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THE ROLE OF SEED PRIMING IN SEMI-ARID AREA FOR MUNG BEAN PHENOLOGY AND YIELD

AHMAD KHAN, SHAD KHAN KHALIL, AMIR ZAMAN KHAN, KHAN BAHADER MARWAT AND ASHFAQ AFZAL

NWFP Agricultural University, Peshawar, Pakistan

Abstract

Patchy plant stand due to uneven germination is one of the major constraints in mung bean (*Vigna radiata* W.) production. Enhanced emergence and establishment of the mung bean crop are considered to be the most important factors contributing to the crop yield. Mung bean cultivars (NM-92 and NM-98) seed were primed for 6 and 12 hours in different solution of water and osmotic solution (ψ_o) of polyethylene glycol (PEG-8000) equivalent to 0, -0.2, -0.5 and -1.1 MPa (Mega Pascal). The primed seed along with control (un-primed) were sown in field experiments at the Research Farm of NWFP Agricultural University Peshawar during 2003 and 2004. Delayed phenological observations were recorded in NM-98 compared to NM-92, but no differences in yield and yield components were observed for both cultivars of mung bean except grains pod^{-1} being higher for NM-98. Primed seed performed better when compared to control, and resulted in 12 % more grain yield. A decrease in osmotic potential in treatment solution from 0 to -1.1 MPa resulted in better performance, in terms of yield and yield components, but was not consistent. Significant interaction of Varieties x Duration x PEG Treatment for days to emergence, grain and biological yield suggest the differential response of each treatment levels over the other. It was concluded that hydro-primed and/or seed primed in -0.5 MPa osmotic potential solution of PEG were better in phenology and yield than all other treatments.

Introduction

Mung bean is an important source of protein in South and South East Asia where the diet is mostly cereal based. It is cultivated both as Rabi as well as Kharif season crop throughout Pakistan. Poor crop establishment is often cited as a major constraint for its production (Rahmianna *et al.,* 2000). Variable rainfalls in early summer coupled with periods of high temperatures are the major production limitations of mung bean in Peshawar region of Pakistan. Extreme soil temperature caused drought by evaporating soil moisture at planting coupled with low rainfall reduces seed germination and early vigor.

Technology that enhance early emergence and stand establishment would enable the crop to capture more soil moisture, nutrients and solar radiation and ultimately crop yield. Enhanced seed germination is possible by a wide variety of pre-sowing hydration treatments with the objectives to allow water uptake and germination metabolism to proceed to a point just short of radical (Bradford, 1986) and is called seed priming. Seed priming can be accomplished through different methods such as hydro-priming, osmo-priming, solid matrix priming and using plant growth regulators (Harris *et al.,* 1999; Capron *et al.,* 2000).

Priming is a viable technology to enhance rapid and uniform emergence, high vigor, and better yields mostly in vegetable and flower species (Bruggink *et al.,* 1999) and some field crops (Harris *et al.,* 2007), in soybean (Khalil *et al.,* 2001, Arif *et al.,* 2008). Chiu *et* *al*., (2002) observed enhanced germination in sweetcorn when primed using polyethylene glycol. However, some workers showed no or limited benefits of seed priming, For example, Giri & Schillinger (2003) noted that none of the seed-priming media used (i.e., water, KCl and polyethylene glycol) improved field emergence and subsequent grain yield in deep-planted winter wheat. Little or no effect of seed priming was found in corn in a semiarid environment in Zimbabwe by Murungu *et al*., (2004).

It was hypothesized that in early summer, seed priming with water or osmotic solutions of PEG before planting would lead to enhanced phenology and higher yield of mung bean. The objective of this study was to assess seed-priming effects on emergence duration, phenology and grain yield of mung bean**.**

Materials and Methods

Experimental site: Two experiments were carried out during summer of 2003 and 2004 at the Research Farm of NWFP Agricultural University Peshawar, Pakistan (17º, 35´ N and 35º, 41´ W). The soil of the experimental farm was a silt clay loam, well drained, fine textured soil derived from piedmont alluvium, deep well developed and belonging to Great Group Haplustalfs. The experimental site has a warm to hot, semi-arid subtropical continental climate with a mean annual rainfall of about 360 mm. Rainfall data were collected and are summarized in Fig I.

