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Research Article

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Influence of Organic Manures, Inorganic Fertilizers and Bio-Fertilizers on Yield and Quality Attributes of Potato (Solanum Tuberosum L)

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Abstract

Studies on effect of organic, inorganic and bio-fertilizers on yield and quality attributes of potato (Solanum tuberosum L.) variety Kufri Jyoti, comprising of 10 different treatments using randomized complete block design with three replications were conducted at Post Graduate Centre, University of Horticultural Sciences, Campus, Gandhi Krishi Vignana Kendra, Bangalore during Rabi 2011. Application of 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T_7) showed significantly maximum number of tubers per plant (7.87), tuber yield per plant (363.33 g plant^{-1}) and tuber yield per hectare (34.13 t ha^{-1}). This treatment also produced maximum tuber dry matter (21.67%), starch content (78.20%) non-reducing sugars (0.84%) and total sugars (1.74%) which were on par with T_3, T_4 and T_6 during rabi 2011.

Keywords: Potato, Organic; Inorganic; Manures; Biofertilizers; Kufri Jyoti, Quality Attributes.

Introduction

Potato (Solanum tubevosum L.) is one of the most important food crops after wheat, maize and rice owing to its great yield potential and high nutritive value and accounts for nearly half of the worlds annual output of all root and tuber crops (Dibyendu et al., 2010)[5]. It is a heavy feeder of plant nutrients having higher requirement of nitrogen, phosphorus potassium and other nutrients.

In India, high yielding Indian potato varieties and improved agro-techniques have made tremendous impact on potato production. The country is placed third in the list of major potato producing countries of the world next to China (75 million metric tons) and Russia (37 million metric tons). It produces more than 26.53 million tons of potatoes from an area of 1.37million hectares with an average yield of 19.37 t/ha, which made the country as a major producer of potatoes along with China, Russia, Netherlands and Poland (Anon., 2005)[1].

In Karnataka, potato occupies an area of 49,300 hectares with an annual production of 6.14 lakh tones and the productivity is 12.45 t/ha. Potato is grown mainly as rain fed crop in the districts of Hassan, Belgaum, Dharwad and Chikmaglore during Kharif (June-September) besides as an irrigated crop during Rabi (November-February) in districts of Kolar and Bangalore Rural. Hassan and Chikmglore are the major potato producing districts under Southern Transitional Zone of Karnataka contributing nearly 60 per cent of the total production in the State (Anon, 2010)[2].

The Eastern Dry Zone agro climatically classified as Zone 5, includes 11 Taluks of Kolar and Bangalore Districts and two Ta-

luks of Tumkur District. The Zone is at an altitude of 800 to 900 m above sea level which is geographically located at an altitude of 13° 15' East and longitude of 78° 24' West. It is generally an undulated plateau. The zone has mainly three soil type viz. red loamy, red sandy and red lateritic where red loamy is dominating (48.94%).

The climate of this zone is semi-arid with annual rainfall of 679.1mm to 888.9 mm. The February months will be practically dry and cool with temperature around 14°C. The mean monthly maxima and minima temperatures range between 25.9-33.4° C and 15-21° C respectively. In this region, potato occupies an area of 11,376 ha grown mainly as irrigated crop during Rabi with the productivity of 18.2 tons per ha where Kufri Jyoti was the leading variety grown in this Agro climatic region (Anon., 2010)[2].

Modern nutrient management strategy has shifted its focus towards the concept of sustainability and eco-friendliness. Intensive use of only chemical fertilizers to achieve high production has created various problems. Continuous application of heavy doses of chemical fertilizers without organic manures or biofertilizers has led to a deterioration of soil health in terms of physical and chemical properties of soil, declining of soil microbial activities, reduction in soil humus, increased pollution of soil, water and air.

