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Effect of fertility level and microbial inoculation on yield, nutrient concentration and uptake of Urdbean [*Vigna mungo* (L.) Hepper] in sandy loam soil of Rajasthan

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Abstract
A field experiment was carried out with an objective to study the effect of fertility levels and microbial inoculation on yield, nutrient concentration and uptake in urdbean [*Vigna mungo* (L.) Hepper] at Agronomy farm, S.K.N. College of Agriculture Jobner, Jaipur (Rajasthan) during *Kharif* season of 2018 on loamy sand soil. The experiment of fertility levels and microbial inoculation was carried out with 20 treatments that was carried in RBD with three replications. Results revealed that application of 100% RDF significantly increased the yield determining characters of urdbean *viz*., number of pods/plant, number of grain/pod, harvest index. It also recorded significantly higher grain (2236 kg/ha) over control. However, it showed statistical equivalence with 75% RDF, 50% RDF wherein, the maximum values of most of the yield attributes. Results further indicated that seed inoculation with PGPR + PSB + VAM significantly enhanced number of pods/plant, number of grain/pod, straw yield, biological yield, harvest index the over PGPR, PGPR + PSB, PGPR + VAM and control. It also produced the highest grain (1241 kg/ha) and straw yield (2258kg/ha) over control.

Keywords: Urdbean, PGPR, PSB, VAM, microbial inoculation, fertility level

Introduction
Pulses, known as grain legumes are next to cereals in terms of agricultural importance and have been considered best option for diversification and intensification of agriculture across the globe because of their intrinsic values such as nitrogen fixing ability (15-35 kg/ha), high protein content and ability to thrive well in less endowed environment. In India, pulses are grown on 25.76 M ha area with production of 16.47 million tonnes (Anonymous 2017-18). pulses are considered as life blood of agriculture. They occupy a unique position in every known system of farming as main, catch, cover, green manure and intercrop and their inclusion in crop rotation keep the soil alive and productive. In India, where people are predominantly vegetarian, pulses are main source of high-quality protein and thus gain vital importance in daily diet. Pulses account 25.76 million hectare area with production of 16.47 million tonne in our country (Anonyms 2017-18). Pulses are not only improving soil health by enriching N status and long-term fertility but also increase sustainability of cropping system. It meets up to 80% of its N requirement by symbiotic N-fixation. Production of pulses in our country is far below the requirement to meet even the minimum level of per capita per year consumption. The per capita availability of pulses is reduced from 21.1 kg in 1951 to 15 kg/capita/year in year 2012. In the year 2015, the per capita availability of pulses was 47.2 g, while the minimum requirement is 84 g/capita/day as prescribed by Indian Council of Medical Research, New Delhi (Anonyms 2017-18).
Urdbean [*Vigna mungo* (L.) Hepper] is one of the important self-pollinated leguminous crop grown throughout India. It is generally consumed in the form of dal. It is chief constituent of papad, idly and dosa. It contains about 24% protein, 60% carbohydrates, 1.3% fat, 3.5% minerals and 0.9% fibre. High values of lysine make urdbean an excellent complement to rice in terms of balanced human nutrition. Being a short duration crop, it fits well in various multiple and intercropping systems. In India, it is grown on an area of 3.19 million hectare sharing the production of 1.9 million tonnes with productivity of 596 kg/ha (Anonymous (2017-18). It is mainly grown in the states of Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Uttar Pradesh, Rajasthan, Tamil Nadu and Orissa. Maharashtra is the leading acreage holder and producing state in country.

In Rajasthan, this crop occupies an area 2.98 lakh hectare with production of 1.14 lakh tonne (Anonymous 2017-18). It is mainly grown on arid and semi-arid districts like Chittorgarh, Udaipur, Ajmer, Jhalawar, Kota, Bundi, Baran, etc. Despite of being such an important crop, the average productivity of crop in the state is quite low than its potential. Hence, our research efforts should be aimed to remove the constraints which are responsible for its poor productivity. The productivity of crop is largely influenced by fertility management. Being a legume crop, urdbean has capacity to fix atmospheric-N through root nodules. The major part of nitrogen is met through *Rhizobium* present in the root nodules. Hence, crop requires starter dose of additional nitrogen and phosphorus for growth and development. Chemical fertilizers have been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production (Nambiar and Abrol, 1992) [4]. Keeping this view, a field experiment was carried out at Jobner with the objective to study the effect on productivity, nutrient concentration and uptake of urdbean crop under varying levels of fertility and microbial inoculation.