Treatments: Seeds of 2 mung bean cultivars NM-92 and NM-98, obtained from the Research Farm of NWFP Agricultural University, Peshawar and Agricultural Research Institute, Rataculachi Dera Ismail Khan, NWFP, respectively were primed for 6 and 12 h in 4 levels of PEG-8000 i.e., 0, 100, 200, 300 g PEG liter^{-1} distilled water, of osmotic potential equivalent to 0, -0.2, -0.5 and -1.1MPa, respectively (Michel, 1983). Except for the control treatment (un-primed), 18 g (>360 seeds) of each cultivar for all these four levels of PEG were primed in 200 ml solution for 6 and 12 h in conical flasks. An aquarium pump was used for continuous oxygen supply. The seeds without any treatment were termed as control (un-primed). The primed seeds were washed with distilled water and then allowed to air-dry at room temperature (30 ºC) according to the procedure outlined by Giri & Schillinger (2003), weighted periodically at a regular interval of 3 hours for determination of moisture contents, after (24±1 h) of post priming storage the original moisture content of each lot were restored.

Experimental design: A total of 20 treatments i.e., 2 x 2 x 5 (2 varieties, 2 seed treatment durations and 5 priming treatments) in factorial arrangement were evaluated in a randomized complete block design with 4 replications in each year. Planting was done on 17th May in 2003 and 29th May in 2004 under recommended agronomic practices. A total of 360 seeds of each cultivar for each treatments including control (un-primed) were sown per plot size of 3 x 1.8 m with 6 rows of 3 m length and 30 cm apart. After germination, manual thinning was done in order to maintain a 10 cm plant-to-plant distance in all 6 rows of each plot. N and P fertilizers as starter dose @ 20 kg N ha^{-1} as Urea (46% N) and 60 kg P_2O_5 ha^{-1} as single super phosphate (18% P_2O_5) were broadcast pre-planted. Weeds were controlled manually as well as by application of chemical herbicides.

Observations and measurements: Daily rainfall and temperatures were recorded in both years. Observations were made daily to record emergence, flowering and physiological maturity. Emergence was the period from sowing to the emergence of 70% seedling in each row of each plot. The period from sowing until the appearance of the first 50% of flowers was termed as "days to flowering" in mung bean. The sum of time taken to the first 50% of flowering appearance and subsequent time till 50% of the pods started yellowing was regarded as "days to physiological maturity". Due to its indeterminate nature, maturity in mung bean crop is difficult to be precisely measured but the first 50% of pods yellowing were taken as a yard stick for determining the maturity. Yield components (pods plant^{-1}, grains pod^{-1}, and grain weight) were recorded at physiological maturity from 5 randomly selected uniform plants in each plot. However, for biological and grain yield, 4 central rows were harvested, sun dried, thrashed and then converted into yield ha^{-1} accordingly.

Statistical analysis: Analysis of variance (ANOVA) was used to detect the significance of treatments effects on the different variables measured. Data from both seasons from the given experimental site were analyzed together and treatment values were expressed as a mean of two seasons. In case of significant differences, standard error of means (Gomez & Gomez, 1983) was used to separate the means. The statistical software GenStat release 8.1 (GenStat, 2005) was used for analysis of all data.

Results

The mean air temperature was (31.5°C in 2003 and 31°C in 2004) during the growing season and remained >30°C, in both years during the emergence and seedling establishment period (Fig. 1). The growing season of 2003 received limited rainfall particularly during the seedling establishment period, while 2004 was an extremely dry one. However, the seedling emergence in both years was successful because of seed priming effects. Published data showed 8% more germination in the osmo-primed treatment in 2003 (Khan *et al.*, 2005). Overall seedling emergence was greater (91%) in 2003 than (79%) in 2004 (Data not shown). After pods initiation, more moisture was available for plants in 2003 (Fig. 1), which affected plant growth severely, and caused a reduction in the final output.

