IMPROVEMENT OF MASH BEAN PRODUCTION UNDER RAINFED CONDITIONS BY RHIZOBIUM INOCULATION AND LOW RATES OF STARTER NITROGEN

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ABSTRACT:-The study was conducted at research farm of PMAS - Arid Agriculture University, Rawalpindi during autumn 2009. Two mash bean varieties viz., NARC Mash-II and NARC Mash-III and the treatment combinations applied were control, 20, 40 and 50 kg N ha^{-1}, 750 g inoculum ha^{-1}, inoculum + 20 kg N ha^{-1}, inoculum + 40 kg N ha^{-1}, inoculum + 50 kg N ha^{-1}. The experiment was laid out in a split plot design, keeping varieties in main plots and fertilizer/inoculum combinations in sub-plots. The results showed significant differences for all the plant characters under the study. The crop maturity was earlier in control and inoculation + 20 kg N ha^{-1} as compared to all other treatments. Inoculation in combination with 50 kg N ha^{-1} significantly delayed crop maturity. The maximum mean average grain yield (681.5 kg ha^{-1}) was augmented with the application of inoculation alone and non significant differences were noted among the varieties. Biological yield were also significantly increased by inoculation and nitrogen fertilization but inoculation alone was more effective by giving maximum economic yield. Various treatments exhibited significant differences for harvest index; however, maximum harvest index (22.04 %) was recorded in control plots. N in soil was increased by inoculation in combination with 40 and 50 kg N ha^{-1} and 50 kg N ha^{-1} alone, nevertheless, maximum N in soil was recorded in inoculation + 50 kg N ha^{-1}.

Key Words: Vigna mungo; Maturing; Rhizobium Inoculum; Nitrogen Fertilizer; Yield; Yield Components; Pakistan.

INTRODUCTION

Mash bean (*Vigna mungo* L) is an important pulse crop of Pakistan. It is a good substitute of animal protein and forms a balanced diet when it is taken with cereals (Considerine, 1992). Being a leguminous crop, it maintains soil fertility as it fixes atmospheric nitrogen through symbiosis with rhizobial strain and contributes to soil nitrogen. It is short duration crop and cultivated mostly in rainfed areas. It is a drought resistant crop that can tolerate the adverse environmental conditions and hence can be successfully grown in rainfed areas of Pakistan. The area sown under this crop was 27600 ha in the country with the total production of 13600t (GoP, 2010). The yield of pulses in Pakistan is lower than most of the Asian countries.

The reasons of low yield in Pakistan are numerous but nutritional imbalance appears to be the major one, in general, the soils of

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rainfed areas of Pakistan are deficient in plant nutrients and have a very low organic content (Ahmad et al., 1988). Nitrogen estimated from the organic fractions of rainfed (*barani)* soils ranges from 0.03 to 0.07 % (Frederich et al., 1991) low soil nitrogen has been recognized as a key factor in inefficient water use and low crop yields in the rainfed area of Pakistan (Khan et al., 1989)

Specific bacteria invade the legume root hairs and establish a mutually beneficial association inside the cortical root swellings or nodule, where free air nitrogen is fixed (Allen and Allen, 1981). Furthermore, effective nodulated grain legumes contribute to soil nitrogen reserves and optimize yield without expensive nitrogen fertilizer input on nitrogen deficit soils (Gladstones, 1975). The amount of nitrogen fixed by mash bean is 0-55 kg ha^{-1} among the farmer's fields in Swat and Dir valleys of NWFP (Shah et al., 1997).

Although mash bean can meet its nitrogenous requirements by fixing the atmospheric nitrogen, but starter dose of nitrogen help in increasing yield because of better plant establishment (Nazir, 1986). However, it was reported that high soil nitrogen levels, applied or residual, reduced nodulation and N fixation on one hand (Wani et al., 1995) while on the higher doses of nitrogen increase cost of production. The suppression in biological nitrogen fixation is particularly due to nitrate fraction in the root growth environment agronomic practice for ensuring and adequate supply of N for legume crop than the application of fertilizer nitrogen (Marufu et al., 1995).

