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Performance of Maize (*Zea mays* L.) as Influence by Nutrient Management Practices under Rained Conditions

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ABSTRACT: Expanding eco-friendly approaches to improve plant growth and crop productivity is of great importance for sustainable agriculture, keeping this in view, a field experiment entitled "Performance of maize (*Zea mays* L.) as influence by nutrient management practices under rainfed conditions", was carried out at the faculty of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, in the kharif of 2016. The soil of the experiment field was sandy loam in texture with a pH of 6.9, was neutral in reaction, and had medium nitrogen (240 kg/ha), P_2O_5 (23.2 kg/ha), and K_2O (156.80 kg/ha) concentrations. The experiment was laid in RCBD design having nine treatments with three replications. The findings of the experiment revealed that nutrient management practices had a significant impact on growth of maize. Among all the treatments, application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB resulted in the higher plant height, leaf area index, and accumulation of dry matter as compared to other treatments, while control treatment had lower values for all these growth parameters. It was found that nutrient content and uptake was also significantly influenced by nutrient management practices. Among different nutrient management practices application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB recorded higher nutrient content (grain + stover) and uptake of maize (uptake of N, P and K).

Keywords: Nutrient management, PSB, KSB, growth, nutrient content.

INTRODUCTION

Maize (*Zea mays* L.) is an important multipurpose cereal crop species (after wheat and rice), used as food, feed, fodder, fuel, and in the creation of industrial products (glucose, starch, dextrin, cornflakes, corn oil, and so on), and is grown in climates ranging from 58°N to 40°S. Maize crop covers over 190 million hectares worldwide, yielding approximately 1438 million tonnes (FAO, 2019). The United States, China, Brazil, Mexico, India, Romania, the Philippines, and Indonesia are among the major producers of maize. Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Karnataka, Gujarat, Andhra Pradesh, Jammu and Kashmir, Himachal Pradesh, and Maharashtra are major producers of maize in India. Maize crop covers around 9.50 million hectares in India, with an annual production of 27.23 million tonnes and a productivity of 2.87 tonnes hectare^{-1} (DES, 2019). Maize is the second most important cereal crop in the union territory of Jammu and Kashmir, after rice, and is cultivated on 0.31 million hectares with a yield of 0.51 million tonnes and an average productivity of 1650 kg ha^{-1} (DES, 2019). There are numerous opportunities to increase maize productivity using various agronomic tactics. In addition to other natural constraints, one of the primary causes of low maize production in the state of Jammu and Kashmir is a failure to supply plant nutrients in a balanced proportion. Plant nutrients are essential for enhancing maize productivity. Because it is exhausting in nature and requires more energy, nitrogen is a crucial yet limiting nutrient for increased plant development and productivity in this crop. Regarding triggering metabolic activity and the conversion of energy, chlorophyll, and protein synthesis, it is regarded as the most important nutrient for the crop. It controls better potassium, phosphorus, and other element utilization and makes up 40–50% of the dry weight of plant cell protoplasm, which makes it a limiting factor under such circumstances. Phosphorus is another important nutrient for plants. It takes involved in a variety of plant processes, from cell division to the growth of a strong root system. Protein synthesis, seed germination, and pod development are all encouraged. Additionally, according to Jaggi (1998), it plays a significant role in guaranteeing timely and uniform crop ripening as well as increasing crop maturity. It is a part of ATP and ADP, the two chemicals that biological activities depend on the most. Potassium, which is also the most prevalent cation in plants, is another essential nutrient. It is necessary for cation-anion equilibrium, stress resistance, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, and phloem transport. Only a small portion of supplied plant nutrients are converted into insoluble complexes in the rhizosphere, with negligible effect on agricultural output (phosphorus and potassium are extensively utilised by plants). In order for plants to receive the necessary nutrients to reach their genetic potential for producing crops, rhizosphere activity facilitates the transformation, mobilisation, and solubilization of nutrients from a finite pool in the soil. It has been demonstrated that the bacteria Bacillus subtilis, Pseudomonas striata, and Pseudomonas fluorescence can convert phosphorus from its fixed state into accessible forms. When organic acids like citric acid, fumaric acid, malic acid, and succinic acid are created, the pH of their surroundings is lowered, which causes phosphate to become soluble in soil (Banik and Dey 1982). Biofertilizers play an important role in maintaining soil fertility. They are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers. Nitrogen fixing and P-solubilizing inoculants are important bio fertilizers used in maize. Bio-fertilizers provide nutrients to the plants and maintain soil structure. The presence of microorganism in biofertilizers has a very unique feature; for an instance P solubilizing bacteria solubilizes P from the soil and make the fertilizers readily available for plants. It has been observed that application of biofertilizer in maize has increased the growth rate and yield (Farnia *et al.,* 2015).

