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Scientific Research and Essays

Full Length Research Paper

Studies on chemical solutions and storage duration on keeping quality of cut gladiolus (*Gladiolus grandiflorus* L.) spikes ('White Prosperity')

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The experiment was carried out to investigate the effect of different chemical solutions (C_1= sucrose (20%) + [Al_2 $(SO_4)_3$.-16H_2O 300 ppm], C_2= sucrose (20%) + [Al_2 $(SO_4)_3$.-16H_2O] 300 ppm + GA_3 50 ppm and C_3= Control (Distilled water)) and five storage durations viz., (S_0 = 0 days, S_1 = 7 days, S_2 = 14 days, S_3 = 21 days and S_4 = 28 days) on keeping quality of cut spikes of gladiolus 'White Prosperity'. The results showed that chemical solutions as well as storage durations significantly influenced the studied parameters. Among the chemical solutions, C_2 was significantly superior with regard to days to open basal floret, vase life, number of florets opened, floret size, longevity of open florets and fresh weight gain/loss, while the lowest values of these parameters were recorded in control treatment. Similarly, shorter storage durations of 0 days (S_0) recorded higher vase life, longevity of open floret and total water absorption, while days to open the basal floret and floret size were superior in S_3 storage and rest of the parameters were significantly higher in S_2 storage duration. The spikes stored in S_4 treatment did not open either pulsed with chemical solutions or in control.

Key words: Aluminium sulphate, gladiolus, gibberellic acid, sucrose, storage duration, quality parameters.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is an important ornamental and commercial flower known as queen of the bulbous plants, belongs to *Iridaceae* family and is valued for its wide range of flower colours, attractive shapes, varying sizes, large number of florets per spike, excellent keeping quality and popular as cut flower in the domestic and international market. Gladiolus is grown under varying climatic conditions and its spikes possess good vase life with variously-coloured elegant florets, which open in an acropetal succession.

Keeping quality is an important parameter for the evaluation of cut flower quality, for both domestic and export markets. One of the greatest problems in postharvest flower physiology is the blockage of vascular

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system, due to air or bacterial growth, which reduces water uptake and this blocks xylem vessels leading to water stress (Van Meetern et al., 2001) that expresses in the form of early wilting of flowers (Henriette and Clerkx, 2001), as a result of premature loss of cell turgidity and might appear when water uptake and transpiration are out of balance during a lasting. Adding chemical preservatives to the holding solution is recommended to prolong the vase life of the cut flowers. All holding solutions must contain essentially two components; sugar and germicides. The sugar provides a respiratory substrate, while the germicides control harmful bacteria and prevent plugging of the conducting tissues. Among all the different types of sugars, sucrose has been found to be the most commonly used sugar in prolonging vase life of cut flowers. The exogenous application of the sucrose supplies the cut flowers with substrates needed for respiration, and enables cut flowers harvested at the bud stage to open, which otherwise could not occur naturally (Pun and Ichimura, 2003). Cut flowers should be free of any deterioration, as this is one of the principal entry points for decay organisms. A major form of deterioration in cut flowers is the blockage of xylem vessels by air and microorganisms that cause xylem occlusion (Hardenburg, 1968). The $Al_2(SO_4)_3$ is a very important germicide in preservatives used in floral industry and acts as an antimicrobial agent which can led to increase water uptake. Its application increases the vase life as well as the fresh weight (percentage of initial) of the cut flowers and prevent the growth of the microorganisms in xylem vessels of the cut flower stems and maintained water uptake and becomes more effective when sugars particularly sucrose are coupled with it (Pun and Ichimura, 2003). On the other hand, gibberellic acid (GA_3) helps in breaking dormancy, stimulates the synthesis of specific RNA for protein metabolism. Cut flowers are living actively metabolizing plant parts and petals are an excellent model system for the study of fundamental senescence processes. If flowers are to provide their longest possible decorative role, controlled rate of opening or their development is needed with colour stability. The objective of this work was to investigate the effect of storage duration and chemical solutions on keeping quality of cut gladiolus 'White Prosperity' spikes especially when used for flower arrangements and interior decorations.

