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Research Paper

Effect of Sowing Time, Spacing and Seed Treatments with *Rhizobium* and Phosphate Solubilizing Bacteria on Seed Yield, its Contributing traits and Seed Quality Parameters in Mung bean (*Vigna radiata* (L.) Wilczek)

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ABSTRACT:- *An experiment consisted three dates of sowing (July 15, August 1 and August 16), three spacing (20 cm x 10 cm, 3o cm x 10 cm and 40 cm x 10 cm) and six fertilizer and seed treatments (Control-without fertilizer and seed treatment with microbial inoculants),recommended dose of fertilizer (RDF) as basal dose (12.5 kgha^{-1} N and 40 kgha^{-1} P_2O_5), seed treated with Rhizobium and Phosphate Solubilizing Bacteria (PSB), alone and or in combination, seed treated with Rhizobium and PSB + RDF , seed treated with Rhizobium and PSB + RDF as basal dose + Borax spray (100 ppm) at flower initiation in split-plot design with three replications in order to explore the possibility of enhancement of quality seed production in mung bean cv NDM 1 during wet (kharif) 2013. The seed yield and harvest index and their contributing traits namely, number of pods plant-^{1}, pod length, number of seeds pod-^{1} and 1000 seed weight were decreased significantly as delayed the sowing. Spacing 30 x 10 cm was appeared superior as compared to either 20 x 10cm or 40 x 10 cm. Use of Rhizobium, PSB and Borax had also shown significant advantage over control and or no-inoculation. The treatment comprised seed treated with Rhizobium and Phosphate Solubilizing Bacteria + Fertilizer (12.5 kgha^{-1} N and 40 kgha^{-1} P_2O_5), as basal dose + Borax spray (100 ppm) at flower initiation being applied at 30 cm x 10 cm spacing apart and sown on 15th July may be exploited to realize higher seed yield and harvest index and also to improve seed vigour in the terms of germination, seedling length, vigour index and field emergence of mung bean*.

KEYWORDS:- *Sowing time, spacing, Rhizobium, PSB, borax, quality seed, mung bean*

I. INTRODUCTION

Mung bean, being an important pulse crop, is grown in most of tropical and sub-tropical parts of the world. It is the third important pulse crop in India, covering an area of 2.86 million hectares, accounting for 12 per cent of the total acreage, but constitutes only 8 per cent of the total pulse production of the country. In spite of its considerable genetic improvement, the yield potentials have not yet been exploited in totality as visualized by its average productivity as low as 4.68 q ha-^{1} in India. Inclusion of only quality seed in its cultivation leads to increase 15-20% seed yield. Availability of quality seed of improved variety at reasonable price to the door of real growers is still a big challenge because apart from the genetic constitution, a number of physiological, biochemical and lack of required packages of practices during the critical stages of crop growth have found to be some of the yield barriers of mung bean [1-2].Timely sowing at the proper spacing along with application of recommended doses of fertilizer [3], microbial inoculants [4] and boron foliar spray [5] have been found to cop-up such bottlenecks to a considerable extent in pulses. However, such studies are meagre in mung bean. The present study was therefore undertaken to study the effect of sowing time, spacing, recommended dose of fertilizer, seed treated with *Rhizobium* and PSB alone or in combination and boron spray prior to flowering leading to the improvement of seed yield and seed quality parameters in mung bean.

II. MATERIALS AND METHODS

2.1. Experimental Site

The field experiment was conducted at the Crop Research Station, Masodha Unit-II of the University, Faizabad, Uttar Pradesh (26^{0} 43′ N, 82^{0} 80′ E and 113 m above mean sea level). The soil of the experimental site was alluvial in nature and neutral in reaction (pH 7.6), medium in organic carbon, available nitrogen, phosphorus and high in potassium, about sufficient in micro-nutrients (Table 1).