Hence, considering the economy, environment friendliness and maintain better soil health, it is imperative that plant nutrients are to be used effectively by adopting the integrated nutrient management practices. The basic principle behind this concept is to supply both the chemical fertilizers and organic manures for a sustainable crop production in most efficient manner, although the modern technique of intensive crop production needs the use of chemical fertilizers.

The concept of integrated nutrient management is an approach that seeks to increasing crop production and quality produce is gaining popularity from the point of soil health, productivity and eco-friendly. Hence, applying of nutrients in combination of organic, inorganic and biofertilizers is of pertinent importance instead of providing inorganic fertilizers alone. The role of organic fertilizers in plant nutrition is now attracting the attention of agriculturists and soil scientists, throughout the world. Potato productivity and nutrient cycles, however, are integral parts of the exploitation of soil health and have led to soil degradation through nutrient depletion and erosion, so that long term strategies are needed to avoid the use of chemical fertilizers without adversely affecting crop productivity.

The use of organic manures, compost and biofertilizers has received increased attention in our cropping systems. The use of biofertilizers is one of the important components of integrated nutrient management, as they are cost- effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Integration of chemical and organic sources and their efficient management has shown promise in not only sustaining productivity and soil health but also in meeting a part of chemical fertilizer requirement of crop (Hegde and Dwivedi, 1993)[8]. Singh and Kushwah (2006)[22] suggested the combined use of organic and inorganic sources of nutrients in potato.

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But presently, there is no information regarding integrated nutrient management for achievement of different yield of "Kufri Jyoti" potato which is the major cultivated variety of this region. Keeping above factors in view, an experiment was conducted with "Kufri Jyoti" potato.

Materials and Methods

The present study was carried out at Post Graduate Centre, University of Horticultural Sciences, Campus, Gandhi Krishi Vignana Kendra, Bangalore during Rabi 2011. The experimental field was located at the latitude of 130 04' North and longitude of 770 34' East with an altitude of 921 meters above the mean sea level. The maximum and minimum temperatures in a year range between 29.10C and 17.40C respectively. The major rainfall is received from South-West monsoon between June and September and from North-Eastern monsoon between October and January. The annual mean relative humidity of the location is 67.9 per cent.

The experiment was carried out in red sandy loam soil having pH of 6.28 to 7.16. Soil samples of the experimental site were collected before and after the experiment and their physical and chemical properties were analysed as per standard procedures. The experiment was laid out in a Randomized Complete Block Design (RCBD), consisting of ten treatments which were replicated thrice. Plot size 3.15 m x 2.0 m, Crop/Variety: Potato/ Kufri Jyoti, spacing: 45cm x 20 cm, Season: Rabi 2011. Each treatment consists of the following combinations with different levels of organic manures, inorganic fertilisers and biofertilizers. T_1 – 100% RDF (125:100:125 kg NPK/ha), T_2 –100% RDF + 100% FYM (25 t/ha), T_3 – STCR targeted yield of 20 t/ha (155:150:129 kg NPK/ha), T_4 – 50% RDF + 100% FYM (25 t/ha) + Azotobacter (12 kg/ha) + Phosphobacteria (12kg/ha), T5 – 75% RDF + Vermicompost (1.5 t/ha) + Azotobacter (12 kg/ha) + Phosphobacteria (12 kg/ha), T_6 – 50% RDF + Azotobacter (12 kg/ha) + Phosphobacteria (12 kg/ha), T_7 – 50% RDF + 50% FYM + Vermicompost (1.5 t/ha) + Azotobacter (12 kg/ha)+ Phosphobacteria (12 kg/ha), T_8 – 100% FYM (25 t/ha) +50% N supplied through neem cake (62.5 kg/ha) + Azotobacter (12 kg/ha), T_9 – 100% FYM (25 t/ha) + 50% N supplied through poultry manure (1.5 t/ha) + Azotobacter (12 kg/ha), T_{10} – 100% FYM (25 t/ha) +50% N supplied through Vermicompost (1.5 t/ha) + Azotobacter (12 kg/ha) (Paul et al., 2002, Banafar et al., 2005, Singh et al., 2007)[15, 3, 20]. The variety used in this study was Kufri Jyoti; it is a most popular variety in Eastern dry zone of Karnataka (Marwaha et al., 2010)[12]: where, RDF - Recommended dose of fertilizer (125:100:125 kg NPK/ha), FYM - Farm Yard Manure (25 t/ha), STCR: Soil Test Crop Response. STCR targeted yield equations developed by AICPR on STCR for potato crop

