58	12.83	18.70	101.88	39.31
W_1(hand weeding 20 and 50 DAS)	12.91	1.10	327.37	1.93	15.94	20.02	110.40	39.59
W_2(atrazine @ 1.0 a.i kg ha^{-1}pre-emergence + hand weeding 20 DAS)	14.11	1.12	340.53	2.23	18.63	22.27	122.69	40.71
W_3 (atrazine @1.0 a.i kg ha^{-1}pre-emergence + isoprotron a.i @ 1.0 post emergence)	14.06	1.11	337.46	2.21	16.19	21.26	119.40	40.66
SE(m) $\pm$	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)								
F_1 (60:40:20)	14.49	1.08	330.40	1.84	14.88	19.83	109.45	40.26
F_2 (75:50:30)	15.85	1.13	336.80	2.17	16.48	21.58	117.06	41.00
F_3 (90:60:40)	16.19	1.14	340.00	2.25	17.22	21.83	119.07	40.55
SE(m) $\pm$	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)								
W_0(no weeding)	14.05	1.09	319.24	1.78	13.92	18.59	103.58	40.03
W_1(hand weeding 20 and 50 DAS)	15.09	1.11	335.20	2.06	16.11	20.29	112.12	40.24
W_2(atrazine @ 1.0 a.i kg ha^{-1} pre-emergence + hand weeding 20 DAS)	16.45	1.13	346.40	2.31	17.92	22.38	124.25	41.13
W_3 (atrazine @1.0 a.i kg ha^{-1} pre-emergence + isoprotron a.i @ 1.0 post emergence)	16.21	1.13	343.20	2.20	16.80	22.07	120.82	41.03
SE(m) $\pm$	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

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})				
F_1 (60:40:20)	44.60	45.68	67.75	**67.78**
F_2 (75:50:30)	46.58	47.99	68.59	**69.07**
F_3 (90:60:40)	46.99	48.28	70.27	**70.79**
SE(m) ±	0.19	0.17	0.73	**0.59**
$CD_{0.05}$	0.59	0.53	1.85	**1.04**
Weed management				
W_0	40.83	42.27	63.05	**63.31**
W_1	44.89	46.32	68.51	**68.80**
W_2	49.54	50.69	72.14	**72.56**
W_3	48.96	49.99	71.45	**71.83**
SE(m) ±	0.24	0.26	0.75	**0.65**
$CD_{0.05}$	**0.74**	**0.82**	**1.94**	**1.21**

The study revealed that seed yield increased significantly upto fertility level F_2 (75:50:30) beyond which level the differences remained unmarked (Table 2). The yield components viz., cobs per plant, grains per cob and grain weight increased significantly upto F_2 (75:50:30) level thereby the combined effect of these components resulted in yield increase as yield is equivalent to the product of cobs per plant, grains per cob and grain weight. Similar effect of fertilizer levels on maize yield and its components was reported by Maqsood *et al.*, (2000). The higher uptake of nutrients by the crop produced 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 cell enlongation, phosphorous directly governs the energy relations of the 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 from F_1 (60:40:20) to F_2 (75:50:30) but significantly decreased with increase in fertility level from F2 (75:50:30) to F3 (90:60:40).

Highest harvest index was recorded with F_2 (75:50:30) which suggested that the capacity of photosynthates to translocate from source to economic part (grain) was higher with F_2 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 per plant, grain rows, number of grains per plant and 100-seed weight (Table 1) recorded under W_2 (atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) and W_3 (atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron @

1.0 kg a.i. ha^{-1} post emergence) treatments as well as unweeded treatments 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 per plant.

Higher number of grains per cob could be attributed to better translocation of metabolites for seed development and decrease in number of grains in W_1 (hand weeding 20 and 50 days after sowing) and W_0 (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} recorded significantly lower density of both monocot and dicot weeds and also recorded higher 100-seed weight and grain yield of maize as compared to other treatments.

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 W_2 (atrazine @1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) followed by W_3 (atrazine @ 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 improved yield component viz.; higher number of cobs/plant, grains per cob 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 and efficient 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 also significantly higher under W_2 (atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) and W_3 (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 yield and stover yield is the effect of 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 W_0 (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 W_2 (atrazine @ 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) treatment though at par with W_3 (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 as well as 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 compared to no weeding treatment. Similarly, Riaz *et al.,* (2007) obtained 34% increase in grain yield of maize with integrated weed management i.e. atrazine treatment at 2-3 leaf stage of weeds + hand weeding at 50 DAS over no weeding treatment. The said treatment also gave highest net benefit compared to other treatments with lowest in no weeding. Further, Khan *et al.*, (2012) 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 the main crop for nutrients, light and moisture.

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