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# Influence of Nutrient Management Practices on Yield and Economics of Maize (*Zea mays* L.) Under Rainfed Conditions

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**ABSTRACT: During the *kharif* season of 2016, a field experiment was carried out at the farm of the Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, to investigate the "influence of nutrient management practices on yield and economics of maize under rainfed conditions". The experimental field's soil was sandy loam in texture, neutral in response (PH= 6.7), with medium nitrogen (240 kg/ha), $P_2O_5$ (23.2 kg/ha), and $K_2O$ (156.80 kg/ha). The experiment was set out in an RCBD design with nine treatments and three replications. Grain yield (70.50 q/ha), stover yield (124.22 q/ha), and yield attributes were higher with RDF (90N + 45 $P_2O_5$ + 20 $K_2O$ + 10 $ZnSO_4$) kg/ha+ seed inoculation with PSB and KSB (T6) compared with other treatments except for the 90% RDF of $P_2O_5$ and $K_2O$ + seed inoculation with PSB and KSB (T6) (T9). RDF + seed inoculation with PSB and KSB (T6) yielded 7.9% higher grain yield and 8.0% higher stover yield than RDF (90N, 45$P_2O_5$, 20$K_2O$, 10$ZnSO_4$) kg/ha. B:C ratio was also higher when RDF+ seed inoculation with PSB and KSB was used (3.85), followed by 90% ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB + KSB (3.74), RDF (90N, 45 $P_2O_5$, 20 $K_2O$, 10$ZnSO_4$) kg/ha (3.61), 80% ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB (3.48), 70 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB + KSB (3.31), P- omission (2.89), K-omission (2.85), seed inoculation with PSB + KSB (2.41), control (2.33).**

**Keywords:** Yield, economics, nutrient management, PSB, KSB.

## INTRODUCTION

Maize (*Zea mays* L.) is the third most important multipurpose cereal crop species after wheat and rice. It is grown in a wide range of climates from 58°N latitude to 40°S latitude and is used for food, feed, fodder, fuel, and the production of industrial products like glucose, starch, dextrin, cornflakes, and corn oil. Around 190 million hectares of land are planted with maize worldwide, producing 1438 million tonnes (FAO, 2019). Several significant nations that grow the maize crop include the United States, China, Brazil, Mexico, India, Romania, the Philippines, and Indonesia. Important States that produce maize in India are Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Karnataka, Gujarat, Andhra Pradesh, Jammu & Kashmir, Himachal Pradesh, and Maharashtra. With an annual yield of 27.23 million tonnes and productivity of 2.87 tonnes hectare$^{-1}$, maize is grown on around 9.50 million hectares in India (DES, 2019). In the union territory of Jammu and Kashmir, maize is grown over an area of 0.31 million hectares, producing 0.51 million tonnes with an average productivity of 1650 kg ha$^{-1}$. It is the second-most significant cereal crop in the region after rice (DES, 2019). As a result, there is enough room to use diverse agronomic strategies to boost maize productivity. In addition to other natural limitations, one of the main causes of the low productivity of maize in the state of Jammu and Kashmir is the failure to provide plants with adequate amounts of nutrients. A crucial component in raising maize production is plant nutrition. Since this crop is labor-intensive and requires more energy than other crops, nitrogen is a crucial and limited nutrient for improved plant growth and productivity. For the crop to stimulate metabolic activity and transform energy, chlorophyll, and protein synthesis, it is regarded as the most crucial nutrient. It controls the more effective utilization of potassium, phosphorous, and other elements, makes up 40 to 50 percent of the plant cell's protoplasm on a dry weight basis, and may operate as a limiting factor in such circumstances. Another intriguing plant nutrient is phosphorus. It participates in a variety of plant functions, from cell division to the establishment of strong roots. It promotes protein synthesis, seed germination, and pod setting. It also has a significant role in accelerating crop maturity (Jaggi, 1998) and ensures timely and uniform ripening of the crop. It is a component of ATP and ADP, the two substances most crucial to life's functions. Another necessary nutrient is potassium, which is also the most prevalent cation in plants. It is crucial for stress resistance, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, and phloem transport. It also plays a crucial function in the activation of enzymes. Only a small portion of applied plant nutrients are utilised effectively by plants (Phosphorous and Potassium are two examples), and the remainder is quickly transformed into insoluble complexes in the rhizosphere without having the anticipated effects on crop output. Rhizosphere activity enables nutrient transformation, mobilisation, and solubilization from a finite pool in the soil, followed by required nutrient intake by plants to reach crop genetic potential. Bacillus subtilis, Pseudomonas striata, and Pseudomonas fluorescence are examples of phosphorus solubilizing bacteria that are known to transform the fixed form of phosphorus into accessible forms. In order to get the phosphate in soil to dissolve, organic acids such as citric acid, fumaric acid, malic acid, and succinic acid are produced (Banik and Dey 1982). Therefore, the use of biofertilizers in addition to chemical fertiliser needs to be assessed to improve maize productivity and nutrient usage efficiency under the current climatic conditions.