In recent years, because of the shortage of energy, with concomitant increases in nitrogen fertilizer prices, the possibility of pollution caused by nitrogen fertilizer have lead to the exploration of cropping system that do not require heavy nitrogen fertilizer. So, in areas where both economic reasons and low nitrogen fertilizer efficiency make optimum nitrogen fertilization difficult, leguminous crops remain an important source of grain legume and the role they play in maintaining soil productivity. Thus a study on mash bean and nitrogen management was proposed to ascertain suitable combination of rhizobium inoculation and N-fertilizer rates in terms of plant/soil nitrogen levels. Moreover, the study will also evaluate the varietals response in mash bean to various inoculation / fertilization combinations on crop growth and dry matter partitioning.

MATERIALS AND METHOD

Field experiment was conducted at the Research Farm of PMAS-Arid Agriculture University, Rawalpindi during autumn 2009 to study the response of two mash bean varieties, NARC Mash-II and NARC Mash-III to different combination of nitrogen fertilizer and rhizobium inoculation. The experiment was replicated thrice in split plot arrangement and the treatments were control, 20, 40 and 50 kg N ha^{-1}, inoculation, ino-culation+ 20 kg N ha^{-1}, inoculation + 40 kg N ha^{-1}, inoculation + 50 kg N ha^{-1}. The crop was planted with a single row hand drill @ 25 kg ha^{-1} in 30 cm apart rows with plant to plant distance of 10 cm. Recommended dose of phosphorus

(50 kg ha^{-1}) was applied in the form of single super phosphate before sowing.

Rhizobium was applied by coating the seed of two genotypes with Rhizobium inoculum (10^{11-12} rhizobium g^{-1} of inoculum) @ 750 g ha^{-1}. All agronomic practices were kept uniform for the treatments. After emergence, weeds were removed manually 15, 30 and 45 days after sowing. Soil samples were collected before sowing from the experimental field and after harvesting from each sub plot. Crop was harvested in 1st week of October and threshed manually. The total biomass and grain production were determined for the three central rows of each plot. Data regarding days to crop maturity, plant height at maturity, biological yield (kg ha^{-1}), and harvest index from central three rows were recorded. The data collected were analyzed statistically using Fisher's Variance Technique and Least Significance Difference test at 5% probability level to compare the difference among the treatment means (James et al., 1997).

RESULTS AND DISCUSSION

Crop maturity data showed that inoculation and nitrogen fertilizer significantly affected days to crop maturity but the varieties and interaction for varieties with treatments were non-significant (Table 1). Khan et al. (2008) also concluded that crop maturity was delayed by N-fertilizer and its combination with inoculation. The maximum days (84) to crop maturity were recorded in inoculation + 50 kg N ha^{-1} while minimum days (80) to crop maturity were recorded in control. The crop took 83 days to mature in the plots treated with inoculation + 40 kg ha^{-1} which was followed by 50 kg N ha^{-1} and sole inoculation where crop mature in 82 days. The crop with 40 kg ha^{-1} mature in 81 days which was at par with 20 kg N ha^{-1}, inoculation + 20 kg N ha^{-1}, and only inoculation. The two genotypes showed the same effect with each treatment. Results showed that inoculation and higher doses of

Table 1. Effect of inoculation and nitrogen fert ilizer on days to crop maturity

Treatments	NARC Mash -II	NARC Mash -III	Mean
Control	79.67	80.00	79.83 E
20 kg N ha^{-1}	81.00	81.33	81.17 CD
40 kg N ha^{-1}	80.67	81.00	80.83 D
50 kg N ha^{-1}	81.67	82.00	81.83 BC
Inoculation	81.67	81.67	81.67 BCD
Inoculation + 20 kg N ha^{-1}	81.00	81.33	81.17 C D
Inoculation + 40 kg N ha^{-1}	82.33	82.67	82.50 B
Inoculation + 50 kg N ha^{-1}	83.33	83.67	83.50 A
Mean	81.42	81.71	

Treatment = 0.8779 Varieties = NS and Treatments x Varieties = NS
Means followed by sam,e letters do not differ significantly at P= 0.05

nitrogen fertilization took more days to mature the crop as compared to control. The difference may be due to difference in flowering period which was differently influenced by inoculation and fertilizer application. Similar results were reported by Onder (1995).

