EFFICACY OF FERTILIZER MANAGEMENT ON CARROT PRODUCTIVITY AND QUALITY (REVIEW)

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ABSTRACT: *Carrot is a root vegetable of high nutritious value. Like other plant species, carrot roots uptake minerals for nutritional requirements from the growing media. The growing media or soil needs continuous input of minerals from external sources for plant growth and development for sustainable yield and quality. Increasing demand of 'organic' food and health concerns due to the application of chemical fertilizers has realized the need for application of organic manure to meet the increasing requirements of growing plants. This review briefly presents the scope of application of chemical fertilizers and organic manure for sustainable productivity and quality of carrot roots. An appropriate combination of chemical fertilizers and organic manures is a possible way-forward to achieve reasonable yield and quality.*

INTRODUCTION

Carrot (*Daucus carota* L.) originated in central Asia and Afghanistan is considered the center of its diversity [1]. Carrot was spread both eastward and westward since its domestication and roots consumption began in 700 AD. Turkey is assumed to be the secondary center of its diversity. The world carrot production is continuously increasing[2]. Root colour and flavor are the most important qualitative factors for selection of varieties [3].Continuous market research and parallel breeding programs are successfully delivering carrot in a range of colours and flavours meeting the requirements of the specific consumer groups [4]. Root size and shape are also considered important selection parameters [5]. Besides these factors, the medicinal value of carrot has always been acknowledged [6,7].

Plants fulfill their nutritional requirements from uptake of minerals largely through soil [8].Soils of the cultivated areas have an ability to minimally sustain the plant growth with the nutrients held from previous crop rotation, but these nutrients are not in sufficient amounts to meet the increasing requirements for higher production[9]. Nutrients applied on a growing crop are mainly consumed by plants for growth and development. Left over nutrients in the soil leach down [10] and become unavailable to the next crop. Resultantly, soils in the commercial crops growing areas do not hold sufficient quantity of nutrients to provide the amounts required by the plant for sustainable production and yield. Application of chemical fertilizers is generally discouraged due to the increasing proportion of consumers of 'organic' food [11]. Therefore, the nutrient management through organic sources of fertilizers to promote soil health and better plant nutrition has achieved a great deal of consideration on a global level. The organic sources improve physico-chemical characteristics and fertility of soil in terms of organic carbon and nitrogen content, permeability, balanced supply of nutrients and plant available water capacity[12].

This manuscript presents a brief review on the efficacy of different combinations of fertilizers on productivity and quality of carrot fruit.

Chemical fertilizer requirement of carrot

Carrot yield and nutritional quality are affected by the types of fertilizers applied. Among the chemical constituents of the fertilizers, N plays a dominant role in affecting the nutritional quality [13]. Carrot root yield was improved by hundred percent recommended dose of N, P and K fertilizers compared to application of organic fertilizer alone or combined application of mineral and organic fertilize [14]. The most commonly used fertilizer levels were N which was ranged between 75 - 150 $kg.ha^{-1}$, 25 - 125 $kg.ha^{-1}$ of P and 0 - 175 $kg.ha^{-1}$ of K [15].

Nitrogen fertilization has received most attention of researchers with regard to carrot quality[16].Increased root yield applied by increased N levels were reported [17, 18]. However, high N rate up to 336 $kg.ha^{-1}$ increased the nitrate level above the recommended dose for baby food [19, 20].

Increasing trend of organic food consumption

Proportion of organic food consumers is increasing[21] with the increasing awareness of health and food safety concerns[22]. There is a widespread belief that organic food is substantially healthier and safer than conventional food, and consumers are willing to pay significant price premiums to obtain it [23, 24].The specific regulations governing organic production, however, vary across countries as well as between certifiers [25]. The non-use of synthetic chemicals and a number of other environmentally sound techniques practiced by organic farmers remain part of the allure of the organic movement, and underlie consumer belief that organic food is virtually free of the hazards found in conventional produce [26]. It is the consumer perception of the quality and safety that primarily drives the continuously growing demand for organic food products [27]. In fact, in some cases (e.g. organic baby food), the organic label is by far the most important characteristic that consumers value in food; its nutrient content being far less appreciated [28].

