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Increasing the Quality and Yield Attributes of Late Sown Forage Sorghum through Seed Priming of Different Growth Substances

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Abstract- A field trial was conducted at Agronomic Research Area, University of Agriculture Faisalabad during August 2015, to evaluate the effect of priming and foliar applications of different growth promoting substances on sorghum. The experiment was laid out in randomized complete block design (RCBD) with three replications. Net plot size was 3 m × 1.8 m. The research trial was comprised of eight treatments i.e. control (no seed treatment), hydropriming, priming with $CaCl_2$, hardening with $CaCl_2$, priming with moringa leaves extract, priming + foliar application of $CaCl_2$, priming + foliar application of moringa leaves extract and hardening+ foliar application of $CaCl_2$. All the priming treatments significantly affected E_{50}, MET, plant height, stem diameter, fresh weight of plant, dry weight of plant, number of leaves, leaf area, fresh weight of leaves, protein contents, fiber contents, total ash percentage fresh forage yield and dry matter yield of the sorghum crop. It may be concluded that seed priming along with foliar applications of growth promoting substances may serve as an appropriate treatment for accelerating the emergence as well as final yield of the crop and priming, along with foliar applications of MLE is the best choice in this regard.

Index Terms- seed priming, sorghum, yield and quality, hydro priming, moringa extract, CaCl2

I. Introduction

Fooder crops in Pakistan are grown on an area of 2236 thousand hectares, with production of 49237 thousand tons of green fodder (Government of Pakistan, 2015). Existing forage production in Pakistan is far less than requirement. Fodders supply 2-3 times cheaper feed than other concentrates (Shehzad*et al.,* 2012).

In Pakistan, there are two fodder scarcity periods i.e. May-June and October-November. There are many factors that limits the production of livestock in Pakistan, among which fodder scarcity periods and allotting more area to cash crops are important. Due to this reason the animals are generally underfed which affect the production of livestock. Due to the shortage of fodder crops, dairy farmers depends on wheat straw and other concentrates which are used as larger rates to feed animals, moreover wheat straw does not contain sufficient amount of nutrients to fulfill the nutritional demand of animals.

Sorghum (*Sorghum bicolor* L.*),* locally known as jowar or charry, belongs to family Poaceae, is a multi-purpose cereal crop used for forage as well as for grain purpose. Sorghum is a dual-purpose, short- day annual crop of kharif season mostly grown as a fodder crop in Pakistan. Its fodder is quite succulent, palatable and highly relished by milch animals.

Sorghum is grown on an area of 171,000 hectares with annual production of 103,000 tons (Govt. of Pakistan, 2015). As it is mentioned earlier that sorghum is a drought resistant crop so, it enjoys reasonable importance in rain-fed areas of Pakistan and covers almost 50 % of the requirement of rain-fed areas with providing feed to livestock even in winter fodder scarcity periods. Many factors can reduce the forage yield and quality of sorghum such as improper sowing time (Sattar*et al*., 2010), poor seed health (Farooq *et al*., 2006), imbalanced use of fertilizer, improper irrigation (Kibe*et al*., 2006), planting of low yielding varieties and weeds infestation (Abouziena *et al*., 2008). In addition to this, the poor crop stand which is caused by temperature and water stress in rainfed areas affect the sorghum crop (Sharma-Natu*et al.,* 2006). All these factors lead to fodder scarcity issue in Pakistan.

Early onset of monsoon especially in arid areas of the country due to which sowing of crop at optimum time is difficult, reduces the yield as well as the quality of sorghum crop. So there is a need of technique that might enhance germination rate, repair damaged seeds and give good crop establishment, so that the goal of obtaining the maximum yield with late sowing of crop could be achieved. Presently exogenous application of growth promoting substances is a new, easy and short gun approach to increase germination rate, growth and yield (Afzal *et al.*, 2008; Bakht*et al.*, 2011). As sorghum produces allelo chemicals internally, so it respond better to exogenous applied plant hormones also (Davies, 1987).

Seed priming is the technology that enhances early emergence and stand establishment and enable the crop to capture more soil moisture, nutrients and solar radiation. Rapid and uniform crop emergence is an essential pre-requisite to obtain the yield potential and quality in annual crops, which ultimately increase the profit (Parera and Cantliffe, 1994). Priming repairs damaged seeds (Butler *et al*., 2009) or the seeds which are exposed to abiotic stresses such as salinity (Ehsanfar*et al*., 2006), and improves the germination performance.