are used here: FN= 2.181 x T (quintal/ha)-223.57 x Soil N (% OC), FP_2O_5 = 1.134 x T (quintal/ha)-0.304 x Soil P_2O_5, FK_2O= 1.434 x T (quintal/ha)-0.284 x Soil K_2O.

The recommended dose of NPK (125:100:125 kg/ha) Farmyard manure (25 t/ha), Vermicompost (1.5 t/ha) and bio-fertilizers like Azotobacter (12 kg/ha) and Phosphobacteria (12 kg/ha) were applied as per the treatments. Fifty percent of N and full dose of P and K were applied in the furrows as per treatments and were thoroughly mixed in soil. The remaining half of the nitrogen was top dressed at 30 days after planting. Recommended doses of farmyard manure (25 t/ha), NPK (125:100:125 kg/ha) biofertilizers like azotobacter (12 kg/ha), phosphobacteria (12 kg/ha), poultry manure (1.5 t/ha), neem cake (62.5 kg/ ha) and vermicompost (1.5 t/ ha) were calculated as per the treatments and applied. Fifty per cent of the nitrogen in the form of urea and full doses of phosphorous in the form of single super phosphate and potash in the form of muriate of potash were applied in the furrows as per treatments and were thoroughly mixed in soil. Full doses of recommended farmyard manure, Vermicompost and biofertilizers were applied according to the plan and mixed well in soil before sowing. Remaining half dose of the nitrogen was top dressed at 30 days after sowing. Azotobacter (AZT) and phosphobacteria (PSB) cultures were obtained from the department of Agricultural Microbiology, University of Agricultural Sciences, GKVK, Bangalore and applied to the furrows along with FYM prior to sowing of tuber seeds.

The land was ploughed with disc plough and brought to fine tilth by passing cultivator twice. Weeds and stubbles were removed and finally the land was levelled. Later the experimental plots were formed as per plan. The plots were provided with well decomposed farmyard manure as per the treatment and mixed thoroughly. Furrows were made for sowing according to the recommended spacing between rows and plants.

Furrows were opened to a depth of 5 cm using guddali and tuber seeds were sown at the rate of one per hill in the furrows at 20 cm. The planting was done 26-09-2011. The plots were irrigated once in 5 days depending on crop stage, soil and weather conditions. Irrigation was given by furrow irrigation system and the crop was not allowed to suffer from moisture stress. The experimental plots were kept free from weeds by manual weeding at regular intervals. Earthing up of soil to the base of the plant was attended two times in a crop period i.e. once in the beginning and other after top dressing with urea at 30 days after sowing.

Regular plant protection measures were taken up against the incidence of pests and diseases. Potato seed tubers obtained from Chambal Agritech Chandigarh were used for planting, which were procured from regulated market of Chikkabhallapur. The whole tubers weighing approximately 25g were dipped in 0.4 per cent solution of Mancozeb for ten minutes, dried under shad and later used for planting. The crop was first sprayed with a mixture of Dithane M-45 at 40 g in 18 litres of water and Malathion 50 EC at 2ml per litre to control diseases and insects as a prophylactic measure. At the later stages of the crop growth, Malathion 5 per cent dust was applied to control aphids.

