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# Influence of organic and inorganic sources of nutrients on soil health and quality parameters of pop corn

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## Abstract
The field experiment was conducted at crop research farm of Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura during *kharif* 2017. The experiment was laid in RCBD having twelve treatments and three replications. The treatments where $T_1$(Control),$T_2$ (RDF) (120:60:40 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$ respectively), $T_3$ (FYM @ 15t $ha^{-1}$), $T_4$ (Vermi-compost @ 5t $ha^{-1}$),$T_5$ (Poultry manure @ 5t $ha^{-1}$), $T_6$ (75% RDF + FYM @ 10t $ha^{-1}$), $T_7$ (75% RDF + FYM @ 10t $ha^{-1}$ + *Azospirillum* + PSB + KSB) $T_8$ (FYM @ 10t $ha^{-1}$ + *Azospirillum*), $T_9$ (FYM @ 10t $ha^{-1}$ + *Azospirillum* + PSB), $T_{10}$ (FYM @ 10t $ha^{-1}$ + *Azospirillum* + PSB + KSB), $T_{11}$ (Vermi-compost @ 5t $ha^{-1}$ + *Azospirillum* + PSB + KSB), $T_{12}$ (Poultry manure @ 5t $ha^{-1}$ + *Azospirillum* + PSB + KSB).The results of the study showed that the treatment ($T_2$) recorded highest quality parameters viz. popping percentage (83.5%), popping expansion volume (13.2 ml), flake size (2.7 cm), protein content (8.8%), total nitrogen, phosphorous and potassium uptake were (127.44, 36.72 and 159.33 kg $ha^{-1}$), respectively but was at par with 75% RDF + FYM @ 10t $ha^{-1}$ + AZO + PSB + KSB ($T_7$) while significantly lowest quality parameters viz. popping percentage (73.1%), popping expansion volume (11.6 ml), flake size (1.8 cm), Protein content, total nitrogen, phosphorous and potassium uptake were 49.80, 12.86 and 69.118) kg $ha^{-1}$, respectively were recorded for the treatment ($T_1$).

**Keywords:** Biofertilizers, FYM, Popcorn, Poultry manure, RDF, Vermi-compost

## Introduction
Maize known as the "Queen of Cereals" due to its high genetic yield potential than any other cereal counterparts is the third most important cereal crop in India after rice and wheat. It occupies an important position in world economy and trade as a food, feed, fuel and industrial grain crop. Being a C4 plant, it is an efficient converter of absorbed nutrients into food. The productivity of maize is highly dependent on its nutrient management. Maize is a heavy feeder crop and because of this nature, very efficient converter of solar energy into dry matter (Awotundun, 2005) [3]. The use of chemical fertilizers is the quickest and surest way of boosting crop production. However, the continued application of chemical fertilizers leads to deterioration of soil health with reduced organic carbon and increased multi-nutrient deficiencies. As such the judicious use of fertilizers from different sources in the crop will maintain the environmental sustainability for generations without affecting the environmental health (Dadarwal *et al.*, 2009) [6]. Maintaining and improving soil quality is thus crucial if agricultural productivity and environmental [1] quality are to be sustained for future generations (Reeves, 1997) [26]. The use of organic manures has been proposed as one of the main pillars of sustainable agriculture. The application of organic sources of nutrients not only helps in enhancing the productivity but has the beneficial effect on soil properties as well (Pathak *et al.*, 2005) [21]. Organic manures induce improvement in physical, chemical, and biological properties of soil. Nutrients available in organic manures are released slowly, remain in the soil for longer time and are available to plants, thereby, maintain soil fertility and enhance the yield (Belay *et al.*, 2001) [5]. These are valuable resources as they provide large amounts of macro and micro nutrients for crop growth and eco-friendly alternative to mineral fertilizers. Building up of these macro and micro nutrients, counteracting deleterious effects of soil acidity, salinity and alkalinity and substances of soil health are the key beneficial effects

associated with organic manures. The organic sources besides supplying N, P and K also make unavailable sources of elemental nitrogen, bound phosphates, micro-nutrients and decomposed plant residues into available forms to facilitate plants to absorb the nutrients. Whereas mineral fertilizer and organic manures used separately or combined have beneficial effects upon soil and crop, their combined use is expected to yield rewarding dividends (Rayar, 2000) [24]. According to Rayar (2000) [24], application of mineral fertilizers alone to boost the yield may be favorable for few growing seasons. Such agronomic practice would undoubtedly lead to regrettable consequences. This might involve complete crop failure or drastic reduction in yield due-largely to non-supply of some vital secondary and trace elements to soil because of exhaustive nature of the crop and initiation of soil degradation. On the other hand, by combining application of organic manures and mineral fertilizers, the yield is expected to stabilize over the years, indicating a substantial improvement in soil fertility.