For that reason, in this experiment an effort was be made to quantify the influence of different nutrient management practices yield and economics of maize under rainfed conditions.

## MATERIALS AND METHODS

The experiment was conducted at Crop Research Farm of Division of Agronomy, Faculty of Agriculture Wadura Sopore, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir during *Kharif* 2016. Climatically the experimental site falls in temperate zone of north western Himalaya characterized by hot summers and very cold winters. At the beginning of the experiment, composite soil samples were collected and subjected to mechanical and chemical analyses. 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 a pH of neutral. Nine treatments were included in the trial, which was set up using a randomised 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 withPSB + KSB and T9: 90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB + KSB.

Total number of young cobs of 10 randomly marked plants in each plot were counted before picking and then averaged as number of cobs/plant. From the five randomly selected cobs from each plot the number of grain rows per cob were counted and mean number of rows per cob calculated**.** The 100 seeds were taken from cobs in each plot and were weighed separately and were taken as seed index. The grain yield of each net plot was thoroughly cleaned and sun dried. The yield from each plot was recorded separately as kg/ plot and then converted in q/ha. After removal of the cobs from stalks, the maize stover was cut from ground level with the help of the sickles, sun dried and weighed to determine the stover yield in q/ha. The total green cob yield and green fodder yield of each net plot was recorded and was expressed as biomass yield in q/ ha. It was calculated by dividing the economic yield *i.e.,* grain yield to the biological yield *i.e.,* grain yield + stover yield. Benefit cost ratio was determined by dividing net returns with operatingcost and expressed as benefit over 1 rupee invested.

## RESULTS AND DISCUSSION

Table 1 provides information on the number of grains/cob as affected by various treatments. Data showed that compared to the other treatments, applying RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha and seed inoculating with PSB + KSB considerably increased the number of grains/cob. The information in Table 1 relates to the number of cobs/plant as impacted by various treatments. Data revealed that the application of RDF+Seed inoculation with PSB + KSB significantly influenced the number of cobs per plant than other treatments. However the application of RDF + Seed inoculation with PSB+KSB was at par with the application of 90% ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB which was at par with RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha. The data pertaining to seed index as affected by various treatments revealed that the application of RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha + Seed inoculation with PSB + KSB significantly influenced the seed index than rest of the treatments. However the application of RDF+ Seed inoculation with PSB+KSB was at par with the application of 90% ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB. More photosynthates might have been produced as a result of the increased growth traits (plant height, LAI) influenced by nutrition management techniques. The supply of photosynthates might have increased due to greater flowering and flower fertilisation, which resulted in more cobs/plant and grains/cob. Additionally, superior grain formation was achieved in most cereals by having a larger absorbing surface during reproductive processes due to appropriate metabolite production and their transfer to grain. It appears that the application of RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$ kg/ha + Seed inoculation with PSB + KSB) not only supplied an adequate amount of NPK, but may also have played a significant role in improving the physico-chemical and biological properties of soil, possibly improving crop growth and ultimately improving yield attributes of the test crop. The significant increase in plant productivity brought about by seed inoculation with PSB and KSB may also be attributable to its profound impact on the accumulation of nutrients and dry matter. Given that crop yield is a function of several yield-attributing factors that depend on complementary interactions between vegetative and reproductive growth of the crop, the greater availability of both of these growth inputs might have maintained adequate supplies as per need of plant for yield impact on improving productivity of individual plant. Positive effects of favourable PSB and KSB on both crop phases ultimately resulted in the achievement of higher yield attributes. These results are in conformity with the earlier findings of Panwar (2008); Dadarwal *et al.* (2009); Tank (2000); Channabasavanna *et al.* (2007); Dilshad *et al.* (2010).