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2.2. Treatments Details

The experiment was conducted on mung bean cv NDM 1 in split- plot design with three replications during the wet (*Kharif*) season of 2013. The Narendra Mung (NDM) 1 has been developed through pedigree selection from cross between G. 65 x UPM 70-3-4. The variety matures within 65-70 days with a yield potential of 12-15 q ha-[1]. It is resistant to Yellow Mosaic Virus. Plants erect, medium tall, remain green at maturity, seed shinning colour, medium bold (3.2 g 100 seed-[1]), suitable for wet (*Kharif*) and dry (summer) seasons, recommended for inter cropping with pigeon pea and sugarcane and popular as ruling variety in the state. The treatment combinations comprising three dates of sowing (July 15, August 1 and August 16), three spacing (20 x 10 cm, 3o cm x 10 cm and 40 cm x 10 cm) and six fertilizer and seed treatments (Control-without fertilizer and microbial inoculation ,recommended dose of fertilizer (RDF) as basal dose (12.5 $kgha^{-1}$ N and 40 $kgha^{-1}$ P2O5), seed treated with *Rhizobium* and Phosphate Solubilizing Bacteria (PSB) alone and or in combination, seed treated with *Rhizobium* and Phosphate Solubilizing Bacteria (PSB) + fertilizer as basal and seed treated with *Rhizobium* and Phosphate Solubilizing Bacteria (PSB) + fertilizer as basal dose + Borax spray (100 ppm) at flower initiation. The gross plot size was 5 m × 2.5 m^2. Recommended dose of fertilizer (12.5 $kgha^{-1}$ N and 40 $kgha^{-1}$ P_2O_5) was applied in the form of 100 kg ha^{-1} Di-ammonium Phosphate in furrows prior to sowing. The crop was sown on a fine prepared seed bed with a seed rate of 12.5 kg ha–[1]. *Rhizobium* and phosphate solubilizing bacteria at the rate of 5 g kg–[1] seed and 7.5 g kg seed-[1], respectively were applied as seed treatment and dried in shade before sowing. Three hand weeding were properly done in order to keep the plots free from weed infestation. Boric acid at 100 ppm was sprayed uniformly prior to flowering.

2.3. Parameters recorded

Ten plants were randomly selected and used to record the plant height, number of branches plant-[1], number of pods plant-[1], number of seeds pod-[1] and test weight (1000 seed weight). Total dry matter and grain yield were also recorded from each plot. Four hundred seeds were placed in biological oxygen demand (BOD) incubator to record the germination, seedling length and seed vigour index as per ISTA Rules (7).

2.4. Statistical Analysis

Data were evaluated by split-plot analysis of variance (ANOVA) by using the program SPSS 11.0 for windows. The significance of the treatment effect was determined using *F*-test and mean value using the least significant difference method (LSD).

III. RESULTS AND DISCUSSION

3.1: Seed yield, harvest index and it contributing traits 3.1.1: Sowing time

Perusal of data presented in Table 2 clearly revealed that seed yield, harvest index and its major contributing traits viz., number of pods plant-[1], pod length and number of seeds pod-[1] were decreased with delayed the sowing. Similarly, the plant height was also significantly reduced as sowing was delayed. Mung beans are responsive to day light length and temperature. Short days result in early flowering, while long days result in late flowering. The optimum temperature range for growth is between 27 °C and 30 °C (7). Thus the crop sown on August 16 harboured by quite lower temperature than 27 ^{0} C (Table 4) at reproductive phase of the crop which affected seed development and finally resulted lower seed yield and its quality parameters.

3.1.2: Spacing

Optimum plant population play an important role for harnessing the yield potential. Narrow and wide spacing in either way were not suitable for obtaining the even optimum yield. In the present study, 20 cm x 10 cm spacing depicted lowest seed yield, harvest index as well as their contributing traits whereas plant height was maximum at this spacing. The maximum seed yield and harvest index along with it contributing traits under study were observed at 30 cmx 10 cm spacing followed by 40 cm x 10 cm spacing. Thus the optimum spacing was realized as 30 cm x 10 cm which found sufficient for full expression of canopy of the variety NDM 1 under studied (Table 2).

3.1.3 Seed treatment

Seed treated with *Rhizobium* and PSB alone or in combination along with recommended dose of fertilizer increased nearly one and half times seed yield and harvest index in comparison to control. Further, the maximum seed yield *i.e.* 13.54 q ha-[1] was obtained by the treatment combination of *Rhizobium,* PSB and foliar spray of Borax in addition of recommended fertilizer. The increased seed yield and harvest index were mainly owing to contribution of increased yield contributing traits like number of pods plant-[1], pod length, number of seeds pod-1 including seed weight. Significant differences in seed yield, harvest index and their contributing traits might be attributed due to the increased availability of Nitrogen [4], Phosphorus [4] and Boron [8] which resulted in higher growth and development and finally yields.

