Effect of major nutrients on yield and quality of *Jatropha curcas*

VEENA N. KALANNAVAR*, S.S. ANGADI, V.C. PATIL, S.G. ANGADI, A.S. BYADAGI AND S.J. PATIL
Department of Agronomy, College of Agriculture, University of Agricultural Sciences,
DHARWAD (KARNATAKA) INDIA

ABSTRACT

A field experiment was conducted at the Main Agricultural Research Station (MARS), College of Agriculture, Dharwad to study the effect of major nutrients on yield and quality characteristics of Jatropha during *kharif* 2007-08. Results revealed that application of 100:100:150 kg $N:P_2O_5:K_2O$ ha^{-1} recorded significantly higher Jatropha seed yield (3937.50 kg ha^{-1}) over 150:150:150 kg $N:P_2O_5:K_2O$ ha^{-1} (2775 kg ha^{-1}) which was superior over control (875 kg ha^{-1}) and was at par with all other treatment combinations. Similarly, significantly higher physiological attributes like chlorophyll content (2.08 mg g^{-1} fresh weight), shelling percentage (64.83 %), oil yield (1461.28 kg ha^{-1}) and biodiesel yield (1200.46 l ha^{-1}) were also recorded with 100:100:150 kg $N:P_2O_5:K_2O$ ha^{-1} which were superior over all other treatment combinations including control but oil content was significantly higher in control (40.07%) as compared to all other treatment combinations.

Key words : Major nutrients, Jatropha, Yield, Quality

INTRODUCTION

India is the second most populous country in the world and meeting its energy requirements in a sustainable manner continues to be a major challenge. The huge gap between demand and supply may be met by import. The net import burden was increased from Rs.1,01,963 crores in 2004-05 to Rs.1,50,557 crores in 2005-06 and taking into account, the average prices till now during the current year, the import bill for 2006-07 could be of the order of Rs.1,90,000 crores (Punia *et al.*, 2006). In this context, generating biofuels as potential energy sources for the future is the most logical step. Under Indian conditions, plants which produce non-edible oil in appreciable quantities and suitable for large scale cultivation in all kinds of soils, besides, waste lands can be considered for bio-diesel production. In India, plants like Jatropha, Pongamia, Cimarouba spp *etc.* are known to produce bio-diesel and have wider adaptability. The work on these crops conducted elsewhere is meagre. Among the bio-diesel crops, *Jatropha curcas* is a large shrub able to thrive under different soil types and varied climatic conditions with the rainfall of 250-1200 mm. Seeds of Jatropha contain about 35-40 per cent of oil and kernels about 55-60 per cent and the average seed yield is about 60 to 80 q ha^{-1} after 6 years (Gour, 2004). Despite its focus as an important economic biofuel crop, little is known about the nutritional requirement of Jatropha. Being an energy plantation, Jatropha may utilize large quantities of nutrients from soil itself and will definitely deplete soil fertility if not properly fertilized. It is, therefore, necessary to maintain soil fertility status for sustainable production of Jatropha. Hence, the present investigation was carried out to find out suitable dose of fertilizers and its effect on yield and quality attributes.

MATERIALS AND METHODS

A field experiment was conducted to study the effect of major nutrients on yield and quality of *Jatropha curcas* at the Main Agricultural Research Station, College of Agriculture, Dharwad during *kharif* 2007-08. The soil had pH 7.50, organic carbon 0.76 per cent and the available N, P_2O_5 and K_2O were 305, 31.3 and 346.6 kg ha^{-1}, respectively. The experiment was laid out in Factorial Randomized Block Design with three replications. There were 28 treatment combinations consisted of three factors with three levels of nitrogen (50,100 and 150 N ha^{-1}), three levels of phosphorus and potassium (100,150 and 200 kg P_2O_5 ha^{-1}) with an absolute control (0:0:0 kg $N:P_2O_5:K_2O$ ha^{-1}). Ring basins were prepared all around each plant at radii of one and a half feet distance to facilitate better storage of water and efficient utilization of nutrients. Nitrogen, phosphorus and potassium were applied (in the form of urea, single super phosphate and muriate of potash, respectively) as per treatments around the basin at one feet distance from the trunk and common dose of 10 t ha^{-1} FYM (Farmyard manure) was applied (0.4 kg FYM $basin^{-1}$) by ring method. Fertilizer and FYM were covered with soil. Nitrogen was top dressed as per treatments around the basin at one feet distance from the trunk and then covered with soil during second flush.