Effect of Seed treatment duration: The data regarding seed treatment duration has no effects on phenology and yield component of mung bean (Table 1). However, prolonged duration of 12 hours resulted in enhanced phenology and yield component compared to 6 hours but were not statistically different from each other (data not shown). Seed treatment durations had no effect on grain yield (Fig. 2). However, greater yield were obtained from seed treated for 12 hours than 6 hours.

Effect of mung bean cultivars: Early emergence, flowering and maturity in mung bean enable the crop to be harvested before the heavy rain begins (July and August) in the Peshawar region (Fig. 1). Significantly earlier flowering (43 d) and maturity (55.5 d), were observed for NM-92 cultivar when compared with NM-98 (Tables 2 and 1). A greater germination and post emergence seedling survival, as shown by NM-92, carries no significance in terms of accomplishment of appropriate crop stand.

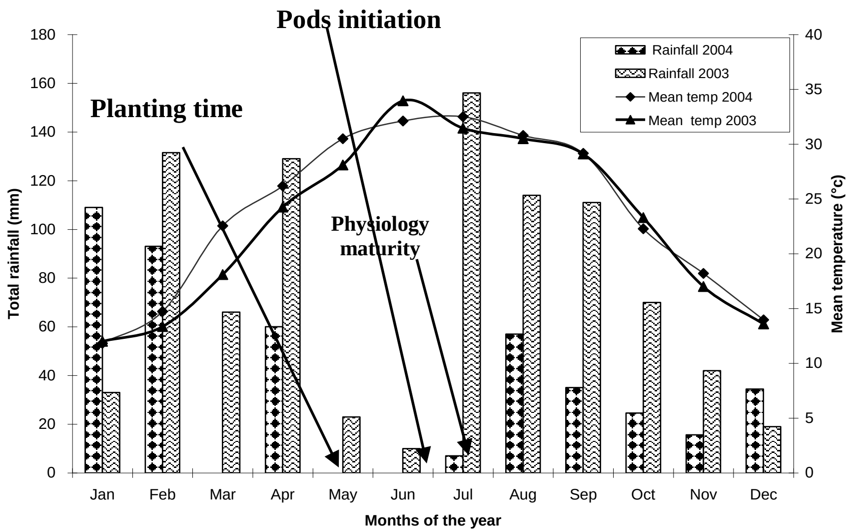

Fig. 1. Total precipitation (mm) and mean air temperature (°C) at the experimental site in Peshawar during 2003 and 2004.

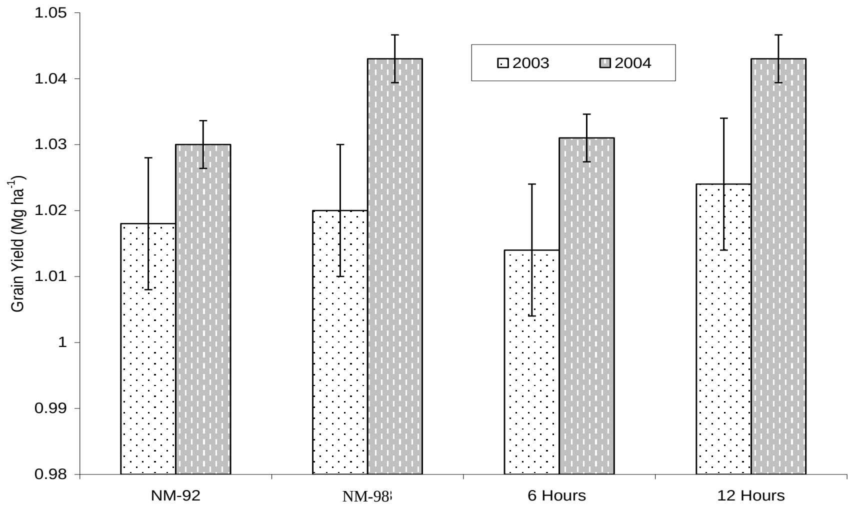

Fig. 2. Grain yield (Mg ha^{-1}) of mung bean cultivars and seed priming duration in 2003 and 2004 average over 5 priming treatments, vertical bars are the standard error of mean.