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Table 1: Soil properties of experimental site

Soil parameter	Value
pH	7.6
Electrical conductivity (dSm-1)	0.15
Soil Organic Carbon (%)	0.44
Available Nitrogen (kg/ha -1)	133
Available Phosphorus (Olsen'P ,kg ha-1)	12
Available Potassium (kg ha-1)	119
Available Sulphur (kg ha-1)	10.15
Available Zinc (ppm)	0.60
Available Boron (ppm)	0.50
Available Manganese (ppm)	3-4
Available Iron (ppm)	10-12
Available Copper (ppm)	0.40

Table 2: Effect of sowing schedule, spacing and seed treatments on seed yield and its contributing traits in mung bean cv. NDM 1

Treatment	Plant height (cm)	No. of pods plant-1	Pod length (cm)	No. of seed pod-1	Seed yield (q ha-1)	Harvest index
Sowing date						
July 15	68.60	32	9.54	10	12.56	32
August 1	65.40	29	9.11	09	11.08	30
August 16	60.10	26	8.50	08	10.04	29
LSD (0.05)	3.92	3.74	0.63	1.11	1.36	2.49
Spacing						
20 cm x 10 cm	70.10	30	8.61	08	11.35	30
30cm x 10 cm	65.45	34	9.08	10	12.59	32
40 cm x 10 cm	62.11	31	8.72	09	12.00	31
LSD (0.05)	4.03	2.91	NS	1.20	0.78	1.04
Inoculants / spray						
Control (without fertilizer and inoculants)	60.54	21	7.12	06	06.50	23
RDF (12.5 $kgha^{-1}$ N and 40 $kgha^{-1}$ P_2O_5)	64.42	32	8.46	08	08.86	30
RDF + Rhi (5 g kg seed-1)	65.76	35	8.68	09	09.70	31
RDF+ PSB (7.5 g kg seed-1)	66.50	37	8.83	09	10.52	32
RDF + Rhi+ PSB	68.20	40	9.01	10	11.87	33
RDF + Rhi + PSB + Borax (100 ppm)	70.62	44	9.54	10	13.54	35
LSD (0.05)	3.44	8.07	1.31	2.00	2.26	5.26

Table 3: Effect of sowing date, spacing and seed treatments on seed quality parameters in mung bean cv NDM 1

Treatment	Germination (%)	1000 seed weight (g)	Seedling length (cm)	Vigour index	Field emergence (%)
Sowing date					
July 15	85	33.24	22.60	1921	81
August 1	80	30.15	20.00	1600	73
August 16	74	28.37	18.58	1375	65
LSD (0.05)	5.03	2.90	2.12	241	6.72

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Spacing					
20 cm x 10 cm	**81**	**31.42**	**21.34**	**1729**	**74**
30cm x 10 cm	**82**	**33.35**	**22.52**	**1847**	**75**
40 cm x 10 cm	**82**	**33.48**	**22.08**	**1811**	**74**
LSD (0.05)	**NS**	**1.85**	**1.94**	**NS**	**NS**
Inoculants / spray					
Control (without fertilizer and inoculants)	**73**	**30.00**	**18.50**	**1351**	**65**
RDF (12.5 $kgha^{-1}$ N and 40 $kgha^{-1}$ P_2O_5)	**80**	**32.25**	**22.19**	**1775**	**75**
RDF + Rhi (5 g kg $seed^{-1}$)	**83**	**34.16**	**24.96**	**2072**	**78**
RDF+ PSB (7.5 g kg $seed^{-1}$)	**84**	**34.15**	**24.90**	**2092**	**80**
RDF + Rhi+ PSB	**85**	**34.46**	**25.45**	**2163**	**81**
RDF + Rhi + PSB + Borax (100 ppm)	**86**	**35.21**	**26.05**	**2240**	**82**
LSD (0.05)	**6.14**	**2.08**	**3.78**	**317**	**7.16**

Table 4: Temperature (^{0} C) at experimental site during crop duration (July-October, 2013).