RESULTS AND DISCUSSION

Effect of NPK levels on quality parameters of Jatropha:

Chlorophyll content:

The leaf chlorophyll content (Table 1) is the key factor determining the rate of photosynthesis. Application of

* Author for correspondence

100:100:150 kg N:P_2O_5:K_2O ha^{-1} enhanced the chlorophyll biosynthesis and recorded the maximum total chlorophyll content (2.08 mg g^{-1} fresh weight). This may be due to balanced supply of all the nutrients along with FYM (Table 1). Application of 100 kg N ha^{-1} recorded significantly higher chlorophyll content. This may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. The delay in leaf senescence could also be attributed to higher chlorophyll content. It may also be attributed to higher activity of the enzyme nitrate reductase which catalyzes the reduction of nitrate to nitrite and is a rate limiting step in the nitrogen metabolism (Beevers and Hageman, 1969). Application of 100 kg P_2O_5 ha^{-1} to *Jatropha* recorded significantly higher chlorophyll content over no phosphorus application and was superior than 150 and 200 kg P_2O_5 ha^{-1}. The reduction in chlorophyll content is attributed to reduction in photosynthesis and radiation use efficiency under low phosphorus supply (Lauer *et al.*, 1989). Potassium application at 150 kg K_2O ha^{-1} recorded significantly higher chlorophyll content at all the growth stages. This may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. It has also been suggested that the application of potassium increased the availability of assimilates which in turn prolonged photosynthesis.

Shelling percentage:

Combined application of 100:100:150 kg N:P_2O_5:K_2O ha^{-1} and FYM (Table 1) recorded higher shelling percentage (64.83%). This may be attributed to the combined effect of FYM and inorganic fertilizer, which have synergistic effect. Application of FYM increased the supply of easily assimilated major nutrients to plants, besides mobilizing unavailable nutrients into available form leading to higher sink accumulation which in turn increased the shelling percentage. These results are inconformity with the findings of Laxminarayana and Patiram (2005). Application of 100 kg N ha^{-1} recorded higher shelling percentage over 50 and 150 kg N ha^{-1}. This may be attributed to higher number of leaves, leaf area and chlorophyll contents which might have increased the photosynthetic rate with more of assimilate supply to the sink which might have allowed the seed to grow to their full size with an obvious increase in shelling percentage (Dahatonde, 1978). The increase in shelling percentage can be related to supply of sufficient amount of phosphorus at 100 kg P_2O_5 ha^{-1}. Application of 150 kg K_2O ha^{-1} to *Jatropha* resulted in higher shelling percentage and this may be attributed to higher phloem tissue development leading the plants with better potassium supply and better provision of ATP enhanced the sink translocation and sink strength thus improving shelling percentage (Table 1). The results are in conformity with the findings of Bandopadhyay and Samul (1999).

Oil cake NPK content:

In the present investigation, application of 150:200:200 kg N:P_2O_5: K_2O ha^{-1} recorded higher oil cake nitrogen (4.438%) as compared to all other treatment combinations and can be attributed to the synergistic effect of the nutrients and high nitrogen mobility. The concentration of nitrogen in oil cake increased consistently with increasing levels of N application from 4.30 to 4.438 per cent. This may be attributed to the fact that nitrogen is highly mobile and exhibits more upward translocation to the reproductive sinks rather than leaves, petiole and stem indicating seeds as significant and strong sinks for nitrogen. Integration of 50:150:200 kg N:P_2O_5:K_2O ha^{-1} showed higher oil cake phosphorus content. This may be attributed to the mobilization of native soil phosphorus by the organic acids released from FYM and enhanced phosphorus use efficiency by the plants and thus recorded higher phosphorus content of oil cake. Application of 100:100:150 kg N:P_2O_5:K_2O ha^{-1} recorded higher oil cake potassium content (1.68%) and higher level of potassium accumulated higher potassium content and may be attributed to the tendency of the crop to accumulate more and more nutrients in the sinks (Yin and Vyn, 2002).

***Oil content, oil yield and biodiesel yield*:**

In the present investigation, application of 100:100:150 kg N, P_2O_5 and K_2O ha^{-1} to *Jatropha* recorded less oil content (37.02%) as compared to control (40.07%) but, the oil yield (1461.28 kg ha^{-1}) and biodiesel yield (1200.46 l ha^{-1}) were higher at 100:100:150 kg N, P_2O_5 and K_2O ha^{-1} as compared to all other levels including control which is mainly due to higher seed yield. The reduction in oil content at the highest nitrogen reflects the inverse relationship between seed oil content and seed protein content. The negative correlation is related to the competition for carbon skeletons during carbohydrate metabolism (Bhatia and Rabson, 1976). The reduction in seed oil content in low phosphorus supply may be due to insufficient photosynthate supply to reproductive organs from leaves because of lower leaf area and LAI (Giaquinta and Quebedeaux, 1980). Potassium involves in plant metabolic activities as an enzyme activator (Yin and Vyn, 2002). The enhanced activity and carbohydrate translocation by potassium application at 150 kg K_2O ha^{-1} might have increased the oil content.