MATERIALS AND METHODS

The present work was conducted at the Laboratory of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, S. K. University of Agricultural Sciences and technology of Kashmir, Srinagar, J&K, India during 2014. Experiment was arranged in a complete randomized design with four replications. Five spikes were used per replication. Spikes of gladiolus 'White Prosperity' were harvested from the field-grown crop, at tight bud stage (when colour was visible in basal 1-2 florets) and stored under wet refrigerated conditions (3.5 to 4.0°C temperature; 85 to 90% R.H.) for 0, 7, 14, 21 and 28 days. The spikes were subjected to three treatments with chemical solution. In treatment 1 (C_1) the spikes were subjected to pre-storage treatment with pulsing solution containing sucrose (20%) + $Al_2(SO_4)_3$.-$16H_2O$ (300 ppm) for 20 h at 23±2°C temperature, 60 to 70% relative humidity and 24 h illumination (1000 lux intensity) provided by white fluorescent tubes, in an air-conditioned laboratory, held in water during storage. In treatment 2 (C_2), the spikes were treated with chemical solution containing sucrose (20%) + $Al_2(SO_4)_3$.-$16H_2O$ (300 ppm) + GA_3 50 ppm and in treatment 3 (C_3) the spikes were subjected to distilled water i.e. control treatment. The treatments were given by dipping basal 5 to 7 cm portions of the spikes in the respective solution.

The observations were recorded on days for basal floret to open, vase life (days), florets opened (%), floret size (cm), longevity of open floret (days) and per cent change in fresh weight after storage. The results were interpreted according to Steel and Torrie (1980) and the differences between the means of the treatments were considered significant when they were equal or more than the least significant difference (L.S.D.) at the 5% level.

RESULTS AND DISCUSSION

Effect of chemical solution

The results of the experiment revealed that pre-storage pulse treatment recorded superior keeping quality characters of gladiolus cut spikes as compared to control treatment. Perusal of data (Table 1) showed that C_2 treatment took significantly less days to open basal florets which was followed by C_1 and maximum days were taken by C_3 (control). It has earlier been reported that pulsing treatment with 20% sucrose as well as vase solution containing 4% sucrose took significantly less days to open basal florets of cut gladiolus spikes (Singh et al., 2007). Sucrose is reported to promote microbial growth in vase solution but when applied in combination with $Al_2(SO_4)_3$.-$16H_2O$ (400 mg l^{-l}), it significantly improved vase life and opening of florets in gladiolus due to inhibition of microbial contamination of vase solution (Singh et al., 2000). Among the treatments vase life was enhanced significantly more than double by C_1 (8.57 days) as compared to 4.06 days recorded by control (C_3), while C_2 recorded 7.53 days vase life. Significantly highest percentage of florets opened and floret size was recorded in C_2, whereas minimum values of these parameters were exhibited by control treatment. These results might be due to the presence of sucrose in the solution that had acted as a food source or respiratory substrate and delayed the degradation of proteins and improved water balance of cut flowers. Steinitz (1982) opined that addition of sucrose to the solution increased the mechanical rigidity of the stem inducing cell wall thickening and lignifications of vascular tissues. Sucrose antagonized the effect of ABA, which promoted senescence. Sugars alone, however, tend to promote microbial growth, therefore, the combination of $Al_2(SO_4)_3$ improved the vase life of cut flowers as $Al_2(SO_4)_3$ is a very effective biocide, which completely inhibited the microbial growth. However, dilute solution of sucrose

Table 1. Effect of dry refrigerated storage of cut gladiolus 'White Prosperity' spikes with pre-storage pulsing treatment for 24 h).

Treatment	Days for basal floret to open	Vase life (days)	No. of florets opened (%)	Floret size (cm)	Longevity of open floret (days)	Per cent gain/loss in FW after storage	Total water absorbed (ml spike^{-1})
Chemical solution (C)							
*Su (20%)+ **AS 300 ppm - (C_1)	1.19	8.57	63.66	9.02	3.88	1.12	42.40
Su (20%)+AS 300 ppm+ GA_3 50 ppm - (C_2)	1.02	7.53	66.86	9.28	4.30	1.23	45.09
Control (Distilled water) - (C_3)	1.58	4.06	57.37	7.87	2.79	0.38	28.90
CD (P = 0.05)	**0.06**	**0.14**	**0.61**	**0.13**	**0.07**	**0.09**	**1.23**
Storage duration (S)							
0 days (S_0)	2.36	10.16	84.66	11.61	6.03	0.00	69.11
7 days (S_1)	1.80	9.66	89.22	11.97	5.28	2.98	55.64
14 days (S_2)	1.30	8.33	77.88	10.64	4.13	2.00	44.61
21 days (S_3)	0.86	5.33	61.38	9.39	2.85	0.94	19.63
28 days (S_4)	0.00	0.00	0.00	0.00	0.00	-1.35	5.00
CD (P = 0.05)	**0.10**	**0.21**	**1.07**	**0.27**	**0.17**	**0.15**	**2.13**