Day	July		August		September		October	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1	28	34	30	38	27	38	24	32
2	30	39	28	38	28	38	22	26
3	29	37	29	39	28	39	25	32
4	29	38	32	40	28	39	22	26
5	31	36	33	40	27	39	24	27
6	31	40	30	39	27	39	23	33
7	31	48	29	37	26	39	23	34
8	32	36	28	38	25	39	24	35
9	30	38	29	38	26	40	25	36
10	30	37	27	37	26	39	25	36
11	29	34	27	36	26	40	24	34
12	28	38	28	38	27	38	24	36
13	29	37	28	36	26	40	24	30
14	29	35	28	39	27	40	21	24
15	31	40	30	40	27	40	21	26
16	32	40	27	41	26	40	21	29
17	32	40	27	39	26	39	21	32
18	31	43	27	37	27	41	23	33
19	31	41	27	38	26	38	24	33
20	28	37	29	37	27	36	23	33
21	29	40	27	37	27	37	23	34
22	30	39	25	36	27	38	21	35
23	30	41	27	39	27	39	23	34
24	31	40	27	40	27	38	22	36
25	31	39	28	40	27	39	22	33
26	32	41	28	40	28	37	23	33
27	31	38	28	41	28	37	22	32
28	29	38	25	37	27	37	21	32
29	29	40	27	33	26	39	20	33
30	30	43	26	37	25	36	20	34
31	32	42	27	36	-	-	21	34

3.2: Seed quality parameters

3.2.1: Sowing time

Sowing time played significant role for all the seed quality parameters under studied (Table 3). As such delayed planting not only reduced the seed yield but affected the seed quality as well. All the treatments showed the germination percentage above the minimum seed certification standard except to the sowing done on August 16 and the seed of control plots which revealed the germination percentage below to the certification standard (75%).Germination is one of the requirements of quality seed under Seed Act to meet seed certification. The seed development in late developing pods was not properly occurred and therefore the embryos in such seeds remain rudimentary and ultimately not produced normal seedlings.

3.2.2: Spacing

The role of spacing on seed quality parameters namely , seed size, germination, seedling length, vigour index and field emergence was not pronounced where as its significant contribution has been realized for seed yield, harvest index and its contributing traits. There was no significant effect of spacing for germination, vigour index and field emergence (Table 3).

3.2.3: Seed treatment

Seed treated with *Rhizobium* and the PSB alone or in combination not only increased seed yield, harvest index and their contributing traits but also improved the seed quality parameters namely, germination, seedling length, seed size (1000 seed weight), vigour index and field emergence. In addition to *Rhizobium* and PSB, the foliar application of Boric Acid is also realized for higher seed quality traits. The present findings are in very close to the reports of [4, 8] and [9].

The rhizobia inoculant and phosphate solubilizing bacteria (PSB) are commonly applied to seeds of legume crops to ensure effective nitrogen fixation by *Rhizo*b*ium* and solubilisation of native phosphorus by PSB, thereby making the two essential nutrients available to the crop [4]. Boron is highly required during reproductive growth [8] being functionally associated with water availability, sugar translocation, cation and anion absorption, and metabolism of N, P, carbohydrate, and fat [5]. Therefore ,the treatment combination of July 15 sowing, spacing 30 cm x 10 cm, recommended dose of fertilizer, seed treated with *Rhizobium* (5 g kg^{-1}seed) and the PSB (7.5 g kg^{-1}seed) followed by foliar application of boron (100 ppm) led to physiological and bio-chemical activities of the crop plants in order to harness the full genetic potential [2] and ultimately resulted in higher seed yield, harvest index and its contributing traits, and seed quality parameters in mung bean.

IV. CONCLUSION

Based on the above findings, it is concluded that the quality seed production of mung bean could be maximized by sowing the duly treated seed with *Rhizobium* and Phosphate Solubilizing Bacteria along with recommended doses of fertilizer at spacing of 30 cm x 10 cm in the mid of July and later followed by foliar application of boron at prior to primordial stage of the crop.

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