Integration of different sources of organic manure and micro-nutrients on growth, yield and quality of potato (*Solanum tuberosum* L.) grown under new alluvial soil condition

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**ABSTRACT**

Field experiment was conducted during *rabi* season of 2009-10 and 2010-11, to study the effect of application of different sources organic manure and micro-nutrients on growth, productivity and quality of potato (*Solanum tuberosum* L.) grown under alluvial soil. The different sources of organic and micronutrients were integrated into 8 possible treatments viz. RDF (NPK @ 200:150:150 kg ha⁻¹), 50% of RDF + well decomposed FYM @ 10t ha⁻¹, 50% of RDF + well powder neemcake @ 0.5t ha⁻¹, RDF + Zinc sulphate @ 20kg ha⁻¹ as soil application, RDF + ammonium molybdate @ 1kg ha⁻¹ as soil application, RDF + sodium tetraborate @ 1kg ha⁻¹ as soil application, RDF + tuber soaking with 40g inc sulphate + 10g ammonium molybdate + 10g sodium tetraborate, RDF + foliar spray of 1% K₂O₃ salt. All the treatments resulted in improvement of growth and tuber yield characteristics, out of these treatments where organic sources of nutrient were integrated registered significantly maximum effect. Highest leaf area index, leaf area duration, dry matter production, tuber bulking rate and tuber yield in potato were recorded in the treatment 50% recommended dose of NPK + 10t FYM ha⁻¹, while the lowest was observed in 100% inorganic fertilizer treatment (RDF). Organic treatment were also in favour of producing medium and large size tuber, whereas, micronutrient were in favour of producing extra large size tuber. Highest value of starch and reducing sugar content were also recorded under the treatment where the crop received organic manure.

**Key words:** Organic manure, Micronutrients, Potato, Productivity, Qualit.

**INTRODUCTION**

The external input oriented agriculture, which was part of our green revolution strategy, has depleted soil environment considerably in all major agricultural production systems. This is reflected in the declining trend of total production from same land diminishing response of food grain increase to applied fertilizer nutrients, reduction in organic matter content of fertile soils. The physical, chemical and microbial environment of the soil has slowly but steadily deteriorated (Reganold, 1995). Continuous removal of micronutrients from soil by the recently introduced fertilizer responsive improved varieties of crops particularly cereals which produce high biomass on fertilizer application, reduced the concentration of micronutrient in soil solution below that required for the plant growth.

In order to feed the burgeoning population, food production has to be increased manifold. However, with the declining cultivable land area, it is certain that we will end up our what-so-available resources and ultimately compromising with a vulnerable and unsafe environment. Given a per income growth of 3.5% or more per annum, India may need nearly 300 million tons (MT) of cereals by 2020 (Bhalla et al., 1999). But the country’s production capacity is not likely to exceed 260 MT by that time. This implies a cereal gap of 40 MT or more per year after 2020. Importing huge amount of cereals is an option, but this could be a heavy burden on India’s trade balance.

The other alternative would be to diversify from non-traditional foods. Root, tuber crops and short duration crops like potato, cassava, sweet potato etc can be major contribution, if not principal, alternative source of food and nutrition (Scott et al., 2000). Attempts to improve productivity of this crop were initiated by the various provinces of pre-independent century. It has however, great favour with the farmers as a cash crop because of its ability to grow under varied agro-ecologies, nutritive value and marketable qualities.

Organic fertilizer and micronutrients are essential for crop production both in plain and hills. It has a direct influence on soil nutrient availability from soil native pool and applied fertilizers, water retention capacity and bulk
density. Availability of micronutrients in soil depends upon the organic matter present in it. In this context, use of organic matter and micronutrients is an excellent option owing to low cost and environment friendly nature. It helps to maintain long-term soil fertility and ecological sustainability required for crop production. Potato plants require micronutrients to produce optimum yield. Micronutrients help to increase the rate of photosynthesis and translocation of photosynthates leading to increased size and number of tubers. Even though the micronutrient elements are required in very small quantity, many of Indian soils may not supply them in sufficient quantity needed for healthy growth and optimum yield of any crops. Therefore, keeping the above points as guideline, the present study was undertaken to investigate the effects of different organic and micronutrient sources on yield and quality of potato.