Different priming techniques are used to enhance the germination and seedling growth under controlled conditions, among which osmopriming, hydropriming, halopriming and hormone priming are important (Ghiyasi*et al*., 2008).

*Moringaoleifera*belonging to family Morangaceae is exceedingly valuable tree and proved as a good source of antioxidant agents (Khalafalla*et al.*, 2010). The extract of moringa leaves is a good growth promoter of different crops (Afzal *et al.*, 2012; Ashfaq*et al.*, 2012). The foliar application of moringa leaf extract is important to increase the seasonal leaf area duration (SLAD), photosynthesis, chlorophyll contents and time to stay green there by delaying leaf senescence (Yasmeen *et al.,* 2013).

Keeping all in view the present study was planned to evaluate different priming and foliar application techniques on the productivity and quality of late sown forage sorghum.

II. MATERIALS AND METHODS

To assess the quality and yield of forage sorghum through seed priming and foliar applications of different growth promoting substances an experiment was carried out at Agronomic Research Area, University of Agriculture Faisalabad, The experiment was laid out in randomized complete block design (RCBD) with three replications. Net plot size was 3 m × 1.8 m. Sorghum variety 'Hegari' was used for this experiment. Crop was sown during last week of August, 2015 using seed rate of 80 kg ha^{-1}. Crop was sown in 30 cm apart rows. Recommended dose of nitrogen and phosphorous @ 150 kg ha^{-1} and 60 kg ha^{-1},respectively was applied to all the experimental plots uniformly. Half dose of nitrogen and all phosphorous was applied with 1^{st} irrigation while remaining half dose of nitrogen was applied 30 days after sowing. Irrigations was applied according to the need of the crop. The treatments used were: control (no seed treatment), hydropriming, priming with $CaCl_2$, hardening with $CaCl_2$, priming with moringa leaves extract, priming + foliar application of $CaCl_2$, priming + foliar application of moringa leaves extract and hardening+ foliar application of $CaCl_2$. After each treatment seeds were dried at their original moisture. Daily observation for emerging seedling continued for 9 days after sowing. The seedlings were evaluated as described in Seedling Evaluation Handbook (AOSA. 1991). Time taken for 50 % emergence of seedlings (E_{50}) was calculated by using the formula of Coolbear*et al.* (1984).

$$E50 = ti + \frac{(\frac{N}{2} - nt)(tj - ti)}{nj - ni}$$

Where N is the final number of seeds emerged, n_i and n_j are the cumulative number of seeds germinated by adjacent counts at time t_i and t_j.

Mean emergence time (MET) was calculated by using the equation of Ellis and Roberts (1981).

$$MET = \frac{\Sigma\, Dn}{\Sigma\, n}$$

Where n is the number of seeds emerged and D is number of days.Plant density at harvest, plant height, stem diameter, number of leaves per plant, fresh weight of leaves per plant, leaf area per plant, fresh weight per plant and dry weight per plant were recorded of 5 randomly selected plants per replicate and averaged. Fresh forage yield was calculated by selecting the whole plot of each replication then cut and weighted (kg) separately with the help of spring balance, then converted into tons per hectare. Dry matter yield was determined by known weights of chopped green forage from each plot was taken and dried at 105 ^{0}C for 24 hours. Dry matter percentage was calculated and this dry matter percentage was further used for determining dry matter yield per plot, which was then converted into tons per hectare.

Crude fiber was calculated by using following procedure:

2 g of oven dried sample was taken, digested it into 200 ml of 1.25 % H_2SO_4 in 500 ml beaker, heated for 30 minutes. Then the contents were filtered through a thick linen cloth, then the residues were washed and digested again with 200 ml of 1.25 % NAOH for 30 minutes. Then the residues were put in a pre-weighted china dish and dried in hot air for 24 hours at 105 ^{0}C. After recording the dry weight, samples were placed in muffle furnace at 600 ^{0}C till grey or white ash was obtained. The weight of ash was recorded. Crude fiber was calculated by using following formula:

$$\text{Crude fiber \% age } = \frac{\text{Weight of dry residue} - \text{weight of ash}}{Weightofmoisture} \times 100$$