No significant variations for pods m^{-2} and 1000 grain weight for mung bean cultivars were observed. Greater total above ground biomass (6.8 Mg ha^{-1}) and grains pod^{-1} (9.6) were observed for NM-98 compared with NM-92 (Table 2 and 1).

Mung bean cultivars had no effect on grain yield (Fig. 2). The early flowering and enhanced germination did not translate into grain yield in both cultivars of mung bean.

Table 1. Analysis of variance for days to emergence (DE), days to flowering (DF), days to maturity (DM), pods m^{-1}(PPM), grains pod^{-1} (GPP), thousand grain weight (TGW), grain yield (GY) and biological yield (BY) during the 2003-2004 growing season.

Source of variation	df	DE	DF	DM	PPM	GPP	TGW	GY	BY
Year (Y)	1	*	NS†	**	NS	NS	NS	NS	NS
Varieties (V)	1	NS	**	**	NS	**	NS	NS	**
Duration (D)	1	NS	NS	NS	NS	NS	NS	NS	NS
V x D	1	NS	NS	NS	NS	NS	*	**	NS
PEG treatment (T)	4	**	**	**	**	**	**	**	**
V x T	4	**	**	**	**	NS	NS	**	**
D x T	4	**	NS	NS	**	**	NS	NS	NS
V x D x T	4	NS	**	NS	NS	NS	NS	*	*

*=Significant at $p \leq 0.05$, **=Significant at $p \leq 0.01$, †NS=Non-significant.

Table 2. Phenology and yield components of mung bean as affected by mung bean cultivars.

Parameters	NM-92	Nm-98	*S.E* (114df).sig
Days to emergence	3.6	3.7	0.059 NS
Days to flowering	43.0	44.7	0.135 **
Days to maturity	55.5	56.6	0.271 **
Pods m^{-2}	595.3	612.6	8.851 NS
Grains pod^{-1}	8.6	9.6	0.187 **
1000 grain wt (g)	45.6	45.6	0.140 NS
Grain yield (Mg ha^{-1})	1.02	1.03	0.015 NS
Biological yield (Mg ha^{-1})	6.2	6.8	0.076 **

S.E=Standard error of mean, NS=Non-significant, **=Significant at $p \leq 0.01$

Table 3. Phenology and yield components of mung bean cultivars as affected by priming treatments compared to control.

Parameters	$Mean (primed)	Mean (dry seed)	Increase due to priming %	*S.E* (114df).Sig
Days to emergence				
NM-92	3.3	4.6	-27.2	0.13**
NM-98	3.6	3.8	-6.3	
Days to flowering				
NM-92	42.5	44.1	-4.0	0.30**
NM-98	44.9	45.1	-1.0	
Days to maturity				
NM-92	42.5	44.1	-3.7	0.30**
NM-98	44.9	45.1	-0.6	
Pods m^{-2}				
NM-92	622.8	517.1	20.4	19.79**
NM-98	636.5	528.5	20.4	
Grains pod^{-1}				
NM-92	8.9	7.8	14.0	0.42**
NM-98	9.9	8.4	18.9	
1000 grain wt (g)				
NM-92	46.0	44.4	3.5	0.31**
NM-98	45.9	44.7	2.6	
Grain yield (Mg ha^{-1})				
NM-92	1.06	0.91	16.12	0.03**
NM-98	1.05	0.97	7.99	
Biological yield (Mg ha^{-1})				
NM-92	6.25	5.90	6.04	0.17**
NM-98	7.20	6.17	16.67	

S.E=Standard error of mean, **=Significant at $p \leq 0.01$

$ =Primed mean is the average of osmo-primed and hydro-primed treatments

Table 4. Phenology and yield components of mung bean as affected by different priming treatments