## Materials and Methods

The present study was carried out during the rainy (*kharif*) season of 2017 at Research Farm of the Division of Agronomy, Faculty of Agriculture and Regional Research Station, Wadura, SKUAST-K. Jammu and Kashmir (latitude 34° 172′ N, longitude 74° 332′ E and at an altitude of 1524 meters above mean sea level. The experimental site was well drained with uniform topography. Climatically the experimental site falls in temperate zone of north western Himalaya characterized by hot summers and very cold winters. The average annual precipitation is 812 mm (average of past 30 years) most of which is received from December to April in the form of snow and rains. The maximum and minimum temperatures were 24.67 and 10.05 °C, respectively and the total precipitation amounted to 232.7 mm during crop growth period of 2017. The total number of sunshine hours recorded during the crop growth period was 328 hours and the mean maximum and minimum relative humidity were 79.75 and 56.04%, respectively during the crop growth period. The soil of the experimental field was silty-clay loam in texture, medium in organic carbon, available nitrogen, phosphorous and potassium with neutral pH and normal electrical conductivity (Table 1).

**Table 1:** Physico-chemical properties of soil of experimental field

| Depth | Texture | $EC_{Ds/m}$ | pH | O.C% | N% | P% | K% |
|---|---|---|---|---|---|---|---|
| 0-30 cm | Silty clay loam | 0.44 | 6.60 | 0.74 | 243.2 | 20.5 | 160 |

The experiment comprising of twelve treatments including control was laid out in a Randomized Block Design with three replications. The twelve treatments are $T_1$(Control),$T_2$ (RDF) (120:60:40 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$ respectively), $T_3$ (FYM @ 15t $ha^{-1}$), $T_4$ (Vermi-compost @ 5t $ha^{-1}$),$T_5$ (Poultry manure @ 5t $ha^{-1}$), $T_6$ (75% RDF + FYM @ 10t $ha^{-1}$), $T_7$ (75% RDF + FYM @ 10t $ha^{-1}$ + *Azospirillum* + PSB + KSB), $T_8$ (FYM @ 10t $ha^{-1}$ + *Azospirillum*), $T_9$ (FYM @ 10t $ha^{-1}$ + *Azospirillum* + PSB), $T_{10}$ (FYM @ 10t $ha^{-1}$ + *Azospirillum* + PSB + KSB), $T_{11}$ (Vermi-compost @ 5t $ha^{-1}$ + *Azospirillum* + PSB + KSB), $T_{12}$ (Poultry manure @ 5t $ha^{-1}$ + *Azospirillum* + PSB + KSB). The field was prepared by giving 2-3 ploughing with rotavator so as to crush the clods and hard pans, stubbles and weeds etc. were removed from the field followed by equal number of harrowings. After leveling the experimental field, block/replication borders, plot bunds and irrigation channels were made manually as per the layout plan. The required quantity of different manures viz. farm yard manure, poultry manure and vermi-compost as per the treatments was applied in field 15 days before sowing. Urea, Diammonium phosphate and muriate of potash were used as source of nitrogen, phosphorus and potassium, respectively in the form of chemical fertilizers. The nitrogen was applied in three splits 50% as basal, 25% knee high and 25% tasselling stage. While, full dose of phosphorus and potassium were applied as basal as per the treatment details. The seed of KDPC-2 was sown at the rate of 18 kg $ha^{-1}$ in rows 60 cm apart with plant to plant spacing of 20 cm which gave a plant population of 83333.00 plants $ha^{-1}$. Seed was sown uniformly at a depth of 5-6 cm. Thinning was done after about 3 weeks of sowing to maintain plant to plant spacing. Two hand weedings were done at 30 and 50 days after sowing. Row-wise detasseling was carried out soon after tassel emergence in order to maintain quality of popcorn. However, while removing tassels, care was taken not to damage flag leaf which would otherwise affect the net photosynthesis. For quality parameters different procedures were followed. For popping volume, Popcorn samples (15 g) were popped in a modified hot-air popper at the desired air temperature. Before popping, the number and weight of pop corn kernels were measured. Bulk volumes were measured by pouring the popped corn into an 80-mm diameter, 1ooo-ml graduated cylinder. The average of three measurements was recorded. Then, the popped and unpopped kernels were separated and the number of unpopped kernels was counted. From this data the expansion bulk volume (in millimeters per gram) were calculated