Materials and Methods

Research area

The experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner situated at 26º05' N latitude and 75º28' E longitude and at an altitude of 427 meters above mean sea level. The region falls in Agro-climatic zone III-a (Semi-Arid Eastern Plain) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summers and winters. The average annual rainfall of this tract varies from 400 to 450 mm and is mostly received during the month of July to September. The relative humidity fluctuates between 42 to 87 percent. There is hardly any rain during winter and summers. The mean weekly weather parameters for the crop season recorded at the college meteorological observatory. These observations revealed that maximum and minimum temperature ranged between 30ºC to 37.2ºCand 19.1ºC to 36.7ºC, respectively, during *Kharif* 2018. Total amount of rainfall received during 2018 in URD bean crop was 307.8 mm and this was well distributed during crop growth period. The experimental soil was loamy sand in texture, low in organic carbon (0.23%), low available nitrogen (125.8 kg N/ha), medium in available phosphorus (16.10 kg P_2O_5 /ha) and available potassium (150.29 kg K_2O/ha). The soil was non-saline with a pH value of 8.25.

Experimental design and treatment details

The experiment comprised four levels of fertility (control, 50% RDF, 75% RDF, 100% RDF) and five treatments of microbial inoculation (control, PGPR, PGPR+PSB, PGPR+VAM, PGPR+PSB+VAM) thereby making twenty treatment combinations that were laid down in randomized block design and replicated three times. The treatments were randomly allotted to different plots, using random number table of Fisher and Yates (1963) [3]. Seeds of different varieties were sown on the 07th July, 2018 in the rows spaced at 30 cm apart with help of hand operated 'desi' plough with 'pora' attachment using a seed rate of 16 kg/ha. Thinning, hoeing and weeding were done after 20 days of sowing to maintain recommended spacing, proper aeration and weed free field.

Observation and data collection

Five plants were selected randomly from each plot and tagged permanently. The randomly selected plants used for recording the height and branches were used for counting the number of pods/plant, number of grain/pod, grain, straw and biological yield, nutrient concentration (N, P, K) at harvest stage and their average was computed to record per plant. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70^0C till constant weight. The numbers of branches of the five tagged plants of URD bean from each plot were counted at harvest. The mean number of pod per plant in each experimental unit at aforesaid yield stages were worked out and recorded. For counting the number of grain per plant in sampling rows and removed them carefully after wetting the soil and taking the soil up to 30 cm depth. The crop was harvested on 27th September, 2018 after leaving two border rows on each side of plot along the length on both sides, a net area of 3.0 m × 1.8 m was harvested separately from each plot to assess the grain and straw yields from net plot area. In each plot, bundles were tied and tagged properly and transported on threshing floor for proper sun drying. After complete drying, produce of each plot was weighed on physical balance and the threshing was done manually by beating with wooden sticks and winnowed traditionally. The clean grain obtained from individual plot was weighed separately and weight recorded as grain yield (kg/plot) and the total uptake of N, P and K was computed from N, P and K concentration in grain and Stover at harvesting stage.