MATERIALS AND METHODS

The experiment was conducted during rabi season 2009-10 and 2010-11 at the Teaching Farm, Mandouri, Nadia, West Bengal of Bidhan Chandra Krishi Viswavidyalaya located at an altitude of 7.8m above mean sea level having latitude of 22° 57’N and 88° 22’E longitudes. The experimental site falls under the New Alluvial Zone (NAZ). The soil is characterized by alluvial soil with medium fertility status, having sandy loam in texture. The field experiment was laid out in Randomized Block Design with three replication, having 8 treatments viz. T1 - NPK @ 200 :150 :150 kg ha⁻¹, T2 - 50% of T1 + Well decomposed FYM @ 10t ha⁻¹, T3 - 50% of T1 + Well powder Neemcake @ 0.5t ha⁻¹, T4 - T1+ Zinc sulphate @ 20kg ha⁻¹as soil application, T5 - T1 + Ammonium molybdate @ 1kg ha⁻¹as soil application, T6 - T1 + Sodium tetraborate @ 1kg ha⁻¹as soil application, T7 - T1 + Tuber soaking with 40 g Zinc sulphate + 10g Ammonium molybdate + 10g Sodium tetraborate, T8 - T1 + Foliar spray of 1% K₂O₃ salt. The crop was grown during Nov-Feb following recommended package of practices under irrigated condition. The seed tubers having minimum two eyes were planted on raised bed at a distance of 45 cm x 20 cm. Both the organic and inorganic fertilizers were applied to different plots according to the treatment. A basal dose of half of nitrogen, full doses of phosphorous and potassium were applied through urea, single super phosphate and murate of potash respectively, in furrows of each plot and thoroughly mixed with the soil before planting of seed tubers. The rest half of the nitrogen was top dressed at 30 days after planting. Farmyard manure, Zinc sulphate, ammonium molybdate, sodium tetraborate and neemcake were applied to different plots as basal as per treatment schedule, which were incorporated thoroughly into the soil. Potato tubers were dip in solution, prepared by dissolving Zinc sulphate 40 g + 10 g ammonium molybdate + 10 g sodium tetraborate in 100 litres of water for 15 minutes as per the treatment schedule. The tubers were then allowed to dry in shade. Data were collected on germination percentage; plant height, leaf area index, leaf area duration, crop growth rate, tuber bulking rate, haulm yield, tuber yield, starch content and reducing sugar.

RESULTS AND DISCUSSION

Growth and yield: Higher plant heights were recorded in the treatment which were supplied with 100% inorganic fertilizers (NPK @ 200: 150:150 kg ha⁻¹) + tuber soaking with zinc sulphate 40 g + ammonium molybdate 10 g + sodium tetraborate 10 g (T7), 50% inorganic fertilizer (NPK) @ 100:75:75 kg ha⁻¹ + well powder neemcake @ 0.5 t ha⁻¹(T3) and 50% inorganic fertilizer (NPK@ 100:75:75 kg ha⁻¹) + well decomposed FYM @ 10 t ha⁻¹(T2). The two