To increase nutrient use effectiveness and maize production under the current climatic conditions, it is necessary to examine the use of biofertilizers in combination with chemical fertilisers.

Keeping in view the above facts a field experiment entitled " Performance of maize (*Zea mays* L.) as influence by nutrient management practices under rainfed conditions" was carried out.

MATERIALS AND METHODS

The experimental site is located in a temperate region in the northwestern Himalaya, which has hot summers and severely frigid winters. The average annual precipitation is 812 mm (average of the last 30 years), with the majority falling as snow and rain from December to April. At the beginning of the experiment in 2016, composite soil samples were collected and subjected to mechanical and chemical analysis. According to the findings, the soil had a sandy loam texture, a high level of organic carbon, a low level of nitrogen that was readily available, a medium level of phosphorus and potassium that was readily available and pH was neutral. The experiment consisting of nine treatments, laid out in a randomized complete block design with three replications. The various treatments used in the experiment were: $T_{1:}$ (control), T_2: P-Omission, $T_{3:}$ K-omission, $T_{4:}$ Seed inoculation with PSB + KSB, $T_{5:}$ RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha, $T_{6:}$ RDF + Seed inoculation with PSB+KSB, $T_{7:}$ 70% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB, T8: 80 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB+KSB and T9: 90 % (P_2O_5 and K_2O) of RDF+ seed inoculation with PSB+KSB. Plant height of randomly tagged or marked plants in the penultimate rows of each plot was taken at fifteen days interval from base of plant to the apex of flag leaf. The height was averaged and recorded as plant height in centimeters. Plant samples from 50 cm row length in each plot were collected from the penultimate rows at 15 days interval from sowing date upto harvesting stage. After drying for 5-6 days, the samples were oven dried at 60-65^oC to a constant weight. Dry weight of plant samples were recorded in grams and then convertedto q/ ha.

Leaf area index was recorded at fifteen days interval by using the following formula:

Leaf Area Index (LAI) = Leaf area ÷ Ground area

For dry matter accumulation plant samples were collected at harvest for grain and stover from each plot and after that they were sun dried for 24-48 hours in the field and oven dried at 60- 65^oC for 48 hours to a constant weight. The dry weight was recorded in grams and then converted into q/ha. The samples were ground and subsequently the samples used for chemical analyses. The methods followed for the chemical analyses areas under.

Nitrogen content. Nitrogen content of the ground plant samples (grain and stover) collected at harvest was estimated by modified Kjeldahl's method (Jackson, 1973).

Phosphorus content. After triple acid digestion of ground plant samples, phosphorus content of plant samples collected at harvest was determined by Vanado-molybdate phosphoric acid yellow colour method (Jackson, 1973).

Potassium content. Potassium content of the ground plant samples collected at harvest was estimated with the help of Flame Photometer from the digested extract preparedfor phosphorus.

Nitrogen, phosphorus and potassium uptake. Nitrogen, phosphorus and potassium uptake was calculated by multiplying the dry matter (oven dry) accumulated at maturity in grain and stover by respective concentrations of nitrogen, phosphorus and potassium.