Results and Discussion

Yield attributes

The fertility levels registered significantly higher number of pods/plant over control. Every increase in level of fertility significantly improved the number of pods/plant over preceding levels up to 100% RDF. Application of 100% RDF recorded the maximum number of 25.16 pods /plant among all the fertility levels and which was 6.1, 18.8 and 37.1 percent higher than obtained under 75% RDF, 50% RDF and control, respectively. Microbial inoculation with bio fertilizers was also significantly influenced the number of pods/plant in urdbean (Table 1) Inoculation with PGPR + PSB + VAM recorded 24.82 pods/plant that was 7.0, 10.3, 19.0 and 29.9 percent higher over PGPR+VAM, PGPR+PSB, PGPR and control, respectively. Being at par with each other, PGPR+VAM and PGPR+PSB also increased the number of pods/plant by 20.9 and 17.8 percent over control. Results presented in table 1 showed that successive increase in level of fertility increased the number of grains/pod with increasing levels fertility up to 75% RDF. Further increased in fertility level to100% RDF did not bring significant improvement in grains /pods over 75% RDF. Application of 75% RDF increased the pods /plant by 6.9 and 22.9 percent over 50% RDF and control, respectively. The corresponding increase due to 100% RDF was 17.8 and 31.6 percent. Study of the data (Table 1) revealed further that seed inoculation with PGPR, PGPR+PSB, PGPR+VAM and PGPR+PSB+VAM increased the number of grains/pod significantly over control. Inoculation with PGPR+PSB+VAM attained the maximum number of 7.45 seeds/pod among all the treatments indicating a significant increase of 20.2 and 41.1 percent over PGPR and control, respectively. However, it showed statistical equivalence with PGPR+VAM and PGPR+PSB, where in

increase in grains /pod was 37.3 and 32.6 percent over control. It is obvious from the data presented in Table 1 that harvest index in urdbean did not differ significantly due to different levels of fertility as well as seed inoculation with different microbial inoculation.

Yield

It is obvious from the data presented in Table 1 indicated that application of varying levels of fertility significantly influenced grain and straw yield of urdbean. Application of 100% RDF produced the highest grain yield of 1285 kg/ha among all the fertility levels. The magnitude of increase in grain yield due to 100% RDF was 75kg, 200kg and 663 kg/ha over 75% RDF, 50% RDF and control respectively. Application of 75% RDF and 50% RDF also improved the grain yield by 94.5 and 40.2 percent, respectively and thus found next in order. Maximum straw yield was obtained at application of 100% RDF (2236 kg/ha) which increased the straw yield by the quantum of 130, 306 and 665 kg/ha over 75% RDF, 50% RDF and control, respectively. The extent of increase in straw yield under 75% RDF (2106 kg/ha) was 9.1and 34.1 percent over 50% RDF and control, respectively. The data presented in table 1 showed that individual as well as combined inoculation of bio fertilizers had significant effect on straw yield over no inoculation. Seed inoculation with PGPR+PSB+VAM registered the maximum straw yield of 2258 kg/ha and was found significantly superior over rest of the treatments. It registered significant increase in straw yield with the magnitude of increase of 158, 250, 418 and 662 kg/ha in over seed inoculation with PGPR+VAM, PGPR+PSB, PGPR and control, respectively. Being at par with each other, inoculation with PGPR+PSB and PGPR+VAM also gave significantly higher straw yield over inoculation with PGPR and no inoculation. These treatment improved the straw yield by 9.1 and 14.1 percent over PGPR and 25.8 and 31.6 percent over no inoculation, respectively. An examination of data presented in table 1 pertaining to the effect of fertility levels on biological yield of urdbean revealed that biological yield was also influenced in the same manner as grain and straw yield. Application of 100% RDF (3521 kg/ha) increased the biological yield by margin of 205, 506 and 1328 kg/ha over 75% RDF, 50% RDF and control, respectively. Application of 75% RDF and 50% RDF also significantly increased the biological yield over control by 51.2 and 37.5 percent, respectively. An appraisal of data presented in table 4.10 revealed that amongst seed inoculation through bio fertilizers, highest biological yield of urdbean was recorded under inoculation with PGPR+PSB+VAM (3500 kg/ha). This treatment registered significant increase of 7.5, 12.5, 22.7 and 41.5 percent, over PGPR+VAM, PGPR+PSB, PGPR and control, respectively which was significantly superior over seed inoculation with PGPR, PGPR+PSB, PGPR+VAM and no inoculation by 22.7, 12.5, 7.5 and 41.5 percent, respectively. Being at par with each other, inoculation with PGPR + PSB and PGPR + VAM also gave 11.7 and 16.1 percent higher straw yield over inoculation with PGPR and 32.6 and 37.8 percent higher over no inoculation, respectively.