| Treatments | Germination Percentage(%) | Plant height(cm) | Leaf area index | Leaf Area duration (dm² days) | Crop growth rate(gm²/day⁻¹) | Tuber bulking rate(gm²/day⁻µ) |
|------------|---------------------------|------------------|----------------|-----------------------------|---------------------------|-------------------------------|
| T1: NPK @ 200 :150 :150 kg ha⁻¹ | 98.93 | 47.09 | 1.59 | 35.95 | 517.95 | 8.45 |
| T2: 50% of T1 + Well decomposed FYM @ 10t ha⁻¹ | 99.91 | 51.03 | 2.2 | 49.48 | 777.6 | 13.41 |
| T3: 50% of T1 + Well powder Neemcake @ 0.5t ha⁻¹ | 99.71 | 52.19 | 2.18 | 47.08 | 739.1 | 12.92 |
| T4: T1+ Zinc sulphate @ 20kg ha⁻¹ as soil application, | 99.64 | 49.08 | 1.94 | 43.08 | 676.04 | 11.8 |
| T5: T1 + Ammonium molybdate @ 1kg ha⁻¹ as soil application, | 99.29 | 48.28 | 1.74 | 39.23 | 615.57 | 10.45 |
| T6: T1 + Sodium tetraborate @ 1kg ha⁻¹ as soil application, | 99.94 | 49.66 | 1.81 | 40.49 | 624.93 | 10.33 |
| T7: T1 + Tuber soaking with 40 g Zinc sulphate + 10g Ammonium molybdate + 10g Sodium tetraborate | 99.97 | 52.66 | 1.68 | 38.69 | 581.83 | 9.9 |
| T8: T1 + Foliar spray of 1% K₂O₃ salt | 98.93 | 47.42 | 1.68 | 37.13 | 559.12 | 9.08 |
| S.E.m(±) | 0.15 | 0.79 | 0.059 | 1.17 | 17.88 | 0.25 |
| CD (p≤0.05) | NS | 2.4 | 0.18 | 3.55 | 54.22 | 0.75 |

NPK-Nitrogen, phosphorus, potassium; Zinc sulphate-As a source of Zinc; Ammonium molybdate- As a source of molybdenum; Sodium tetraborate as a source of boron, *Significant at P≤0.05; NS- Non Significant at P > 0.05
treatments supplied with 50% inorganic fertilizer with 10 t FYM ha⁻¹ and Neemcake @ 0.5 t ha⁻¹ also registered better leaf area index, leaf area duration, crop growth rate and tuber bulking rate comparing to other treatments (Table 1).

Better effect of these two treatments on growth parameters of potato might be attributed to combine effect of organic manure and inorganic fertilizers in building up plant tissues, resulting to better vegetative growth which plays a vital role in photosynthesis, carbohydrate transport and other physiological process of the plant. This finding was in agreement with those of Al-Hisnawy (2011), Al-Zehawi (2007), Kate et al., (2005) and Krishnamurthy et al., (2002). Higher crop growth rate was seen in organic matter integrated treatments as recorded the highest value (777.6) in T2 while the lowest was observed in T1. Similar finding of higher crop growth parameters in organic matter integrated treatments were reported by Sood (2007).

Organic manure and micronutrients influenced significantly in yield attributes and yield of potato tubers. Organic integrated treatments were in favour of higher tuber bulking rate and producing medium (26-50 g) and large (51-75 g) size tuber, whereas, micronutrients particularly ZnSO₄ were in favour of producing extra large (>75 g) size tuber. Application of neemcake in conjunction with inorganic fertilizers (T3) also helped in producing more or less equal proportion of medium, large and extra large tubers. As a result the highest tuber yield (28.26 t ha⁻¹) was observed in T2 (50% of RDF + 10 t FYM) and which was at par with T3 (50% of T1 + well powder neemcake @ 0.5t ha⁻¹) and T4 (100% RDF + Zinc sulphate @ 20 kg ha⁻¹ as soil application). The results were in agreement with the finding of Sharma et al., (1988). Due to higher tuber bulking rate, T2 (50% recommended dose of NPK + 10 t FYM ha⁻¹) produced higher number medium, large and extra large tubers resulting in higher tuber yield compared to treatments of T1 and T3. Sharma et al., (1988) reported the highest tuber yield (28.26 t ha⁻¹) in treatment of T2 (50% recommended dose of NPK + 10 t FYM ha⁻¹) produced higher number medium, large and extra large tubers resulting in higher tuber yield compared to treatments of T1 and T3.