The observations on yield and quality attributes were recorded at 90 days after planting. After 90 days of planting when the crop was at maturity, tubers were harvested by digging out manually from each plant. The harvesting was done on 16-12-2011 two weeks after haulm killing. Initially, tubers from five randomly selected plants in each plot (net plot area) were dug out and kept separately. Then, the tubers from net plot were taken out from each treatment. The tubers were dried in the plot and graded into four groups according to their weight viz. small (less than 25g), medium (26 to 50 g), large (51 to 75g) and very large size tubers (more than 75g). The grade-wise weight and number of tubers obtained from five plants were recorded. Then the grade-wise weight of tubers from each plot (including those from the five plants) was recorded. The total weight of tubers was calculated by adding the respective weight of tubers in each grade.

The experimental data collected on various treatments were analysed statistically at the computer centre (ARIS), University of Agricultural Sciences, Bengaluru. Statistical significance of variation between different sources of nutrients were tested by comparing calculated value to Table F value at 1 per cent and 5 per cent levels of probability.

Result and Discussion

Integrated nutrient management significantly influenced yield and quality of potato crop. The plants supplied with 50% RDF + 50% FYM + AZT + PSB (T_2) recorded highest number of tubers per plant (7.87), tuber yield per plant (363.33 g $plant^{-1}$), tuber plot yield (21.50 kg $plot^{-1}$) and tuber yield per hectare (34.13 t ha^{-1}) which was on par with the treatments of T_3, T_4 and T_6, respectively (Table 1). The increase in number of tubers per plant could be attributed to increased vegetative growth observed due to balanced nutrient levels, which stimulated initiation of more stolon, thus increasing the number of tubers per plant. The increased tuber yield could be attributed to better photosynthesis activity and accumulation of carbohydrates which helps in better growth of tubers. Potato tuber yield is also known to be influenced by P fertilizers through its effect on the number of tubers produced, the size of the tubers and the time at which maximum yield is obtained (T_3). The increased tuber yields due to integrated nutrient management of the above said fertilizer levels have resulted in more vegetative growth and accumulation of more photosynthates. Thus, there may be more translocation of photosynthates to sink. Hence, they have resulted in more tuber yield. Higher number of tubers per hill also contributed to significantly higher total tuber yield. The favourable effect of integrated nutrient management through both inorganic fertilizers and organic manures on increasing the tuber yield and production was also noticed by Kumar et al. (2011)[10] and Das et al. (2009)[5]. Use of bio-fertilizer exerted significant effect on influencing yield of tubers during the study. Interaction effect of nutrient management and biofertilizers was found significant in influencing the yield per plot and per hectare of the crop. The results were in agreement with findings of Singh et al. (2007)[20], Manoj Kumar et al. (2012)[11] and Sasani et al. (2003)[17] in potato. Jaipaul et al. (2011)[9] reported that higher tuber yield under integrated use of inorganics + organics and chicken manure + bio-fertilizer probably reflect the greater nutrients availability under these treatments Table 1.

Table 1: effect of integrated nutrient management on number of tubers, tuber yield per plant, plot yield and total yield of potato at harvest

Treatments	No. of tuber plant^{-1}	Tuber yield		
		Yield plant^{-1} (g)	Plot yield (kg)	Total yield (t ha^{-1})
T_1	5.00	243.33	14.51	23.03
T_2	5.33	250.00	15.87	25.19
T_3	6.87	330.00	20.63	32.74
T_4	6.73	299.33	17.33	27.55
T_5	6.67	283.00	16.83	26.71
T_6	6.13	272.33	16.08	25.52
T_7	7.87	363.33	21.50	34.13
T_8	4.73	184.67	12.40	20.00
T_9	5.33	260.33	15.36	24.38
T_{10}	5.27	244.67	14.59	23.16
SE m ±	0.71	45.39	2.38	2.26
CD at 5%	1.49	95.37	5.01	4.75
CV (%)	14.64	20.33	16.64	9.07