Nutrient concentration and uptake

Data presented in Table 2 revealed that the application of various levels of fertility differed significantly in influencing the N concentration in grain and straw of urdbean. Application of 100% RDF recorded highest nutrient concentration of 4.120% in grain and 1.860% in straw, which was significantly higher over 50% RDF and control but found at par with 75% RDF (3.950 and 1.790%). It is further apparent from the data (Table 2) that N concentration in grain and straw was significantly improved due to seed inoculation through bio fertilizers. Combined inoculation of seed with PGPR+PSB+VAM recorded the highest N concentration in grain and straw (4.255 and 1.964%) which was significantly higher over PGPR+PSB, PGPR and control. However, it remained at par with PGPR + VAM in this regard. Results showed that the highest nitrogen uptake was observed with the application of 100% RDF (95.70 kg/ha) which was significantly higher over rest of levels. The quantum increase due to this level of fertility uptake of N was 9.15, 21.41 and 48.09 kg/ha over 75% RDF, 50% RDF and control, respectively. Similarly, 75% RDF was also recorded significantly higher N uptake over 50% RDF and control with percentage increase of by 16.5 and 81.8, respectively. Data pertaining to the effect of fertility levels on phosphorus concentration in grain and straw of urdbean presented in table 2 indicated that P concentration in grain and straw of urdbean was significantly influenced due to different levels of fertility (Table 2). The maximum concentration in grain and straw (0.433% and 0.215%) was recorded under 100% RDF which were 11.6 and 10.2 percent more than 50% RDF and 19.0 and 18.1 percent over control, in grain and straw, respectively. However, it was found statistically at par with the application of 75% RDF. Microbial inoculation with PGPR+PSB+VAM registered 8.8, 16.5 and 28.7 percent in grain and 9.3, 14.9 and 36.0 percent in straw, comparison to PGPR+PSB, PGPR and control. However, it was found at par with PGPR+VAM. Results revealed that application of 100% RDF recorded the uptake of 10.50 kg P/ha and surpassed all the treatment. It significantly increased P uptake by 30.1, 11.2 and 102.3 percent over 50% RDF, 75% RDF, and control, respectively. Inoculation with PGPR+PSB+VAM recorded the highest P uptake of 10.67 kg/ha and found significantly superior over rest of the treatment (Table 2). It enhanced the total uptake of P by magnitude of 13.8, 21.4, 45.6 and 100.1% percent over PGPR+VAM, PGPR+PSB, PGPR and control, respectively. Data pertaining to the effect of fertility levels on potassium concentration in grain and straw of urdbean indicated that K concentration in grain and straw of urdbean was significantly influenced due to different levels of fertility. It recorded 6.2 and 15.4 percent more K concentration in grain and 8.4 and 18.6 percent in straw than 50% RDF and control, respectively. However, it remained at par with 100% RDF wherein the maximum concentration in grain and straw (0.936 and 1.968%) was recorded. Data (Table 2) further showed that potassium concentration was enhanced significantly due to seed inoculation with various microbial inoculants. The highest K concentration in grain and straw (0.957 and 1.985%) was obtained under PGPR+PSB+VAM which were 6.0, 7.8, 15.4 and 25.7 percent higher in grain and 6.4, 8.9, 18.5 and 30.5 percent in straw than PGPR+VAM, PGPR+PSB, PGPR and control, respectively. Results revealed that application of 100% RDF recorded the highest uptake of 56.64 kg K/ha among all the fertility levels which was 12.4, 32.9 and 90.8 percent more than obtained under 75% RDF, 50% RDF and control, respectively. Inoculation with PGPR+PSB+VAM recorded the highest uptake of 57.3 kg K/ha which registered significant increase of 14.2, 21.7,

46.0 and 88.3 percent over PGPR+VAM, PGPR+PSB, PGPR and control, respectively. PGPR + PSB and PGPR +VAM were found at par with each other and increased the uptake of K by 19.9 and 27.8 percent over seed inoculation with PGPR and 54.6 and 64.80 percent over control, respectively.