Table 2: Effect of integration of different sources of organic manure and micro-nutrients on yield and quality of potato (Pooled data for 2 years).

| Treatments | Grade wise tuber yield (t ha⁻¹) |
|------------|---------------------------------|
|            | Small (<25g) | Medium (26-50g) | Large (51-75g) | Extra large (>75g) yield (t ha⁻¹) | Tuber (mg/100g) | Starch (mg/100g) | Sugar (mg/100g) |
| T1: NPK @ 200 :150 :150 kg ha⁻¹ | 3.36 | 7.31 | 7.82 | 3.08 | 21.63 | 10.29 | 102.76 |
| T2: 50% of T1 + Well decomposed FYM @ 10t ha⁻¹ | 2.16 | 9.26 | 12.52 | 4.80 | 28.26 | 12.37 | 126.21 |
| T3: 50% of T1 + Well powder Neemcake @ 0.5t ha⁻¹ | 2.94 | 8.29 | 11.42 | 4.34 | 26.98 | 11.51 | 129.19 |
| T4: T1 + Zinc sulphate @ 20kg ha⁻¹ as soil application | 3.07 | 8.17 | 10.27 | 4.90 | 26.41 | 11.29 | 121.76 |
| T5: T1 + Ammonium molybdate @ 1kg ha⁻¹ as soil application | 3.12 | 8.17 | 9.90 | 4.00 | 25.18 | 11.26 | 123.27 |
| T6: T1 + Sodium tetraborate @ ha⁻¹ as soil application | 3.08 | 8.31 | 10.12 | 4.41 | 25.92 | 11.06 | 120.11 |
| T7: T1 + Tuber soaking with 40 g Zinc sulphate + 10g Ammonium molybdate +10g Sodium tetraborate | 3.08 | 7.34 | 8.48 | 3.68 | 22.59 | 11.42 | 124.94 |
| T8: T1 + Foliar spray of 1% K₂O₃ salt | 3.13 | 7.70 | 8.31 | 3.49 | 22.61 | 10.46 | 113.60 |
| S. Em(±) | 0.14 | 0.20 | 0.39 | 0.26 | 1.10 | 0.27 | 4.66 |
| CD (p<0.05) | 0.43 | 0.60 | 1.19 | 0.79 | 3.33 | 15.42 | 14.15 |

NPK-Nitrogen, phosphorus, potassium; Zinc sulphate-As a source of Zinc; Ammonium molybdate- As a source of molybdenum; Sodium tetraborate as a source of boron, *Significant at P<0.05; NS- Non Significant at P > 0.05

Table 3: Economics of potato crop supplied with different sources of nutrients (pooled data for 2 years).

| Treatments | Total cost of cultivation (Rs. ha⁻¹) | Gross return (Rs. ha⁻¹) | Net profit (Rs. ha⁻¹) | Benefit cost ratio |
|------------|-------------------------------------|-------------------------|----------------------|-------------------|
| T1: NPK @ 200 :150 :150 kg ha⁻¹ | 87678.5 | 281887 | 132164 | 1.53 |
| T2: 50% of T1 + Well decomposed FYM @ 10t ha⁻¹ | 96811.5 | 302204 | 205393 | 2.12 |
| T3: 50% of T1 + Well powder Neemcake @ 0.5t ha⁻¹ | 99811.5 | 282241 | 182429 | 1.83 |
| T4: T1 + Zinc sulphate @ 20kg ha⁻¹ as soil application | 96691.5 | 268100 | 171409 | 1.77 |
| T5: T1 + Ammonium molybdate @ 1kg ha⁻¹ soil application | 102792 | 2650803 | 158012 | 1.54 |
| T6: T1 + Sodium tetraborate @ 1kg ha⁻¹ soil application | 98411.5 | 265202 | 166791 | 1.70 |
| T7: T1 + Tubers soaking with 40 g Zinc sulphate + 10g Ammonium molybdate +10g Sodium tetraborate | 90497.5 | 231663 | 140565 | 1.56 |
| T8: T1 + Foliar spray of 1% K₂O₃ salt | 87840.5 | 229311 | 141470 | 1.61 |