Parameter	PEG Osmotic potential (M Pa)					*S.E* (114df).sig
	Control	**0.0**	**-0.2**	**-0.5**	**-1.1**	
Days to emergence	4.3	3.4	3.4	3.6	3.7	0.094 **
Days to flowering	44.7	43.4	44.6	43.2	43.6	0.214 **
Days to maturity	56.9	55.56	55.8	56.2	56.0	0.214 **
Pods m^{-2}	501.9	593.2	660.0	652.8	612.5	13.99 **
Grains pod^{-1}	7.9	9.3	9.7	9.2	9.4	0.296 **
1000 grain wt (g)	44.3	45.8	45.7	46.6	45.8	0.221 **
Grain yield (Mg ha^{-1})	0.92	1.04	1.06	1.09	1.03	0.023 **
Biological yield (Mg ha^{-1})	6.01	6.47	6.74	7.01	6.59	0.121 **

S.E=Standard error of mean, **=Significant at p$\leq$ 0.01

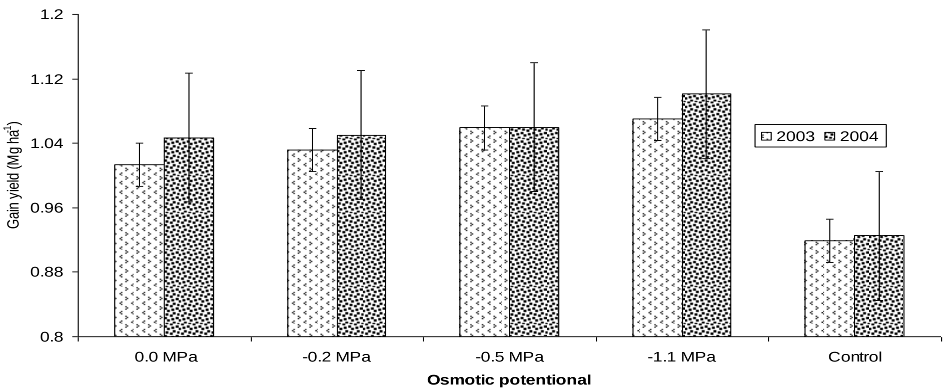

Fig. 3. Effect of priming treatments on grain yield (Mg ha^{-1}) in 2003 and 2004 average over two mung bean cultivars and two priming duration, vertical bar are the standard error of mean.

Effect of seed priming techniques: Phenological observations studied for different priming treatments, showed an earlier emergence and flowering by osmo-primed seeds when compared with dried seeds. Percent increase over control for emergence, flowering and maturity periods were negative (Table 3), which led us to the conclusion that emergence, flowering and maturity were delayed in control treatment. The rapid imbibitions of priming, which occurs during seed priming, is known to disrupt cell membrane and causes localized cell in cotyledons resulted in more vigorous, uniform and early seedling (Table 3) compared to plants in unprimed crops. Among the osmo-priming and hydro-priming (Tables 4 and 1), no differences were noted in terms of phenological feature of mung bean.

Mediation of the data revealed variations in the mean value for pods m^{-2}, grains pod^{-1}, 1000 grains weight and biological yield of priming treatments. A significantly greater number of pods m^{-2} (20.4 and 20.4%), number of grain pod^{-1} (14 and 18.9%), 1000 grain weight (3.5 and 2.6%), and biological yield (6.04 and 16.97%) were recorded for primed seed of NM-92 and NM-98, respectively (Table 3) when compared with unprimed seed. However, the variations among osmo-primed and/or hydro-primed (Table 4 and 1) treatments were statistically not different.