The effect of different treatments on grain yield have presented in Table 2. Perusal of the data indicated that the nutrient management practices significantly affected the grain yield of maize. The grain yield was recorded significantly higher with the application of RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB) than rest of the treatments, except RDF + seed inoculation with PSB+KSB which was statistically at par with 90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB. But 90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB was at par with RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha and produced significantly more grain yield than other treatments. In turn RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha was statistically at par with 80 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB+KSB. Further, 80 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB + KSB was not significant compared to 70 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB + KSB. The P-omission and K-omission were at par with each other. However, control was at par with seed inoculation with PSB and KSB. Stover yield of maize was significantly affected by nutrient management practices as presented in Table 2. The stover yield was recorded higher with the application of (RDF+ Seed inoculation with PSB + KSB) than other treatments. However RDF + seed inoculation with PSB+KSB was at par with 90 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB+KSB. But (90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB) was at par with RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha. In turn RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha was at par with 80 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB + KSB. Biological yield recorded with the application of RDF + Seed inoculation with PSB + KSB was at par with the application of 90 % ($P_2O_5$ and $K_2O$) of RDF +seed inoculation with PSB + KSB as depicted in Table 2. However the Biological yield recorded with the application of RDF + seed inoculation with PSB + KSB was significantly superior over rest of the treatments. But 90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB + KSB was at par with RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha. Harvest index was significantly influenced by nutrient management practices. Data presented in Table 2 revealed that harvest index recorded with the application of (RDF + seed inoculation with PSB + KSB) was significantly superior over rest of the treatment. Yield is the net result of various agronomic inputs influencing growth and yield attributing characters during the life cycle of the crop. The efficiency of different factors is judged mainly by their contribution towards economic yield. Significantly higher grain yield, stover yield, biological yield and harvest index were obtained with application of RDF (90N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB+KSB. The increased yield of maize produced by nutrient management practises could be primarily attributed to their favourable effects on a number of yield-contributing characters, such as the number of cobs per plant, the number of grains per cob, the seed index, and growth characters (such as LAI and dry matter accumulation). The combined application of organic and mineral fertilisers increased grain and stover yield significantly and consistently, according to earlier studies by Afifi *et al.* (2003); Kumar and Thakur (2004); Dadarwal *et al.* (2009). Concomitant release of nitrogen at most critical stages of their need is a key to ensure higher yields. In the present study, seed inoculation with PSB and KSB along with RDF (90 N, 45$P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha resulted in maximum grain yield increase in grain yield, stover yield and biological yield with application of RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB+KSB could be attributed to significant improvement in plant height and dry matter accumulation of maize. Pagar *et al.* (2022) also reported increased yield attributes and yield of sweet corn due to the seed inoculation of biofertilizers over control treatment. Tanveer *et al.* (2020) has also reported significant increase in yield and yield attributes of maize (baby corn) with increase in NPK content.

**Economics.** Perusal of data presented in the Table 3 indicated that the nutrient management practices influenced the relative economics of the crop. Highest net (Rs 82,891), gross return (Rs 1,11961), and B:C ratio (3.85) was observed with treatment RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha + Seed in with PSB + KSB. The next best treatment combination was 90 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB+KSB net return (Rs 78,750), gross return (Rs 1,07482.5) and B:C ratio was (3.74). Whereas lowest economics return was observed with treatment (control). The corresponding value for net returns, gross return and B: C was Rs 35,479.5, Rs 62,079.5 and 2.33, respectively. The efficiency of a treatment is finally decided in terms of the economics (benefit cost ratio) of that treatment. The present investigation revealed that highest gross return of Rs 1,11961, net return of Rs

82,891 and benefit: cost ratio (Rs 3.85) was realized from the treatment RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha + seed inoculation with PSB + KSB, whereas the lowest benefit cost ratio (Rs 2.33) was noticed in control treatment. Ashok *et al*. (2008), Ramesh Naik *et al*. (2008); Kumar and Thakur (2004) ; Ravindra and Agarwal (2004) also reported the similar results.