Plant height data showed that treatment alone and interactions of treatments with varieties had highly significant effect on plant height while the effect of varieties among each other was non-significant (Table 2). Maximum plant height (40.83 cm) was recoded in inoculation and Mash-III which was significantly higher than all other treatments x varieties combination. Inoculation and nitrogen fertilizer application significantly increased the plant height as compared to control except in inoculation + 50 kg N ha^{-1}. The maximum plant height (39.67 cm) was measured in sole inoculation where plants were significantly taller than all other treatments and control. Minimum plant height (33.52 cm) was recorded in control treatment, which were statistically non significant from inoculation + 50 kg N ha^{-1}. The plant height of 38.45 cm was recorded in 50 kg N ha^{-1} which was statistically similar with inoculation + 20 kg N ha^{-1}.The results showed positive effect of inoculation on plant height which may be due to utilization of nutrients by plants more efficiently than that of un-inoculated one. These results are in line with Hoque and Haq (1994) who reported that Rhizobium inoculation significantly increased plant height of lentil.

The biomass determines the overall growth potential of a crop. Data showed that seed inoculation and nitrogen fertilizer application significantly affected biological yield but effect of varieties and the interaction with treatments were non- significant. The maximum biological yield (3407 kg ha^{-1}) which was at par with 40 kg N ha^{-1}, sole inoculation and inoculation + 20 kg N ha^{-1}(Table 3). Minimum dry matter production (2716 kg ha^{-1}) was recorded in control which was at par with 20 kg N ha^{-1}, inoculation + 40 kg N ha^{-1} and inoculation + 50 kg N ha^{-1} The results showed that inoculation and nitrogen fertilizer had positive

Table 2. Effect of inoculation and nitrogen fertilizer on plant height (cm)

Treatments	NARC Mash -II	NARC Mash - III	Mean
Control	32.67 i	34.37 h	33.52 E
20 kg N ha^{-1}	34.23 h	36.07 ef	35.15 D
40 kg N ha^{-1}	36.77 de	38.30 bc	37.53 C
50 kg N ha^{-1}	37.83 cd	39.07 b	38.45 B
Inoculation	38.50 bc	40.83 a	39.67 A
Inoculation + 20 kg N ha^{-1}	39.20 d	37.17 d	38.18 BC
Inoculation + 40 kg N ha^{-1}	35.53 fg	34.83 h	35.18 D
Inoculation + 50 kg N ha^{-1}	32.93 i	35.50 fg	34.22 E
Mean	35.96	37.01	

Treatments = 0.7554 Varieties = NS and Treatments x Varieties = 1.068
Means followed by same letters do not differ significantly at P= 0.05 LSD (0.05)

Table 3. Effect of inoculation and nitrogen fertilizer on biological yield (kg ha^{-1})

Treatments	NARC Mash -II	NARC Mash -III	Mean
Control	2731	2701	2716 B
20 kg N ha^{-1}	2806	2731	2769 B
40 kg N ha^{-1}	3451	3009	3230 A
50 kg N ha^{-1}	3559	3256	3407 A
Inoculation	3315	3302	3309 A
Inoculation + 20 kg N ha^{-1}	3380	3272	3326 A
Inoculation + 40 kg N ha^{-1}	2731	2762	2747 B
Inoculation + 50 kg N ha^{-1}	2793	2747	2770 B
Mean	3095.66	2972.61	

Treaments = 250.2, Varieties = NS and Treatments x Varieties = NS
Means followed by same letters do not differ significantly at P= 0.05

effect on biological yield. The results are also supported by the findings of Sharma (2001), who reported that Rhizobium inoculation along with the starter dose of nitrogen fertilizer increased straw yield of mash bean. It is interesting to note that the combination of 40 and 50 kg N ha^{-1} with inoculation resulted in lower crop biomass as compared to single application of various doses and inoculation. Pathak et al. (2001) observed that 10-20 kg N ha^{-1} yielded higher straw and seed yield which is quite appealing.