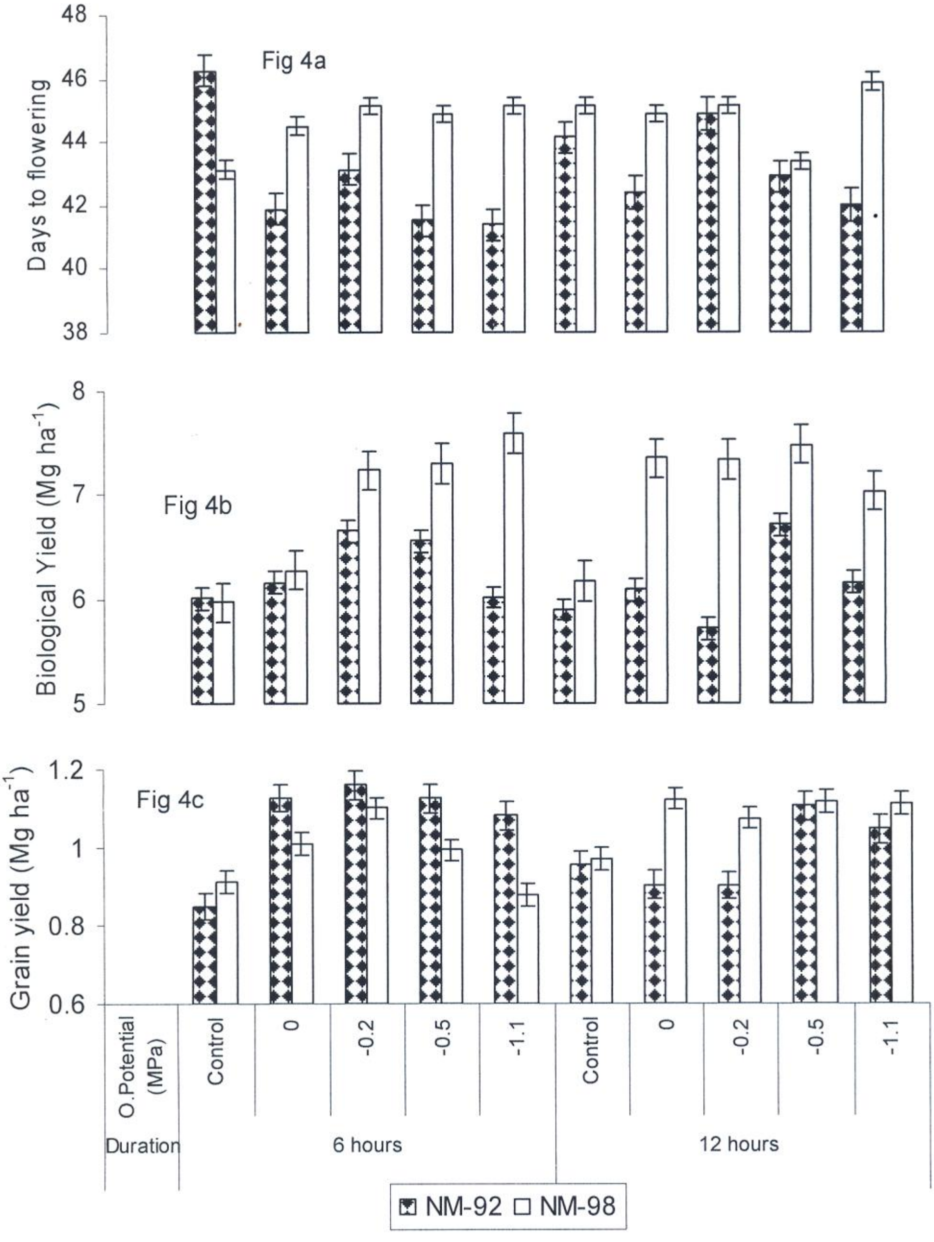

Fig. 4. Interactive effects of (V x D x Priming treatment) on Days to flowering, Biological yield, and grain yield of mung bean, the vertical bars are standard error of means.