**Table 1: Influence of nutrient management practices on yield attributes of Maize.**

| Treatments | | Grains / cob | Seed index (g) |
|---|---|---|---|
| T1 : (control) | 0.91 | 211.60 | 19.69 |
| T2: P-Omission | 1.00 | 233.28 | 21.71 |
| T3: K-omission | 1.05 | 244.95 | 22.43 |
| T4:Seed inoculation with PSB + KSB | 0.95 | 222.18 | 20.64 |
| T5:RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha | 1.21 | 283.54 | 23.08 |
| T6:RDF+ Seed inoculation with PSB+KSB | 1.33 | 312.59 | 23.60 |
| T7:70% ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB + KSB | 1.10 | 257.19 | 22.81 |
| T8: 80 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB | 1.15 | 270.04 | 22.91 |
| T9: 90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB | 1.27 | 297.71 | 23.50 |
| **SEm±** | | **5.20** | **0.16** |
| **C.D (P≤0.05)** | | **15.62** | **0.50** |

**Table 2: Influence of nutrient management practices on Grain yield (q/ha), Stover yield (q/ha), Biological yield (q/ha) and harvest index (%) of Maize.**

| Treatments | Grain yield (q/ha) | Stover yield (q/ha) | Biological yield (q/ha) | Harvest index (%) |
|---|---|---|---|---|
| T1: (control) | 38.92 | 73.99 | 112.91 | 34.46 |
| T2: P-omission | 50.06 | 96.50 | 146.57 | 34.16 |
| T3 :K-omission | 50.77 | 94.54 | 145.31 | 34.91 |
| T4: Seed inoculation with PSB and KSB | 40.87 | 77.69 | 118.56 | 36.17 |
| T5: RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha | 65.28 | 115.02 | 180.31 | 36.23 |
| T6:: RDF+ Seed inoculation with PSB+KSB | 70.50 | 124.22 | 194.73 | 39.13 |
| T7:70% ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB + KSB | 59.41 | 104.67 | 164.08 | 32.97 |
| T8: 80 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB | 62.67 | 110.42 | 173.09 | 34.78 |
| T9: 90 % ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB+KSB | 67.68 | 119. 25 | 186.94 | 37.56 |
| **SEm±** | **1.50** | **3.14** | **4.55** | **0.327** |
| **C.D (P≤0.05)** | **4.55** | **9.52** | **13.76** | **0.989** |

**Table 3: Influence of nutrient management practices on relative economics of Maize.**

| Treatments | Cost of Cultivation (Rs) | Gross Return (Rs) | Net Return (Rs) | B:C |
|---|---|---|---|---|
| T1: (control) | 26600 | 62079.5 | 35479.5 | 2.33 |
| T2: P-omission | 27635 | 79915 | 52280 | 2.89 |
| T3 :K-omission | 28330 | 80882 | 52552 | 2.85 |
| T4: Seed inoculation with PSB and KSB | 27000 | 65189.5 | 38159.5 | 2.41 |
| T5: RDF (90 N, 45 $P_2O_5$, 20 $K_2O$, 10 $ZnSO_4$) kg/ha | 28670 | 103671 | 75001 | 3.61 |
| T6:: RDF+ Seed inoculation with PSB+KSB | 29070 | 111961 | 82891 | 3.85 |
| T7:70% ($P_2O_5$ and $K_2O$) of RDF + seed inoculation with PSB + KSB | 2845.7 | 94348.5 | 65891 | 3.31 |
| T8: 80 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB+KSB | 28595 | 99526 | 70931 | 3.48 |
| T9: 90 % ($P_2O_5$ and $K_2O$) of RDF+ seed inoculation with PSB+KSB | 28732.5 | 107482.5 | 78750 | 3.74 |

## CONCLUSIONS

Investigations on "Influence of nutrient management practices on yield and economics of maize (*Zea mays* L.) 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 high grain yield, stover yield and net returns of Rs 82,891 and benefit cost ratio of Rs 3.85. In view of this, it may be concluded that for obtaining maximum economic grain and stover yield in maize, 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 biofertilizers 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 chemical inputs with adverse effects. There is a need to carry out further investigations on such experiments so as to attain sustainable production systems

**Conflict of Intere**st. None.

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