NPK-Nitrogen, phosphorus, potassium; Zinc sulphate-As a source of Zinc; Ammonium molybdate- As a source of molybdenum; Sodium tetraborate as a source of boron.
to the highest tuber yield (28.26 t ha\(^{-1}\)). The result is in accordance to those of Upadhayay et al. (2003), Goswami (2002) and Grewal and Trehan (1979). Sharif Hussain et al. (2003) also reported higher number large sized tubers in organic and inorganic integrated treatments. Better performances of neemseed powder and ZnSO\(_4\) in producing higher tuber yield of potato were also reported by Mondal et al. (2005), Tiwari and Dwivedi (1991).

**Quality attributes:** Starch content in potato tubers was recorded significantly higher (12.37) under conjoin use of inorganic + organic sources of nutrients (Table 2). The increase in starch content could be due to increased supply of nutrients in general and potassium in particular. Potassium plays an important role in the activation of starch synthetase and also helps in translocation of starch from leaves to tubers (Sud et al., 1992; Shambhavi and Sharma, 2008). Mahendra and Kumar (1998) also reported that organic manure applications along with inorganic fertilizer improve starch content in potato tubers.

Among the different combinations of organic and inorganic fertilizers, 50% RDF (100kg N + 75 kg P + 75 kg Kha\(^{-1}\)) + 0.5 t neemcake\(^{-1}\)recorded maximum reducing sugar content of potato tubers, and it was found to be significantly superior to other treatment. It was closely followed by treatment receiving 50% RDF (100kg N + 75 kg P + 75 kg Kha\(^{-1}\)) + 10t FYM ha\(^{-1}\). The minimum reducing sugar content was recorded in treatment receiving 100% inorganic fertilizer. The supply of nutrients to potato crop through inorganic sources of nutrients provide higher amount of plant available nutrients during different growth and development stages and if the potassium availability remains optimum or high, then it resulted, in reduction of reducing sugar (Sarkar et al., 2007).

**Economics:** The cost of production was highest for crop receiving 100% RDF + ammonium molybdate @ 1kg ha\(^{-1}\) treatment (Rs. 102792) and lowest (Rs. 86722.5) for control (Table 3). The highest net profit (Rs. 205393 ha\(^{-1}\)) was obtained in T2 followed by T3 (Rs. 182429 ha\(^{-1}\)). The B: C ratio was found highest (2.12) under the treatment 50% RDF (100kg N + 75 kg P + 75 kg Kha\(^{-1}\)) + 10t FYM ha\(^{-1}\), followed by 50% RDF (100kg N + 75 kg P + 75 kg Kha\(^{-1}\)) + 0.5 t Neemcakeha\(^{-1}\). Similar findings of higher net income and benefit cost ratio in the treatments where inorganic nutrients were integrated with FYM were reported by Singh and Kushwah (2006), Banafar et al., (2005) and Sasani et al., (2003).

**CONCLUSION**

From the above findings, it can be inferred that substitution of 50% recommended dose of nutrient by organic source FYM @ 10t ha\(^{-1}\) enhanced crop growth rate as well as tuber bulking rate in potato cultivation resulting to higher yield. In areas where there is limitation in FYM availability, it can be replaced by neemcake @ 0.5t ha\(^{-1}\). Application of ZnSO\(_4\) is also useful in producing comparable yield and extra large tubers. These treatments were also found economically sound and can be recommended for potato cultivation under new alluvial soil condition of West Bengal.

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