In harvest index, the physiological ability of a crop to convert proportion of dry matter into economic yield is measured (Table 4). The higher the harvest indices the more is the productive efficiency of a crop and vice versa. The data indicated that treatments and varieties significantly affected seed yield, but effect of nitrogen on varieties x treatments interaction were non-significant. Maximum harvest index (22.04%) was recorded in control which was statistically non significant with 20 kg N ha^{-1}, inoculation + 40 kg N ha^{-1} and inoculation + 50 kg N ha^{-1}. Minimum harvest index (20.23 %) was recorded in inoculation + 20 kg N ha^{-1}

Table 4. Effect of inoculation and nitrogen fertilizer on harvest index

Treatments	NARC Mash -II	NARC Mash -III	Mean
Control	21.96	22.12	22.04 A
20 kg N ha^{-1}	21.22	21.90	21.56 AB
40 kg N ha^{-1}	20.65	21.85	21.25 BC
50 kg N ha^{-1}	20.88	20.39	20.64 CD
Inoculation	20.77	20.76	20.76 CD
Inoculation+20 kg N ha^{-1}	20.03	20.42	20.23 D
Inoculation+ 40 kg N ha^{-1}	21.86	21.69	21.77AB
Inoculation+ 50 kg N ha^{-1}	21.36	21.76	21.56 AB
Mean		21.09	21.36A

Treaments = 0.7755, Varieties = 0.1074
Means followed by same letters do not differ significantly at P= 0.05

Table 5. Effect of inoculation and nitrogen fertilizer on grain yield(kg ha^{-1})

Treatments	NARC Mash -II	NARC Mash -III	Mean
Control	600.0	597.5	598.8 C
20 kg N ha^{-1}	594.4	598.1	596.3 C
40 kg N ha^{-1}	643.2	656.8	650.0 B
50 kg N ha^{-1}	673.5	664.2	668.8 AB
Inoculation	688.3	674.7	681.5 A
Inoculation+20 kg N ha^{-1}	667.9	668.5	668.2 AB
Inoculation+ 40 kg N ha^{-1}	596.9	598.8	597.8 C
Inoculation+ 50 kg N ha^{-1}	596.3	598.5	596.9 C
Mean	632.52	632.02	

Treatments = 0.7755, Varieties = 0.1074

Means followed by same letters do not differ significantly at P= 0.05

which were at par with 50 kg N ha^{-1} and sole inoculation which in turn were at par with 20 kg N ha^{-1}. The trend in harvest index response to various treatments seems to be due to less vegetative growth with inoculation / nitrogen fertilization. The two genotypes showed significant differences and Mash-III gave significantly higher harvest index than Mash-II. The difference in harvest index is attributed to the ability of Mash III to produce same as that of Mash II yield from lower dry biomass.

In Mash-II, inoculation alone showed maximum grain yield (688.3 kg ha^{-1}) while with three different doses of nitrogen alone i.e. 20 kg N ha^{-1} , 40 kg N ha^{-1} and 50 kg N ha^{-1} and with the application of Inoculation +20 kg N ha^{-1} (Table 5), Inoculation+40 kg N ha^{-1} and Inoculation+50 kg N ha^{-1} had shown no positive response to grain yield. Ahmed et al. (2008) also found that lentil gave maximum seed yield with only rhizobium seed inoculation. There is a non significant difference among the varieties. The maximum mean average grain yield (681.5 kg ha^{-1}) was observed with the application of inoculation alone. Pathak et al. (2001) observed that 10-20 kg N ha^{-1} yielded higher seed yield. The same trend was observed in Mash-III. Non significant effect was noticed among the genotypes Mash-II and Mash-III to all the treatments.

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