Table 1: Effect of fertility levels and microbial inoculation on number of pods, number of grains, test weight and yield and harvest index of Urdbean

Treatments	Number of pods /plant	Number of grains/plant	Test weight (g)	Yield (kg/ha)			Harvest index (%)
				Grain	Straw	Biological	
Fertility levels							
Control	18.35	5.69	30.23	622	1571	2193	28.23
50% RDF	26.19	6.36	32.15	1085	1930	3015	35.84
75% RDF	29.71	6.99	34.00	1210	2106	3316	36.34
100% RDF	33.16	7.49	35.80	1285	2236	3521	36.34
S.Em±	0.61	0.16	0.62	23.63	39.85	56.87	0.64
CD (P=0.05)	1.75	0.46	1.76	67.54	113.91	162.56	1.82
Microbial Inoculation							
Control	19.26	5.28	29.80	767	1596	2363	31.92
PGPR	25.01	6.20	31.90	964	1840	2804	33.83
PGPR + PSB	28.66	7.00	33.96	1125	2008	3133	35.33
PGPR + VAM	29.36	7.25	34.60	1156	2100	3256	34.93
PGPR + PSB+VAM	31.98	7.45	34.97	1241	2258	3500	34.92
S.Em+	0.68	0.18	0.69	26.42	44.56	63.59	0.71
CD (P = 0.05)	1.96	0.51	1.97	75.51	127.35	181.75	2.03

Table 2: Effect of fertility levels and microbial inoculation on N, P and K concentration and their uptake in urdbean

Treatments	N concentration (%)		Total N uptake (kg/ha)	P concentration (%)		Total P uptake (kg/ha)	K concentration (%)		Total K uptake (kg/ha)
	Grain	Straw		Grain	Straw		Grain	Straw	
Fertility levels									
Control	3.42	1.64	47.61	0.364	0.182	5.19	0.775	1.563	29.69
50% RDF	3.74	1.70	74.29	0.388	0.195	8.07	0.842	1.711	42.61
75% RDF	3.95	1.79	86.55	0.414	0.205	9.44	0.894	1.854	50.40
100% RDF	4.12	1.86	95.70	0.433	0.215	10.50	0.936	1.968	56.64
S.Em±	0.06	0.03	1.83	0.008	0.004	0.20	0.016	0.040	1.07
CD (P=0.05)	0.19	0.10	5.24	0.021	0.012	0.57	0.046	0.116	3.07
Microbial Inoculation									
Control	3.30	1.48	49.57	0.345	0.164	5.33	0.756	1.521	30.43
PGPR	3.62	1.64	65.95	0.381	0.194	7.33	0.824	1.675	39.23
PGPR + PSB	3.87	1.77	80.12	0.408	0.204	8.79	0.882	1.822	47.07
PGPR + VAM	3.97	1.87	86.27	0.419	0.211	9.38	0.897	1.866	50.15
PGPR + PSB+VAM	4.25	1.96	98.28	0.444	0.223	10.67	0.951	1.985	57.30
S.Em+	0.07	0.04	2.05	0.008	0.005	0.22	0.018	0.045	1.20
CD (P = 0.05)	0.21	0.11	5.85	0.024	0.013	0.64	0.052	0.129	3.43

Conclusion

Based on the results of this experiment, it may be inferred that urdbean variety T-9 was found most suitable for obtaining higher productivity. Similarly, 100% RDF with seed inoculation PGPR+PSB+VAM was observed as the most effective for enhancing grain and straw yields of Urdbean. Overall, it can be concluded that adoption of Urdbean T-9 variety with PGPR+PSB+VAM at seed inoculation can be advocated as sustainable management strategy for enhancing the productivity and quality of urdbean under sandy loam soil conditions of Rajasthan.

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