Crude protein was calculated by using following procedure: 2 g of oven dried grinded plant material was taken. 30 ml of concentrated H_2SO_4 and 5 g digestion mixture (K_2SO_4: $CuSO_4$: $FeSO_4$ = 100: 10: 5 g) were added to it and then digested it on gas heater in Kjeldhal digestion flask until the light green color was appeared, cooled it and made up the volume up to 100 ml. I put 10 ml of that diluted solution in micro Kjeldhal distillation apparatus and add concentrated solution of NaOH. I put a receiving flask containing 10 ml of N/10 standard solution or 2 % boric acid solution and mixed indicator (Bromocresol green and methyl red) in such a way that the delivery after coming through condenser dipped into it. I opened the steam generator plug and let the content of the distillation tube be boiled until whole ammonia was liberated. It was titrated against standard N/10 H_2SO_4. Reading was obtained after titration against H_2SO_4 then multiplied by 6.25 for crude protein determination.

Total ash percentage was calculated by: 5 g of oven dried sample was taken in a pre-weighted china dish. The samples were placed in a muffle furnace at dull red heat (600-650 ^{0}C) till white or grey ash was obtained. Cooled the residue in desiccators and recorded the weight.

$$\text{Ash percentage} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Statistical Analysis: Data collected on different parameters was statistically analyzed using Fisher's analysis of variance technique and the treatments' means were compared by using Honestly Significant Difference (HSD) test at 0.05 probability level (Steel *et al*., 1997).

III. RESULTS AND DISCUSSION

Priming and foliar applications of different growth promoting substances significantly affected the stand establishment, growth parameters and final yield of sorghum. Higher emergence rate, time taken to 50 % emergence and mean emergence time was observed in priming + foliar application of moringa leaves extract (MLE), while all other priming and foliar applications of growth promoting substances significantly affected the stand establishment parameters. In case of growth and yield parameters, priming + foliar application of moringa leaves extract (MLE) performed better compared to all other treatments as shown in table 1 and 2. In case of quality parameters priming + foliar application of moringa leaves extract perfomed best as compared to all other treatments (Table 3).

Treatments	**Means**					
	E_{50}	**MET**	**PP**	**Height**	**SD**	**NL**
No Seed Treatment	5.47^{a}	5.83^{a}	27.67^{d}	205.8^{e}	0.993^{b}	7.67^{d}
Hydropriming	5.05^{ab}	5.16^{b}	31.33^{d}	222.3^{d}	1.126^{ab}	8.00^{d}

Priming with $CaCl_2$	4.00^{bcd}	4.00^{c}	41.00^{c}	238.6^{bc}	1.283^{ab}	9.33^{cd}
Hardening with $CaCl_2$	4.61^{abc}	4.01^{c}	41.67^{c}	235.8^{c}	1.323^{a}	9.33^{cd}
Priming with MLE	3.37^{cd}	3.01^{d}	50.00^{b}	239.7^{bc}	1.333^{a}	9.67^{cd}
Priming + Foliar application of $CaCl_2$	3.26^{cd}	3.75^{c}	52.00^{b}	247.3^{b}	1.370^{a}	12.00^{ab}
Priming + Foliar application of MLE	2.95^{d}	3.00^{d}	59.33^{a}	259.5^{a}	1.376^{a}	$13 .67^{a}$
Hardening + Foliar application of $CaCl_2$	4.36^{abc}	3.80^{c}	50.67^{b}	243.5^{bc}	1.360^{a}	10.33^{bc}
HSD at 0.05	**1.1472**	**0.3406**	**6.2649**	**9.5741**	**0.3159**	**2.2108**

Table: 1. Effect of seed priming and foliar applications of different growth promoting substances on emergence and growth parameters of sorghum under field conditions.

*Means sharing the same letter do not differ significantly at P= 0.05. E50, time to 50% emergence; MET, mean emergence time; PP, plant density at harvest; SD, stem diameter; NL, number of leaves

Table: 2. Effect of seed priming and foliar applications of different growth promoting substances on growth parameters of sorghum under field conditions.