Expansion bulk volume = total bulk volume/initial kernel weight

### Popping percentage

For work out the popping percentage, 500 grains were put in cooker and butter was added, after popping the unpopped and improperly popped grain was separated and their numbers were counted. Thereafter properly popped grain was obtained by dividing 500 and expressed in percentage.

### Flake size

Flake size is worked out by using vernier- caliper scale.

### Protein content

Protein content of pop corn was calculated by multiplying the nitrogen content of grain with a factor 6.25 as proposed by Tsen and Martin (1971) [33]. It was expressed in terms of per cent.

For plant analysis, plant samples collected at harvest from each plot were sun dried for 24-48 hours in the field and then oven dried at 60-65ºC for 48 hours to a constant weight. The dry weight was recorded in grams and then converted into q $ha^{-1}$. The samples were ground and subsequently used for chemical analysis. Nitrogen content of the ground plant samples of pop corn collected at harvest was estimated by modified Kjeldahl's method (Jackson, 1973) [9]. After triple acid digestion of ground plant samples, phosphorus content of plant samples was determined by Vanado-molybdate phosphoric acid yellow colour method (Jackson, 1973) [9]. Potassium content was estimated with the help of Flame Photometer from the digested extract prepared for phosphorous. Nitrogen, phosphorus and potassium uptake was calculated by multiplying the dry matter (oven dry) accumulated at harvest by respective concentrations of nitrogen, phosphorus and potassium**.** Soil samples were taken from each plot in all the replications treatment wise after harvesting of crop and analyzed for available nitrogen, phosphorus and potassium as per methods given in Table 3.1. N, P, K balance sheet in soil were worked out on the basis of initial and final available N, P, K concentration in the surface soil (0-15cm) and its total uptake by crops. Expected balance of a N, P, K was estimated by subtracting the uptake of the nutrient by the crops from the available N, P, K at the beginning (initial available N, P, K) and the added N, P, K through fertilizer. Apparent balance of the N, P, K was estimated by subtracting expected balance from the available N, P, K in soil after the harvesting of crop (final available nutrient). Actual balance of the nutrient was estimated by subtracting the initial available nutrient from the final available nutrient.

**Nitrogen use effecieny**

NUE = (grain yield in fertilized plot – grain yield in control plot (kg ha-$^{1}$)/ Fertilizer N applied (kg ha$^{-1}$)

**Phosphorus use effecieny**

PUE = (grain yield in fertilized plot – grain yield in control plot (kg ha$^{-1}$)/ Fertilizer P applied (kg ha$^{-1}$)

**Potassium use effecieny**

KUE = (grain yield in fertilized plot – grain yield in control plot (kg ha$^{-1}$)/ Fertilizer K applied (kg ha$^{-1}$)

The organic carbon content in soil after harvest of the crop. It was found that the organic carbon content in the soil after the experimentation varied markedly amongst the treatments. Significantly lowest organic carbon content of 0.77% and 0.87% was found with unfertilized control and RDF (120:60:40) N, P and K kg ha$^{-1}$, respectively. Whereas significantly highest organic carbon content was recorded with treatment FYM @ 15 t ha$^{-1}$ which was found at par with rest of the treatments. Relative economics of different treatments was worked out at existing market rates. The net returns were calculated by subtracting the cost of cultivation from gross returns and the benefit: cost ratio (net returns per rupee invested for each treatment) was calculated by dividing the net returns with the cost of cultivation.