The earlier seedling emergence, more pods plant^{-1}, 1000 grain weight (Table 2) have translated into (16.12 and 7.97%) more yield for primed seed of NM-92 and NM-98, respectively when compared with un-primed plants (Table 4). Primed treatments out yielded over dried treatment (Fig. 3). Greater grain yield (1.09 Mg ha^{-1}) was observed for

-0.5 MPa osmotic potential treatment which is statistically at par with other priming treatments (Table 4). Priming has resulted in 11.5% in 2003 and 13% in 2004 (Fig. 3) more yield when compared to dried seed.

Interactive effects of cultivars, duration and priming techniques: Statistical analysis revealed that most of the interactions are not significant (Table 1). However, significant interactions were observed for days to flowering, biological yield and grain yield. The interactive studies of the (V x D x Priming treatment), revealed that the flowering were enhanced (41.38 d) in the plots sown with NM-92 seed primed in -1.1 MPa osmotic potential of PEG for 6 h, whereas delayed flowering were recorded in plots sown with dried seed (Fig. 4a). A significant interaction of (V x D X Priming Treatments) for biological yield, revealed that the highest biological yield (7.59 Mg ha^{-1}) was noted in the plots sown with the NM-98 seeds primed for 12 h in -1.1 MPa osmotic solution of PEG, as compared to the least obtained for dry seed of NM-92 (Fig. 4b). Interactive response of (V x D x priming treatments) for grain yield revealed that, the highest grain yield (1.16 Mg ha^{-1}) was recorded for the NM-92 seeds primed for 6 h in -0.2 MPa osmotic potential of PEG, as compared to the least obtained for dry seed of NM-92 (Fig. 4c).

Discussion

Mungbean seed priming in an osmoticum like polyethylene glycol or simply hydro-priming, is one of the simple, easy and an effective method to enhance the farmer produce and ultimately the farmer income. One of the major problems of semiarid region like central plain of NWFP is the highly erratic rainfall and farmer are concerned that primed crops could suffer very high losses if there is appreciable delay in rainfall after sowing, whereas non-primed seed would not germinate until the rain. However, sowing on conserved moisture as practiced in plain area of NWFP in 2003 and 2004 seems to give consistent benefits.

In the current studies, the seed treatment duration has no effect on any observation. Seed priming duration may play an important role in the imbibitions of seed and enhancement of seedling vigor. However, the effect of the priming duration is difficult to interpret because duration would be the main factor affecting rate and end-point of imbibition when priming in water, but would have less effect when osmotic solution are used, as the rate and final level of imbibition are being controlled more closely by the potential difference.

In present studies, the enhanced phenology in mung bean due to primed seed is associated with faster emergence and reduces germination imbibitions periods (Harris *et al.,* 1999). Components of yield in mung bean have demonstrated that priming treatments have increased grain yield. The priming-related increase in the biomass and grain yield of mung bean was due to a combination of better emergence and better performance per plant (Parera & Cantliffe, 1994). The performance of dried seed was the poorest amongst all treatments, but not a single osmo-primed treatment sustained superior effects in term of pods m^{-2}, 1000 grain weight, and number of grains pod^{-1} compared to water primed treatment. In spite of non-significant variations in osmo-primed and/or hydro-primed seed, the osmo-primed treatments of (-0.2 and -0.5 MPa osmotic potential) were regarded as better than other osmo and hydro-primed treatments in terms of enhanced phenology, and better yield components. Our results confirm the finding of earlier researchers (Rashid *et al.*, 2004) that a five fold increase in yield in mung bean due to priming were observed. Rashid *et al.,* (2006) reported that priming enhanced germination, better establishment and increased yields in a range of crops in many diverse environments.

The priming technique due to its simplicity might be acceptable to the farmer of area as accepted to farmer in other semi arid region and promoted to a wide range of crops, for example maize (Harris *et al.,* 2007), wheat (Harris *et al.,* 2001), mung bean (Rashid *et al.,* 2004), Chick pea (Musa *et al.,* 2001), upland rice in India (Harris *et al.,* 2002) and millet in India (Kumar *et al.,* 2002). The present experiments substantiate our hypothesis that priming affects mung bean production in semiarid plain area of NWFP and the finding of others in similar climates.

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