RESULTS AND DISCUSSION

The data on plant height of maize at 15 days interval during experimentation have been given in Table 1. The results revealed that application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB+KSB significantly recorded maximum plant height (215.51 cm) than other treatments. Furthermore treatment 90 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB, 80% (P_2O_5 and K_2O) of RDF+ seed inoculation with PSB + KSB, 70% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB and RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha were at par with each other and recorded a height of 207.30 cm, 204.60 cm, 202.31 cm and 207.40 cm at harvest respectively. However, lowest plant height (184.50 cm) was recorded in control at harvest stage which was at par with seed inoculation with PSB + KSB. Also treatments K-omission and P- Omission were at par with each other. The fact that nitrogen, an important component of plant tissue, favours rapid cell division and its enlargement, which together with an adequate amount of phosphorus and potassium helps in the rapid cell division and better development of the cell size, may be the cause of the significant effect on the increase in plant height in maize with the application of NPK. By mineralizing organic P in soil and resolving precipitated phosphates, more microbes increase the availability of P to plants (Kang *et al.,* 2002). The result is in accordance with the findings of Pinjari *et al.* (2007). The data on leaf area index of maize at 15 days interval during experimentation have been given in Table 2. The leaf area index increased up to 75 days after sowing and then it showed a decreasing trend. The results revealed that application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB significantly recorded maximum leaf area index (6.97) at 75 days after sowing than other treatments. However, lowest LAI (3.85) was recorded in control at 75 days after sowing which was at par with seed inoculation with PSB + KSB. Nitrogen is an essential constituent of proteins, enzymes and chlorophyll and has been observed to influence the leaf growth and its expansion, resulting in increased leaf area index. The presence of sufficient phosphorus in the plant causes correct leaf expansion, an increase in the number of leaves and their surface area, as well as greater chlorophyll photosynthetic efficiency. This overall improvement has a knock-on effect on the plant's growth. A sufficient supply of potassium is necessary for better crop growth and for improving the source-sink connection, which increases agricultural production. A cofactor of many enzymes, potassium primarily aids in the translocation mechanism and enhances the mobility and use of other elements. Also seed inoculation with PSB and KSB, not only improves physico-chemical and biological properties of soil but, also releases adequate quantities of phosphorous and potassium. Pathak *et al.* (2002); Afifi *et al.* (2003); Kumar *et al.* (2005) also reported increased leaf area index by combined application of organic and inorganic fertilizers. The treatment effects on dry matter accumulation q/ha at 15 days interval of growth *viz.,* 15, 30, 45, 60, 75 DAS and harvest have been presented in Table 3. Perusal of the data revealed that dry matter production went on increasing with the advancement in the age of crop up to harvest and the magnitude of increase was more than double from 15 to 30 DAS in all the treatments. At harvest the dry matter production recorded with treatment RDF (90N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB and KSB was significantly higher than other treatments but was at par to 90% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB. Significantly lower dry matter accumulation was recorded with control treatment. Dry matter accumulation is another important character to express the growth and metabolic efficiency of the plant, which ultimately influence the yield. The increase in periodic dry matter accumulation with nutrient management practices may be attributed to increase in plant height and leaf area index resulting thereby in better light interception by crop which accumulated more photosynthates and thus produced more dry matter.

Nutrient management practices had a significant effect on both nutrient content (Table 4) and nutrient uptake (Table 5). The information in Tables 4 and 5 showed that treatment RDF (90 N, 45 P_2O_5, 20 K_2O, and 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB recorded better nutrient content and uptake, respectively, compared to control treatment, which recorded lower nutrient content. The availability of nutrients in the soil environment and improved translocation in plant systems appear to be the causes of the improvement in nutrient concentration. Further, it is a known fact that seed inoculation with PSB and KSB solubilize the soil phosphorous and potassium thereby increasing availability of phosphorus and potassium to the plants. The positive and significant effect of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB on K-uptake is attributed to better availability of nutrients. Similar results have also been reported by Meena *et al.* (2006); Mahala *et al*. (2006); Pathak *et al*. (2005). In general, nutrient concentration and dry matter production have an impact on a plant's total uptake of a nutrient, as the uptake is mathematically equal to the product of dry matter production and the nutrient in question. Studies on nutrient uptake in maize showed that application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB significantly increased the NPK uptake. Increased availability of nutrients particularly phosphorus following fertilizer application due to quick release can be reasoned for improved nutritional environment both in the rootzone as well as in plant system. This might have helped in better root growth which is responsible for NPK absorption. The increase in P uptake could also be attributed to synergistic effect of PSB in treated seed with unavailable phosphorus of soil. When water soluble phosphorus compounds and nitrogen are applied together, plant roots proliferate extensively in that area of treated soil resulting in more uptake of the nutrient. The present findings are in close agreement with the results obtained by Pathak *et al.* (2005); Backiyavathy and Vijayakumar (2006); Sujatha *et al.* (2008). Further, seed inoculation with PSB and KSB supplied the nutrients in balanced proportion and improved the physical characters, which might have increased the availability of nutrients particularly phosphorus and potassium. The present study revealed a significant increase in dry matter production with application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + Seed inoculation with PSB + KSB). Similar findings were also been reported by Amujoyegbe *et al.* (2007); Kumar and Dhar (2010).