## Results and Discussion

### Quality analysis

Analysis of variance showed that the significantly higher protein content was observed with the application 75% RDF + FYM @ 10t ha$^{-1}$ + *Azospirillium* + PSB + KSB (Table 2) than other fertility levels. This illustrates that increased availability of nitrogen have positive influence on protein content of maize grain. The protein content in grain is directly proportional to the nitrogen status of the plant at the reproductive stages. Application of FYM and higher levels of nitrogen resulted in higher chlorophyll and nitrogen content in plant which might be responsible for observed higher grain protein content. The results are in close conformity with the findings of Kumar *et al.* (2002) [12], Sani *et al.* (2014) [27] and Meena *et al.* (2017) [15]. The popping percentage varied widely among the treatments (Table 2). It was lowest with 73.10 per cent in unfertilized control which increased significantly 83.2 % in ($T_7$). Similar results were made by Negalur (2000) [18], Gangadhar *et al.* (2009) [8] and Nagannagouda (2001) in pop sorghum. The higher expansion volume of popcorn (Table 2) (12.9%) was found with treatment ($T_7$). Similar results were made by Negalur (2000) [18], Gangadhar *et al.* (2009) [8] and Nagannagouda (2001) in pop sorghum. The higher flake size of popcorn (Table 2) (2.6%) was found with treatment ($T_7$) and was found at par with rest of the treatments. The results are in close conformity with the findings of Negalur (2000) [18], Gangadhar *et al.* (2009) [8] and Nagannagouda (2001) in pop sorghum.

### Plant analysis

NPK content of plant tissue showed marked improvement under treatment ($T_7$) (Table 3). It may be attributed to the continuous availability of maximum plant nutrients especially NPK with less losses due to application of high doses of nutrients in integrated form (75% RDF + FYM @ 10 t ha$^{-1}$ + *Azospirillium* + PSB + KSB). The results are in close accordance with the findings of Amanullah (2008) [1], Parthasarathi *et al.* (2013) [22], Sani *et al.* (2014) [27] and Meena *et al.* (2017) [15]. Nutrient uptake in pop corn showed that application of 75% RDF + FYM @ 10 t ha$^{-1}$ + *Azospirillium* + PSB + KSB significantly increased the NPK uptake (table 3). This may be attributed to due to higher nutrients content in cob and forage plus higher cob and green fodder production under the application of 75% RDF + FYM @ 10 t ha$^{-1}$ + *Azospirillium* + PSB + KSB fertility level may have resulted higher uptake. The present findings are in close agreement with the results obtained by Pathak (2005) [21], Backiyavathy and Vijayakumar (2006) [3] and Sujata *et al.* (2008) [32]. Sepat *et al.* (2010) [28] reported that application of RDF along with FYM and biofertilizer (*Azotobacter*, PSB and VAM) produced higher NPK uptake by wheat over RDF alone and control.

### Soil analysis

Nitrogen is highly mobile in soil and is subjected to several losses viz., de-nitrification, volatile losses of ammonia gas and nitrate losses with percolating water. After its removal by the crops and its losses, very little is left in soil. In the present study it was found that nitrogen balance in soil after completion of experiment remained more for different treatment combinations as that of initial nitrogen content except unfertilized control. The highest nitrogen balance (table 5) in soil was found for the treatment FYM @ 15 t ha$^{-1}$. Earlier Kumari and Singaram (1996), Parmar and Sharma (2001) [20] and Kademani *et al.* (2003) [10] also reported similar results. Phosphorus moves very slowly from the point of placement as the phosphate ion is almost immobile in soil and hence retained in a soil not only for a season or so but even for longer period. In fact, phosphorus content (table 6) showed increasing values with all treatment combinations compared to initial status except unfertilized control. Higher phosphorus content recorded with FYM (15 t ha$^{-1}$) could be attributed to the higher release of phosphorus from FYM. The lowest and negative phosphorus balance with unfertilized control could be attributed to non-availability of nutrients. Earlier Dutta (2000) [7] reported increased available phosphorus by 40 per cent with 60 kg N ha$^{-1}$ + FYM + *Azotobacter*. These results are also in close agreement with those of Kumari and Singaram (1996), Parmar and Sharma (2001) [20] and Kademani *et al.* (2003) [10]. Potassium ion is positively charged and tends to attach itself to the colloidal complex and is restricted in movement. Hence, amount and type clay and the amount of organic matter present in soil invariably influence its movement and as such is reported to be retained in soil for longer periods. The investigation revealed marginal increase in the available potassium of soil (table 7) with different treatments compared to initial status, however, a negative balance was seen in unfertilized control. The highest available potassium was recorded in treatment poultry manure @ 5 t $ha^{-1}$. Increase in the NPK status in the soil after application of NPK fertilizers has been also reported by Singh *et al.* (1996) [31] and Shah (2001) [29]. The organic carbon in the soil showed a steady increase compared to initial status before the start of experiment. Highest organic carbon content was observed with treatment FYM (15 t $ha^{-1}$) (Table 4). The higher organic carbon content recorded with all treatment combinations as against initial status could be attributed to application of FYM. Minhas and Singh (1998) [16] and Singh and Aggarwal (2000) [30] reported that application of FYM at significantly increased the organic carbon and available nitrogen in maize. Nutrient use efficiency was influenced by different nutrient management practices. The maximum N use efficiency (table 8) was recorded under application of Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB followed by RDF (120:60:40) N, P, and K kg $ha^{-1}$ and Lowest N recovery was recorded with treatment vermi-compost @ 5 t $ha^{-1}$. Nutrient use efficiency of P varied among different treatment combinations. The highest agronomic efficiency of P was registered with treatment FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB while lowest was noted from treatment FYM @ 15 t $ha^{-1}$. Maximum nutrient use efficiency of K was observed under treatment RDF (120:60:40) N, P, and K kg $ha^{-1}$, respectively followed by rest of the treatments. The minimum value of nutrient use efficiency of K was recorded with treatment FYM @ 15 t $ha^{-1}$. Cassman *et al.* (2002) reported that highest fertilizer recovery was obtained by applying medium fertilizer dose while as lowest was recorded with higher NPK dose. This suggests that applying fertilizer in higher amounts might have resulted in more nutrient losses. Zada *et al.* (2000) [34] reported that nutrient use efficiency increased with increasing fertilizer rates up to a certain level and then started to decline.