Significantly higher tuber dry matter (21.67%), starch content (78.20%) non-reducing sugars (0.84%) and total sugars (1.74%) was recorded in plants provided with 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T_7) which was on par with T_3 (Table.2). The increased dry matter accumulation could be attributed to better vegetative growth and production of more fresh weight. Increased dry matter accumulation is also related to better uptake of nutrients due to the influence of biofertilizers supplied along with chemical fertilizers and organic manures. The better absorption and accumulation of nutrients promotes growth and metabolism. This in turn resulted in production of more dry matter accumulation. Similar results were also reported by Baniuniene and Zekaite (2008)[4], Shamorady (2010)[19] and Gayathri et al. (2009)[7] in fertilizer doses applied along with FYM and Azospirillum in potato.

Increased starch content might be related to better uptake of nutrients due to the influence of biofertilizers supplied along with chemical fertilizers and organic manures. This effect was also due to bacterial activity that enhanced the crop growth during the advanced phase. The increase in starch content was due to increased supply of nutrients in general and potassium in particular. Potassium plays an important role in the activation of starch synthetase and helps in translocation of starch from leaves to tubers. The results obtained agree with those reported by Nandekar et al. (2006)[12], Jaipaul et al. (2011)[9], Shambhavi and Sharma (2008b)[18] and Mondal et al. (2007)[13] Table 1 [].

Table 2: Effect of Integrated Nutrient Management on Quality Parameters of Potato

Treatments	Tuber dry matter (%)	Starch (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
T_1	16.64	70.46	0.85	0.58	1.43
T_2	17.81	72.32	0.83	0.59	1.42
T_3	20.53	73.31	0.87	0.75	1.62
T_4	19.79	73.88	0.87	0.78	1.65
T_5	19.19	73.21	0.87	0.74	1.61
T_6	18.42	72.91	0.86	0.64	1.50
T_7	21.67	78.20	0.90	0.84	1.74
T_8	15.32	68.96	0.82	0.58	1.40
T_9	18.55	71.99	0.85	0.60	1.45
T_{10}	16.87	70.53	0.83	0.58	1.41
SE m ±	0.75	1.50	0.03	0.06	0.07
CD at 5%	1.58	3.16	NS	0.12	0.15
CV (%)	7.50	2.53	4.39	10.82	5.57

The higher accumulation of sugars in the tubers (1. 74%) could be due to better availability of nutrients and synthesis of sugars when plants received combined chemical fertilizers, organic manure and bio-fertilizers. It is also related to application of biofertilizers especially Azotobacter that helped in fixation of atmospheric nitrogen while the applied FYM improve the soil physical and chemical properties which aided in accumulation of more sugars (T_{10}). The higher sugar content under integrated use of inorganics + organics and vermicompost + bio-fertilizer probably reflects the greater nutrients availability under this treatment. 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 in potato. The results are in conformity with the findings of Jaipaul et al. (2011)[9], Mondal et al. (2007)[13], Sud et al. (2007)[23], Sarkar et al. (2007)[16] and in potato crop.

Conclusion

During the study, plants provided with 50% RDF + 50% FYM + VC + AZT + PSB recorded maximum number of tubers per plant, tuber yield per plant, tuber yield per plot and per hectare, higher tuber girth and higher tuber length. The maximum marketable tuber yield per plot and per hectare and the maximum grade D, grade B and grade A tuber yield in potato plants were recorded with application of 50% RDF + 50% FYM + VC + AZT + PSB.

In terms of quality characters, maximum tuber dry matter, starch content, reducing sugars, non-reducing sugars and total sugars; as a regard the nutrients accumulation in different plant parts of potato recorded maximum nitrogen, phosphorus and potassium in stem, leaf and tuber respectively were observed in plants received 50% RDF + 50% FYM + VC + AZT + PSB.

Therefore, this fertilizer combination can be recommended for application in cultivation of potato in the Eastern dry zone of Karnataka.

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