Table 1: Influence of nutrient management practices on plant height (cm) at 15 days interval in maize.

Treatments	Days after sowing							
	15	30	45	60	75	90	105	At harvest
T_1 : (control)	1.82	15.32	70.42	142.24	172.30	178.10	182.70	184.50
T_2: P-Omission	1.82	15.33	75.70	147.25	179.33	185.40	189.80	192.12
T_3: K-omission	1.83	15.33	76.79	148.27	182.36	189.20	192.30	194.21
T_4: Seed inoculation with PSB + KSB	1.82	15.32	70.92	142.84	172.81	179.30	184.30	185.30
T_5: RDF (90N, 45P_2O_5, 20K_2O, 10$ZnSO_4$) kg/ha	1.88	17.04	78.81	150.40	185.81	201.30	205.80	207.40
T_6: RDF+ Seed inoculation PSB+KSB	1.95	18.30	81.60	156.05	192.05	208.60	213.02	215.51
T_7 :70% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	1.86	16.32	76.45	150.24	182.40	193.80	200.40	202.31
T_8: 80 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB+KSB	1.91	17.02	77.23	151.24	184.41	197.20	203.80	204.60
T_9: 90 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB+KSB	1.94	17.04	79.53	153.33	187.81	202.70	206.10	207.30
SEm±	**0.03**	**0.30**	**1.08**	**1.75**	**1.83**	**2.06**	**2.10**	**2.18**
C.D (P≤0.05)	**0.10**	**0.91**	**3.26**	**5.27**	**5.49**	**6.02**	**6.31**	**6.54**

Table 2: Influence of nutrient management practices on leaf area index in maize.

Treatments	Days after sowing							
	15	30	45	60	75	90	105	At harvest
T_1 : (control)	0.11	0.80	2.30	3.23	3.85	2.91	1.20	1.05
T_2: P-Omission	0.12	1.35	2.89	4.64	5.75	5.68	2.88	2.01
T_3: K-omission	0.13	1.40	2.98	4.75	5.98	5.78	2.89	2.05
T_4: Seed inoculation with PSB + KSB	0.12	1.33	2.69	3.41	3.92	3.66	1.25	1.08
T_5: RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha	0.15	1.77	3.23	5.91	6.20	6.13	3.27	2.47
T_6: RDF+ seed inoculation with PSB+KSB	0.17	1.94	3.81	6.61	6.97	6.95	3.94	2.62
T_7: 70% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	0.14	1.54	2.99	4.97	5.99	5.88	2.90	2.43
T_8: 80 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB+KSB	0.14	1.61	3.00	5.07	6.04	5.92	3.06	2.51
T_9: 90 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	0.16	1.86	3.10	5.16	6.63	6.58	3.53	2.59
SEm±	**0.003**	**0.05**	**0.08**	**0.12**	**0.17**	**0.13**	**0.10**	**0.11**
C.D (P≤0.05)	**0.01**	**0.16**	**0.25**	**0.36**	**0.41**	**0.40**	**0.30**	**0.31**

Table 3: Influence of nutrient management practices on dry matter accumulation in maize (q/ ha).