**Relative economics**

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 returns of Rs.1,46820, net return of Rs.1,03910 was realized from the treatment 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB but highest benefit : cost ratio (Rs. 3.6) was realized from treatment RDF (120:60:40) kg $ha^{-1}$ which was having least significant difference from benefit : cost ratio (Rs. 3.4) of treatment 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB, where as the lowest benefit cost ratio (Rs.1.2) was noticed in treatment Vermi-compost @ 5 t $ha^{-1}$. Ramesh Naik *et al.* (2008), Ashok *et al.* (2008), Kumar and Thakur (2004) and Ravindra Singh and Agarwal (2004) [23, 2, 14, 25] also reported the similar results.

**Table 2:** Influence of organic and inorganic sources of nutrients on quality parameters of popcorn (*Zea mays* everta)

| Treatments | | Quality parameters | | | |
|---|---|---|---|---|---|
| | | Popping Percentage | Popping expansion volume (ml) | Flake size (cm) | Protein content (%) |
| $T_1$ | Control | 73.1 | 11.6 | 1.8 | 7.7 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 83.5 | 13.2 | 2.7 | 8.8 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 81.5 | 12.8 | 2.0 | 8.1 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 77.3 | 12.6 | 1.7 | 7.7 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 76.2 | 12.5 | 1.9 | 7.6 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 83.1 | 12.7 | 2.1 | 8.3 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 83.2 | 12.9 | 2.6 | 8.6 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 76.7 | 12.4 | 1.2 | 7.8 |
| $T_9$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB | 77.2 | 12.4 | 2.2 | 7.9 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 81.2 | 12.8 | 2.2 | 8.1 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 78.3 | 12.7 | 2.2 | 8.0 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 79.4 | 12.6 | 2.2 | 8.0 |
| | Sem ± | 1.70 | 0.08 | 0.09 | 0.07 |
| | C.D ($P \leq 0.05$) | 5.04 | 0.22 | 0.27 | 0.02 |

**Table 3:** Influence of organic and inorganic sources of nutrients on N, P & K uptake in grain (kg $ha^{-1}$) of popcorn (*Zea mays* everta)

| Treatments | | N (kg $ha^{-1}$) | P (kg $ha^{-1}$) | K (kg $ha^{-1}$) |
|---|---|---|---|---|
| $T_1$ | Control | 27.33 | 4.93 | 22.85 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 54.71 | 13.58 | 53.54 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 41.86 | 9.66 | 39.92 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 33.88 | 7.28 | 34.44 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 33.55 | 7.42 | 33.82 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 47.08 | 10.62 | 44.60 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 48.63 | 11.36 | 46.86 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 37.7 | 8.7 | 35.67 |
| $T_9$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB | 36.61 | 8.58 | 35.17 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 37.93 | 8.13 | 37.32 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 40.19 | 8.79 | 38.93 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 40.3 | 9.3 | 38.13 |
| | SEm ± | 1.663 | 0.201 | 0.530 |
| | C.D ($P \leq 0.05$) | 4.88 | 0.59 | 1.56 |