Treatments	**Means**					
	FWL	**LA**	**FW**	**DW**	**FFY**	**DMY**
No Seed Treatment	35.67^{e}	312.3^{d}	209.6^{e}	62.0^{e}	40.67^{e}	6.19^{f}
Hydropriming	41.33^{d}	320.6^{cd}	221.3^{e}	64.5^{e}	41.00^{e}	6.87^{e}
Priming with $CaCl_2$	46.67^{c}	339.6^{c}	249.3^{d}	76.5^{d}	46.33^{d}	8.15^{d}
Hardening with $CaCl_2$	46.33^{c}	335.0^{cd}	253.3^{d}	77.3^{cd}	46.00^{d}	7.96^{d}
Priming with MLE	47.00^{c}	343.6^{bc}	294.3^{b}	85.1^{b}	46.67^{d}	8.38^{d}
Priming + Foliar application of $CaCl_2$	51.67^{a}	365.0^{ab}	269.3^{c}	80.1^{c}	51.00^{b}	11.77^{b}
Priming + Foliar application of MLE	52.33^{a}	381.0^{a}	322.0^{a}	90.6^{a}	53.00^{a}	13.59^{a}
Hardening + Foliar application of $CaCl_2$	49.33^{b}	339.0^{c}	313.3^{a}	89.2^{a}	49.67^{c}	9.57^{c}
HSD at 0.05	**1.6478**	**23.271**	**12.413**	**3.0261**	**1.1757**	**0.6327**

*Means sharing the same letter do not differ significantly at P= 0.05. FWL, fresh weight of leaves; LA, leaf area per plant; FW, fresh weight per plant; DW, dry weight per plant; FFY, fresh forage yield; DMY, dry matter yield

Table: 3. Effect of seed priming and foliar applications of different growth promoting substances quality parameters of sorghum under field conditions.

Treatments	Means		
	CF (%)	**CP (%)**	**ASH (%)**
No Seed Treatment	30.777[a]	6.17[e]	7.82[d]
Hydropriming	30.770[a]	6.29[e]	7.86[d]
Priming with $CaCl_2$	29.383[c]	7.05[d]	9.48[abc]
Hardening with $CaCl_2$	29.467[b]	6.92[d]	8.83[c]
Priming with MLE	29.290[bc]	7.73[c]	9.55[ab]
Priming + Foliar application of $CaCl_2$	28.833[d]	8.79[ab]	9.92[a]
Priming + Foliar application of MLE	28.457[e]	9.27[a]	10.17[a]
Hardening + Foliar application of $CaCl_2$	29.120[c]	8.49[b]	8.94[bc]
HSD at 0.05	**0.1944**	**0.6052**	**0.6870**

*Means sharing the same letter do not differ significantly at P= 0.05. CF, Crude fiber percentage; CP, crude protein percentage; ASH, total ash contents

The increase in plant density at harvest, plant height, stem diameter, number of leaves per plant, fresh weight of leaves per plant, fresh weight per plant and dry weight per plant is due to the result of increasing germination rate, decrease in time taken to 50 % emergence and mean emergence time (Table 1). These results was similar to the finding of Yasmeen *et al*., (2013) that increase in different growth and developmental processes are due to the application of moringa leaves extract (MLE). The increase in leaf area is due to the application of moringa leaves extract, because it contains sufficient amount of zeatin, phenolics, carotenoids, ascorbic acid, potassium and calcium Foidle*et al.*, (2001). Moringa leaves extract increases the leaf area of plant and delays the senescence of leaves (Miller, 1992; Galuszka*et al.*, 2001). Priming, along with foliar application of moringa leaves extract showed best results regarding increase in protein contents and total ash contents of the plant thereby decreasing fiber contents (table 3). The reason behind that is, moringa leaves extract contains sufficient amount of minerals like zeatin, ascorbate, calcium and potassium that increases the amount of protein and total ash and decreases the fiber contents (Foidle*et al.*, 2001). Maximum fresh forage and dry matter yield was recorded in priming + foliar application of moringa leaves extract (Table 2). The reason behind that might be faster germination rate as well as reduction in time taken to 50 % emergence (E_{50}) and mean emergence time (MET) (table 1). The primed seed might imbibe water and nutrients more efficiently from moringa leaves extract and emerged earlier due to the early breakdown of food reserves.

IV. CONCLUSION

The study concludes and suggests that priming and foliar applications of growth promoting substances not only increased stand establishment but also the performance of late sown sorghum crop in terms of growth, development, quality and yield attributes. Priming + foliar application of moringa leaves extract (MLE) performed best in increasing the yield and quality of forage sorghum under variable environmental conditions.

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