Application of manures for soil fertility

Considering the adverse effects on soil health and environment, besides the residual effect, excessive usage of inorganic fertilizers is not advisable. Several scientists are advocating the integrated nutrient management with organic and inorganic fertilizers to conserve the soil health and to get good quality produce [14]. The main sources of organic matter are; cattle dung, urine, litter, crop residues / waste like sugarcane trash, straw, poultry, sheep and goat dropping,

waste from fruit and vegetables, press mud from sugar industries, rice husk and bran / dust from textile industries. These all organic matter can be used for building up and maintaining organic matter in soil to conserve the fertility and as well as soil physical condition and to increase the fertilizer use efficiency [29].

Manure is considered as key to restoring the productivity of degraded soils as it supplies multiple nutrients, raises soil pH and improves soil organic matter which in turn improves the physical and microbial properties of the soil [30]. Among organic manures, the nutrient content of poultry manures is among the highest of all manures, and the use of poultry manure as a soil amendment for agricultural crops provides appreciable quantities of all important plant nutrients [31].

Poultry manure is relatively resistant to microbial degradation, but it is essential for establishing and maintaining optimum soil physical condition and important for plant growth. Poultry manure is also very cheap and effective as a good source of N for sustainable crop production, but its availability remains an important issue due to its bulky nature, while inorganic fertilizer is no longer within the reach of poor-resource farmers due to its high cost [32]. However, John *et al*. [33]had advocated for an integral use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients required to sustain maximum crop productivity and profitability, while minimizing environmental impact from nutrient use.

Poultry manure as an organic material is particularly important since it conditions and improves soil fertility and contains all macro-nutrients and most of the micro-nutrients [12, 34]. However, damage to crops and pasture were reported, when poultry manure is applied at high rates (>18 t ha^{-1}) [35]. Similarly, high application rate of poultry manure (180 t ha^{-1}) to loamy sand was reported to increase the concentration of nitrate at 3 m depth from 15 to 179 mg NL^{-1}[36] and an increased concentration of nitrate at 120 cm depth in a silt loam soil [37].

The use of poultry manure in promoting organic farming and in enhancing soil fertility has profound implications in the agricultural production, as well as socioeconomic status of rural livelihoods in the developing world as some city dwellers sells manure for their living income [38]. Poultry manure has frequently been found to increase the yields of pastures and crops including vegetables [35]. Maintenance and management of soil fertility is central to the development of sustainable food systems [39]. Poultry manure contains higher nitrogen and phosphorus compared to other bulky organic manures. The average nutrients contents in poultry manure are N-3.03%, P-2.63% and K-1.4% [40].

Adediran *et al*.[41] compared poultry manure, household, market and farm waste, and found that poultry manure had the highest nutrient contents and gave the greatest increased yield of the crops and soil macro and micronutrients content. Akande and Adediran [42] found that poultry manure significantly increased soil pH, N, phosphorous, potassium, calcium and magnesium and nutrient uptakes in plants. Addition of poultry manure to cultivated land helps to recycle nutrients and reduce fertilizer costs in crop production systems. In addition, application of poultry manure or other organic wastes may also generate a positive residual effect that should be taken into account for the succeeding crops [43]. Use of poultry manure or other animal manure not only increases the soil inorganic N pool [44]but also increases the seasonal soil N mineralization available to the crops [45]. Application of farm yard manure and incorporation of rice and wheat straw improved physical and chemical properties of soil. Maskey and Bhattarai [46] reported that the nutrient value of organic manure such as farm yard manure and compost depends upon the composition of animal feed, fodder, bedding materials, methods of preparation, length and condition of storage, etc. They reported that the nutrient content of farm yard manure and compost prepared under farmers' condition may vary from 0.5-1.4 % N, 0.4-2.4 % P and 0.5-3.5 % K as calculated on oven dry basis.