**Table 4:** Influence of organic and inorganic sources of nutrients on N, P, K and OC (%) content in soil after harvesting popcorn (*Zea mays* everta)

| | Treatments | N | P | K | OC |
|---|---|---|---|---|---|
| $T_1$ | Control | 243.3 | 20.7 | 162.7 | 0.77 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 253.3 | 21.8 | 176.0 | 0.87 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 268.3 | 22.7 | 179.0 | 0.99 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 261.3 | 22.5 | 175.0 | 0.96 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 263.7 | 22.3 | 180.0 | 0.97 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 256.0 | 21.6 | 162.7 | 0.90 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 256.0 | 22.6 | 163.3 | 0.97 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 266.7 | 21.5 | 166.3 | 0.93 |
| $T_9$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB | 266.9 | 22.5 | 172.0 | 0.94 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 264.0 | 22.6 | 163.2 | 0.94 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 267.7 | 22.3 | 172.3 | 0.93 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 267.3 | 21.7 | 178.7 | 0.93 |
| | SEm ± | 10.45 | 0.34 | 1.52 | 0.031 |
| | C.D ($P \leq 0.05$) | 30.66 | 1.00 | 4.49 | 0.09 |

**Table 5:** Nitrogen Balance Sheet

| | Treatments | Initial N kg $ha^{-1}$ (A) | Added N kg $ha^{-1}$ (B) | Total N Uptake kg $ha^{-1}$ (C) | Expected balance (A+B) – C (D) | Final available N kg $ha^{-1}$ (E) | Apparent balance (E-D) kg $ha^{-1}$ (E-D) | Actual balance (E-A) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | Control | 242.3 | 0 | 49.80 | 192.49 | 243.3 | 50.80 | 1 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 242.3 | 120 | 127.44 | 234.86 | 253.3 | 18.44 | 11 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 242.3 | 75 | 94.41 | 222.89 | 268.3 | 45.41 | 26 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 242.3 | 75 | 84.32 | 232.97 | 261.3 | 28.32 | 19 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 242.3 | 60 | 73.08 | 229.22 | 263.7 | 34.48 | 21.4 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 242.3 | 140 | 107.05 | 275.25 | 256 | -19.25 | 13.7 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 242.3 | 140 | 112.19 | 270.10 | 256 | -14.10 | 13.7 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 242.3 | 50 | 82.73 | 209.57 | 266.7 | 57.13 | 24.4 |
| $T_9$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB | 242.3 | 50 | 79.55 | 212.75 | 266.9 | 54.15 | 24.6 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 242.3 | 50 | 83.89 | 208.41 | 264 | 55.59 | 21.7 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 242.3 | 75 | 92.45 | 224.85 | 267.7 | 42.85 | 25.4 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 242.3 | 60 | 87.15 | 215.15 | 267.3 | 52.15 | 25 |

**Table 6:** Phosphorous Balance Sheet

| | Treatments | Initial P kg $ha^{-1}$ (A) | Added P kg $ha^{-1}$ (B) | Total P Uptake kg $ha^{-1}$ (C) | Expected balance (A+B) – C (D) | Final available P kg $ha^{-1}$ (E) | Apparent balance (E-D) kg $ha^{-1}$ (E-D) | Actual balance (E-A) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | Control | 20.5 | 0 | 12.86 | 7.64 | 21 | 13.36 | 0.5 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 20.5 | 60 | 36.72 | 43.78 | 21.8 | -21.98 | 1.3 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 20.5 | 60 | 27.18 | 53.32 | 22.7 | -30.62 | 2.2 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 20.5 | 50 | 23.52 | 46.97 | 22.5 | -24.47 | 2 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 20.5 | 70 | 22.56 | 67.94 | 22.3 | -45.64 | 1.8 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 20.5 | 105 | 30.27 | 95.23 | 21.6 | -73.63 | 1.1 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 20.5 | 105 | 32.2 | 93.3 | 22.6 | -70.7 | 2.1 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 20.5 | 40 | 24.59 | 35.91 | 21.5 | -14.41 | 1 |
| $T_9$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB | 20.5 | 40 | 24.58 | 35.92 | 22.5 | -13.42 | 2 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 20.5 | 40 | 24.92 | 35.58 | 22.6 | -12.98 | 2.1 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 20.5 | 50 | 25.911 | 44.59 | 22.3 | -22.29 | 1.8 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 20.5 | 70 | 25.212 | 65.29 | 21.7 | -43.59 | 1.2 |