*Su = Sucrose, ** AS = Aluminum Sulphate = $Al_2(SO_4)_3$.

provided ideal media for microbial growth. The microbes entered into the vascular bundles and might block the water uptake, thus affecting the keeping quality of cut spikes in vase solution. Further, Grover (2001) reported that maximum floret opening might be due to the higher soluble sugars in the buds and cell division and cell elongation by GA_3 by promoting DNA synthesis in the cell. The present findings are in close agreement with the earlier reports of Namita and Singh (2006); Nelofar and Paul (2008); Marandi et al. (2011); Mehraj et al. (2013) and Mahawar et al. (2015).

Longevity of the open floret was significantly higher in C_2 over other treatments. Such increase in longevity might be attributed that aluminum sulfate inhibited the action of ethylene and leading to a decrease in lipoxygenase (Lox) activity as well as served as an antibacterial component and prevented the growth of microorganism in the xylem and thus maintained water uptake by flower stems (Sarkka, 2005), while sucrose reduced the initial water uptake due to the decrease in osmotic potential of sucrose solution. In addition, sucrose inhibited ethylene synthesis as well as promoting bud opening and inhibiting flower senescence (Ichimura and Hisamatsu, 1999). The present findings are in conformity with the earlier reports of Singh et al. (2007), Nelofar and Paul (2008) and Seyf et al. (2012).

Treatment C_2 exhibited significantly higher gain in fresh weight over other treatments. Similarly, the same treatment recorded the highest total water absorption, while the lowest water absorption was recorded in C_3 (control) treatment. Nelofar and Paul (2008) also reported gain in fresh weight of gladiolus 'White Prosperity' spikes in combined treatment of sucrose and aluminum sulphate. These results might be due to maximum uptake of water by the flowers as influenced by pulsing and germicidal properties of aluminum sulphate in addition to inhibition of ethylene biosynthesis which resulted in gain in fresh weight.

Effect of storage duration

Pulsed spikes of gladiolus held in different dry storage durations varied significantly for keeping quality characters, however, cut spikes kept for 28 days long duration (S_4) did not open florets, hence data on most of the floret quality parameters wasn't recorded for this treatment. The data presented in Table 1 revealed that S_3 storage took minimum 0.86 days to open the basal floret which was closely followed by S_2, whereas, S_4 spikes did not open either pulsed with chemical solutions or in control. It has earlier been reported that the florets of gladiolus lose the ability to open with advancement in the duration of storage (Arora et al., 2001). Significantly maximum vase life was exhibited by S_0 (10.16 days), followed by S_1, S_2

and S_3 recording 9.66, 8.33 and 5.33 days, respectively. Highest percentage of florets opened was recorded in S_1 (89.22%) treatment and the same treatment exhibited significantly highest floret size (11.97 cm), whereas the lowest floret size was measured in S_3 treatment (9.39 cm). The storage duration of S_0 was significantly superior with regard to the longevity of open floret (6.03 days) over other treatments which was closely followed by S_1, S_2 and S_3 with 5.28, 4.13 and 2.85 days, respectively. Percent gain in fresh weight was observed maximum by S_1 (2.98%) while S_4 spikes recorded loss in fresh weight (-1.35%) after storage. Similarly, total water absorbed was measured significantly highest by S_0 (69.11 ml spike^{-1}). The present findings are in agreement with the earlier reports of Nelofar and Paul (2008).

Conflict of Interest

The authors have not declared any conflict of interest.

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Scientific Research and Essays

Full Length Research Paper

Influence of fertility levels and weed management practices on yield and yield attributes of rain-fed maize

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Investigating the response of rain-fed maize to 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 and 4 weed management practices. The results revealed that fertility levels F_3 and F_2 at par with one another recorded significant increase in cob length, number of cobs plant^{-1}, number of grains cob^{-1}, 100-seed weight, grain yield, and stover yield as against F_1 during both the years, however, number of rows cob^{-1}, cob diameter showed significant and consistent improvement with increase in fertility level from F_1 to F_3 during both years of study. Further, fertility levels F_3 recorded significant increase in biological yield over F_1, however, increase in fertility level from F_1 to F_2 increased the harvest index significantly during both years of study. 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 significantly higher with W_2 over W_1 and W_0, however, it was at par with W_3 during 2012 and 2013. W_3 and W_2 at par with one another recorded significantly higher biological yield and harvest index over W_1 and W_0 during both the years of experimentation.