Treatments	Days After Sowing						
	15	30	45	60	75	90	At harvest
T_1 : (control) 4.58	9.17	18.35	46.21	65.70	73.71	80.14	83.72
T_2: P-Omission 4.45	9.08	16.32	69.22	89.02	99.07	105.32	109.60
T_3: K-omission 4.49	9.10	16.34	64.23	84.81	94.81	102.52	104.81
T_4: Seed inoculation with PSB + KSB 4.59	9.30	19.30	45.63	66.62	75.63	82.54	85.63
T_5: RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha 4.80	9.59	21.20	95.26	115.24	125.42	132.60	135.42
T_6: RDF+ Seed inoculation with 4.90 PSB+KSB 4.90	9.60	24.09	108.23	128.03	138.4	145.71	147.35
T_7 :70% (P_2O_5 and K_2O) of RDF + 4.75 seed inoculation with PSB + KSB 4.75	9.48	20.90	88.65	108.75	118.74	126.40	128.74
T_8: 80% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB 4.76	9.49	21.08	94.18	114.20	124.21	131.60	134.21
T_9: 90% (P_2O_5 and K_2O) of RDF + seed 4.85 inoculation with PSB+KSB 4.585	9.58	22.05	98.74	118.70	128.70	135.61	138.70
SEm±	**0.17**	**0.38**	**1.80**	**2.01**	**2.30**	**3.12**	**3.25**
C.D (P≤0.05)	**0.52**	**1.15**	**5.41**	**6.04**	**6.92**	**8.17**	**9.75**

Table 4: Influence of nutrient management practices on N, P and K (%) content of maize.

Treatments	N(%)	P(%)	K(%)
T_1 : (control)	1.23	0.260	1.037
T_2: P-Omission	1.35	0.273	1.142
T_3: K-omission	1.37	0.283	1.199
T_4: Seed inoculation with PSB + KSB	1.24	0.337	1.088
T_5: RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha	1.38	0.330	1.386
T_6: RDF + seed inoculation with PSB + KSB	1.39	0.380	1.527
T_7 :70% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	1.37	0.340	1.258
T_8: 80 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	1.38	0.340	1.320
T_9: 90 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	1.38	0.380	1.455
SEm±	**0.027**	**0.002**	**0.03**
C.D (P≤0.05)	**0.081**	**0.006**	**0.11**

Table 5: Influence of nutrient management practices on NPK uptake in maize.

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)
T_1 : (control)	102.97	21.76	86.23
T_2: P-Omission	147.96	29.59	124.94
T_3: K-omission	148.81	29.34	124.72
T_4: Seed inoculation with PSB + KSB	110.42	28.25	92.48
T_5: RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha	222.05	44.68	186.87
T_6: RDF + Seed inoculation with PSB+KSB	266.61	55.99	223.97
T_7: 70% (P_2O_5 and K_2O) of RDF + seed inoculation with PSB + KSB	191.76	43.77	160.92
T_8: 80 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB+KSB	209.35	45.63	177.15
T_9: 90 % (P_2O_5 and K_2O) of RDF + seed inoculation with PSB+KSB	238.56	52.70	201.11
SEm±	**4.14**	**0.85**	**4.91**
C.D (P≤0.05)	**12.42**	**2.56**	**14.73**

CONCLUSIONS

Investigations on "Performance of maize (*Zea mays* L.) as influence by nutrient management practices under rainfed conditions" revealed that application of RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB recorded significantly higher plant height, leaf area index, dry matter accumulation and nutrient content and uptake by the crop. In view of this, it may be concluded that for obtaining higher growth and nutrient uptake by the crop, it needs to be fertilized with RDF (90 N, 45 P_2O_5, 20 K_2O, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB.

FUTURE SCOPE

The success of future agriculture depends upon sustainability of production systems. The combined use of inorganic fertilizers and bio fertilizers will sustain the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of only chemical inputs with adverse effects. There is a need to carry out further investigations on such experiments so as to attain sustainable production systems.

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