**Table 7:** Potassium Balance Sheet

| Treatments | | Initial K kg $ha^{-1}$ (A) | Added K kg $ha^{-1}$ (B) | Total K Uptake kg $ha^{-1}$ (C) | Expected balance (A+B) – C (D) | Final avail able K kg $ha^{-1}$ (E) | Apparent balance (E-D) kg $ha^{-1}$ (E-D) | Actual balance (E-A) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | Control | 160 | 0 | 69.12 | 90.88 | 162.7 | 71.82 | 2.7 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 160 | 40 | 159.33 | 40.66 | 176 | 135.33 | 16 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 160 | 75 | 124.75 | 110.25 | 179 | 68.75 | 19 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 160 | 30 | 113.95 | 76.04 | 175 | 98.95 | 15 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 160 | 40 | 105.31 | 94.69 | 180 | 85.31 | 20 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 160 | 80 | 141.8 | 98.20 | 162.7 | 64.50 | 2.7 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 160 | 80 | 146.89 | 93.11 | 163.3 | 70.19 | 3.3 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 160 | 50 | 116.02 | 93.98 | 166.3 | 72.32 | 6.3 |
| $T_9$ | FYM @ 10 t ha $^{-1}$ + AZO + PSB | 160 | 50 | 112.64 | 97.36 | 172 | 74.64 | 12 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 160 | 50 | 118.65 | 91.35 | 163.2 | 71.85 | 3.2 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 160 | 30 | 123.63 | 66.37 | 172.3 | 105.93 | 12.3 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 160 | 40 | 119.46 | 80.54 | 178.7 | 98.15 | 18.7 |

**Table 8:** Influence of organic and inorganic sources of nutrients on Nitrogen Use Efficiency, Phosphorus Use Efficiency and Potassium Use Efficiency in terms of Agronomic Efficiency

| Treatments | | NUE | PUE | KUE |
|---|---|---|---|---|
| $T_1$ | Control | 13.60 | 27.30 | 17.75 |
| $T_2$ | RDF (120:60:40) kg $ha^{-1}$ | 13.06 | 16.33 | 12.34 |
| $T_3$ | FYM @ 15 t $ha^{-1}$ | 7.40 | 39.71 | 14.73 |
| $T_4$ | Vermi-compost @ 5 t $ha^{-1}$ | 8.50 | 30.38 | 13.75 |
| $T_5$ | Poultry manure @ 5 t $ha^{-1}$ | 9.20 | 28.20 | 14.75 |
| $T_6$ | 75%RDF + FYM 10 t $ha^{-1}$ | 9.30 | 30.91 | 16.16 |
| $T_7$ | 75% RDF + FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 12.40 | 47.27 | 13.61 |
| $T_8$ | FYM @ 10 t $ha^{-1}$ + AZO | 12.40 | 49.75 | 14.30 |
| $T_9$ | FYM @ 10 t ha $^{-1}$ + AZO + PSB | 10.26 | 53.20 | 15.33 |
| $T_{10}$ | FYM @ 10 t $ha^{-1}$ + AZO + PSB + KSB | 12.00 | 44.53 | 16.52 |
| $T_{11}$ | Vermi-compost @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 14.30 | 49.28 | 15.50 |
| $T_{12}$ | Poultry manure @ 5 t $ha^{-1}$ + AZO + PSB + KSB | 20.50 | 70.00 | 25.21 |

## Conclusion

The main objective of this research is to reduce the need for chemical fertilizers. Results of this experiment represents that applying 75% RDF + FYM @ 10 t $ha^{-1}$ + *Azospirillium* + PSB + KSB is advisable. This treatment is having considerable influence on quality parameters of popcorn because of synergistic effect of organic manures and biofertilizers.

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