Carrots, unlike most other vegetable crops, have not traditionally had animal manures, such as poultry manure, applied before planting or as a side dressing, for fear of root forking. Research trials have indicated increased yield and advanced maturity using poultry manure as a pre-planting treatment without increasing the percentage of root forming [47]. Aliyu [48] reported that the use of farm yard manure plus poultry manure at 5 t ha^{-1} resulted in higher fruit yield of eggplant.

Recommendations for improved productivity and quality

It is not concluded if the organic or the chemical fertilizers affect the nutritional value or quality of the fruit or vegetables [11, 49]. Adequate use of mineral fertilizers and organic manures is of great importance for obtaining high yield and quality of produce in one hand and on the other hand prevention of adverse effects on soil health and environment [14]. However, there is a basic constraint in handling organic fertilizers due to their bulkiness and slowly available nutrient compared to chemical fertilizers [18]. Furthermore, it is difficult to make precise recommendations for chemical fertilizers unless they are site specific since the reports for various fertilizer experiments are quite variable [15].

The model of application of combination of organic and chemical fertilizers has shown remarkable effects of yield and quality. For example, application of 50% recommended dose of fertilizer and farm yard manure (12.5 t ha^{-1}) with reduced level of recommended dose of fertilizer (50%) helps in higher vegetative growth and yield in tomato [50]. Similarly, application of NPK (80:60:50 kg/ha) + farm yard manure (20 t ha^{-1}) helped in obtaining higher plant height, number of leaves t ha^{-1}, internodal length and number of nodes t ha^{-1} in okra [51].Application of farm yard manure (12.5 t ha^{-1}) + wettable sulphur (20 t ha^{-1}) + urea (60 t ha^{-1}) resulted in higher plant height, number of leaves and herbage yield over other treatment in sweet basil [52]. The excreta of birds are fermented very rapidly and if left exposed, 50% of its nitrogen is lost within 30 days. In potato crop, continuous application of farm yard manure produced higher yield than the combined application of P and K as inorganic fertilizers [53]. Sharma *et al.* [54] observed significant and positive effect of farm yard manure on yield as well as indicated that translocation was improved due to application of farm yard manure in summer crop. Sahota and Govind krishnan [55] reported the production of medium sized potato tubers when farm yard manure (20 t ha^{-1}) was applied with recommended dose of fertilizers. However, application of farm yard manure

in potato crop at 15 and 30 tons ha^{-1} increased the tuber yield by 39 and 40%. They further reported that higher yield was due to the improvement in tuber size. Recommended dose of fertilizers in combination with farm yard manure (15 t ha^{-1}) resulted in higher potato tuber yield compared to [56]. Similarly, higher yield of fresh rhizomes was recorded in turmeric through the application of farm yard manure (25 t ha^{-1}) [57]. Application of farm yard manure (25 t ha^{-1}) + NPK recorded significantly higher yield compared to farm yard manure alone and NPK in cabbage, onion and carrot [58]. Hayworth *et al.* [59] demonstrated the beneficial effects of farm yard manure on yield of carrot roots. However, organic manures did not generally increase the yield of carrot [60]. In tomato production, N from compost application led to significantly lower yield than those of other N fertilizers and it was supposed that N in compost was not readily available to the plant as well as higher C: N ratio of the compost [61]. Low N availability can also lead to higher ascorbic acid accumulation, lower and carotenoid concentration [62].Improved tomato fruit quality in terms of total soluble solids applied by high concentrations of NH^+ and low NO_3^- was reported by Gao *et al.* [63]. The 'C/N balance theory', when N is readily available, plants will primarily synthesize compounds with high N content, for example, proteins for growth and N containing secondary metabolites such as alkaloids. When N availability is limited, metabolism changes more towards carbon-containing compounds such as starch, cellulose and non-N-containing secondary metabolites such as phenolics and terpenoids [64]. Therefore, the secondary metabolites produced by the plants could be differed in relation to different forms of fertilizers [49].

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