Key words: Fertility levels, weed management, yield, yield attributes, rain-fed maize.

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. It is the third most important cereal in the world after rice and wheat. It is produced throughout the country under diverse environments. About 54% of the world is suitable for rain-fed agriculture, whereas 80% of agricultural production is form rain-fed areas (Valipour, 2013). Maize is generally grown as rain-fed crop in most of the areas of the world and its productivity is lower, compared to the crop grown under irrigated conditions, however, under irrigated conditions its productivity and intensity can be increased due to maximum utilization of inputs (Valipour, 2014). It is an important source of proteins (10.4%), fat (4.5%), starch (71.8%), fiber (3%), vitamins and minerals like Ca,

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P, S and small amounts of Na. 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. Out of several nutrients provided to plants, nitrogen is a major and limiting nutrient for better plant growth and yield, as this crop is exhaustive in nature and requires more energy. It is considered as most important nutrient for the crop to activate the metabolic activity and transformation of energy, chlorophyll and protein synthesis. It governs better utilization of potassium, phosphorus and other elements and constitutes 40 to 50% of protoplasm of plant cell on dry weight basis and can be a limiting factor under such conditions. Phosphorous is another fascinating plant nutrient. It is involved in wide range of plant processes right from cell division to development of good root system. It plays major role in hastening crop maturity and ensures timely and uniform ripening of the crop. It is constituent of ADP and ATP, the most important substance in the life processes. Potassium is an essential nutrient and is also the most abundant cation in plants. It plays essential roles in enzyme activation, protein synthesis, photosynthesis, osmo-regulation, stomatal movement, energy transfer, phloem transport, cation-anion balance and stress resistance. The major limitation for plant growth and crop production under rain-fed condition is soil water availability. Plants that are continuously exposed to drought stress can form reactive oxygen species (ROS), which leads to leaf damage and, ultimately, decreases crop yield. During drought stress, root growth and the rates of K^+ diffusion in the soil towards the roots are both restricted, thus limiting K acquisition. The resulting lower K concentrations can further depress the plant resistance to drought stress, as well as K absorption. Maintaining adequate plant K is, therefore, critical for plant drought resistance.

Control of weeds is yet another important practice to increase the productivity of this crop under rain-fed conditions. Farmers usually give prime importance to few cultural practices and neglect other factors like weed control. As the maize is usually grown during the hot summer months of May and June when manual method of weed control is difficult to employ therefore, other methods of weed control are more feasible, less laborious, cost effective and economical. Weed management strategies attempt to limit the deleterious effects of weeds growing with crop plants. These effects could be quite variable, but the most common is competition for available resources. The quantities of growth factors used by weeds are thus unavailable to the crop. 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 rain-fed maize.

MATERIALS AND METHODS

The investigation was conducted during *kharif* 2012 and 2013 at Dryland (Kerawa) Agriculture Research Station, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Budgam. The area lies between 34° 0.8′ N latitude and 74° 83′ E longitude at an altitude of 1587 m above the mean sea level. The mean maximum temperature ranged from 24.3 to 31.5°C and minimum from 9.7 to 17.60°C during first growing season and 21.22 to 32.2 and 8.2 to 19.8°C during second growing season. The total rainfall received during the entire growing season of 2010-11 and 2011-12 amounted to 383.70 and 426.10 mm, respectively. The experiment was laid out in 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 at 1.0 kg a.i. ha^{-1} (pre-emergence) + hand weeding 20 days after sowing and W_3 = Atrazine at 1.0 kg a.i. ha^{-1} (pre-emergence) + Isoprotron at 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 × 20 cm between rows and plants. The trial was irrigated when required. Full dose of phosphorus and potassium and $1/3^{rd}$ of nitrogen were band placed as per the treatments just before sowing of seed. Remaining nitrogen was top dressed in two equal splits at knee high and tasselling stages. Nitrogen, phosphorus and potassium were applied through urea, diammonium phosphate and muriate of potash, respectively.

For recording of data on yield attributes viz., cob length (cm), cobs $plant^{-1}$, grains cob^{-1}, cob diameter (cm), number of rows cob^{-1} and 100-grain weight (g) number of cobs of five randomly selected plants from each plot were used. After harvesting the crop, cobs and stalks were properly sun dried and bundled. The bundle weight of each net plot was recorded and was expressed as biological yield in q ha^{-1}. 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% 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% level of significance. The critical difference was determined when "F" test was significant.

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 similar findings. Besides increase in 100-grain weight might be due to enhancement in source efficiency as well as sink capacity (Maqsood et al., 2000).

The study revealed that seed yield increased significantly upto fertility level F_2 (75:50:30) beyond which level the difference was 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. Similar effect of fertilizer levels on maize yield and its components was reported by Maqsood et al. (2000). The stover yield also showed increasing trends as that of grain yield. 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. Abdullah et al. (2007) and Ghaffar et al. (2012) also reported similar findings. 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). Harvest index reflects physiological efficiency of the crop. Higher harvest index obtained with F_2 (75:50:30) level means that the capacity of photosynthates to translocate from source to economic part (grain) was higher. Mahmood et al., (1999), 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

Various yield contributing characters viz., cob length and diameter cobs per plant grain rows and number of grains per plant and 100-seed weight (Table 1) recorded under W_2 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) and W_3 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron *at* 1.0 kg a.i. ha^{-1} post emergence) treatment as well as unweeded treatments were significantly higher than other weed control treatment as well as unweeded treatment. In fact reduced weed competition due to application of atrazine as pre-emergence allowed the crop stand growth better and utilize the available nutrients especially nitrogen which is because of its cell division and cell elongation role improved cob length and diameter as well as 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) reported that maximum 100-seed weight was recorded with 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}.

The results of the investigation reveal that the lowest grain yield was found under unweeded treatments (Table 2). This could be attributed to greater renewal of nutrients and moisture by weeds and a severe crop weed competition resulted in poor source and sink development with poor yield components. The results could be collaborated with the findings of Sinha et al. (2003) and Kolage et al. (2004). Among weed control treatments W_2 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) followed by W_3 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron at 1.0 kg a.i. ha^{-1} post emergence) recorded 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 at 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) and W_3 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron at 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 is defined as a ratio of yield biomass to the total biomass at harvest (Worku and Zelleke, 2007). During the study it was found that lowest harvest index was observed under 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 under W_2 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + hand weeding 20 DAS) treatment though at par with W_3 (atrazine at 1.0 kg a.i. ha^{-1} pre-emergence + isoprutron at 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. Similar results have been discussed by Subhan et al. (2007), Riaz et al. (2007) and Khan et al. (2012).

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

Treatment	Cob length (cm)	Cobs plant^{-1}	Grains cob^{-1}	Cob diameter (cm)	No. of rows cob^{-1}	100-grain weight (g)	Biological yield	Harvest index
Fertility levels (2012)								
F_1	11.49	1.06	318.94	1.73	14.29	19.81	108.35	39.44
F_2	13.96	1.12	332.94	2.09	16.31	20.66	115.16	40.31
F_3	14.23	1.12	334.94	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 (p=0.05)	0.31	NS	5.67	0.28	0.75	0.85	5.83	0.09
Weed management (2012)								
W_0	11.83	1.06	312.00	1.58	12.83	18.70	101.88	39.31
W_1	12.91	1.10	327.37	1.93	15.94	20.02	110.40	39.59
W_2	14.11	1.12	340.53	2.23	18.63	22.27	122.69	40.71
W_3	14.06	1.11	337.46	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 (p=0.05)	0.20	NS	5.74	0.28	0.78	0.92	6.36	0.14
Fertility levels (2013)								
F_1	14.49	1.08	330.40	1.84	14.88	19.83	109.45	40.26
F_2	15.85	1.13	336.80	2.17	16.48	21.58	117.06	41.00
F_3	16.19	1.14	340.00	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 (p=0.05)	0.84	0.02	5.18	0.13	0.67	0.97	6.43	0.15
Weed management (2013)								
W_0	14.05	1.09	319.24	1.78	13.92	18.59	103.58	40.03
W_1	15.09	1.11	335.20	2.06	16.11	20.29	112.12	40.24
W_2	16.45	1.13	346.40	2.31	17.92	22.38	124.25	41.13
W_3	16.21	1.13	343.20	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 (p=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.

Treatment	Seed yield		Stover yield	
	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 (p=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 (p=0.05)	0.74	0.82	1.94	1.21

Conflict of Interest

The authors have not declared any conflict of interest.

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