Similarly, significantly higher total biodiesel production (1200.46 l ha^{-1}) was recorded with an

Table 1: Effect of major nutrients on yield and quality of *Jatropha curcas*

Treatment combinations kg $N:P_2O_5:K_2O$ ha^{-1}	Oil cake N (%)	Oil cake P(%)	Oil cake K(%)	Chlorophyll content (mg g^{-1} fresh weight)	Shelling percentage	Oil content (%)	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Biodiesel yield (l ha^{-1})
50: 100: 100	4.348	2.00	1.62	1.17^{b}	59.56^{g-i}	36.25^{g-k}	2525.00^{b}	915.93^{b}	769.82^{b}
50: 100: 150	4.351	2.01	1.66	1.17^{e-g}	59.57^{g-i}	39.45^{a-c}	2555.00^{b}	1007.89^{b}	778.96^{b}
50: 100: 200	4.358	2.02	1.67	1.46^{c}	63.83^{b}	33.65^{l}	2770.83^{b}	937.69^{b}	844.77^{b}
50: 150: 100	4.358	2.01	1.65	1.12^{fg}	60.40^{e-g}	38.77^{a-d}	2635.00^{b}	1021.73^{b}	803.35^{b}
50: 150: 150	4.400	2.01	1.66	1.33^{d}	63.60^{b}	37.83^{b-i}	2765.00^{b}	1056.38^{b}	842.99^{b}
50: 150: 200	4.352	2.05	1.67	1.18^{e-g}	60.17^{f-i}	35.77^{jk}	2610.00^{b}	933.67^{b}	795.73^{b}
50: 200: 100	4.341	2.02	1.61	1.17^{e-g}	57.90^{j}	37.65^{c-j}	1885.00^{bc}	709.88^{bc}	574.70^{bc}
50: 200: 150	4.346	2.09	1.63	1.17^{e-g}	59.37^{i}	39.73^{ab}	2498.33^{b}	998.11^{b}	761.69^{b}
50: 200: 200	4.348	2.14	1.64	1.08^{g}	57.77^{hi}	38.45^{a-e}	2525.00^{b}	970.86^{b}	769.82^{b}
100: 100: 100	4.378	1.72	1.60	1.17^{e-g}	56.83^{j}	35.27^{kl}	1850.00^{bc}	652.67^{bc}	564.02^{bc}
100: 100: 150	4.375	1.96	1.68	2.08^{a}	64.83^{a}	37.02^{d-k}	3937.50^{a}	1461.28^{a}	1200.46^{a}
100: 100: 200	4.368	1.99	1.68	1.25^{d-f}	61.17^{de}	36.00^{i-k}	2715.00^{b}	976.70^{b}	827.74^{b}
100: 150: 100	4.362	1.74	1.65	1.23^{d-g}	61.17^{de}	38.32^{a-f}	2675.00^{b}	1024.65^{b}	815.55^{b}
100: 150: 150	4.371	1.96	1.66	1.18^{d-g}	60.67^{ef}	38.13^{a-g}	2669.17^{b}	1017.91^{b}	813.77^{b}
100: 150: 200	4.368	1.99	1.66	1.18^{e-g}	59.90^{f-i}	37.53^{c-j}	2585.00^{b}	970.24^{b}	788.11^{b}
100: 200: 100	4.375	1.98	1.62	1.26^{d-f}	61.83^{cd}	38.65^{a-d}	2770.83^{b}	1070.00^{b}	844.77^{b}
100: 200: 150	4.370	1.96	1.62	1.17^{e-g}	58.27^{j}	36.40^{f-k}	1975.00^{b}	722.46^{bc}	602.13^{b}
100: 200: 200	4.367	2.00	1.66	1.17^{e-g}	58.43^{j}	38.23^{a-f}	2200.00^{b}	840.72^{b}	670.73^{b}
150: 100: 100	4.424	1.95	1.62	1.17^{e-g}	58.33^{j}	36.17^{h-k}	1987.50^{b}	726.28^{bc}	605.95^{b}
150: 100: 150	4.400	1.95	1.65	1.18^{d-g}	60.47^{e-g}	37.82^{b-i}	2644.17^{b}	1001.30^{b}	806.15^{b}
150: 100: 200	4.421	1.97	1.65	1.18^{d-g}	60.33^{e-h}	37.52^{c-j}	2620.00^{b}	983.01^{b}	798.78^{b}
150: 150: 100	4.406	1.96	1.61	1.28^{de}	62.50^{c}	38.07^{b-h}	2715.00^{b}	1032.64^{b}	827.74^{b}
150: 150: 150	4.416	1.95	1.67	1.29^{de}	63.50^{b}	38.23^{a-f}	2775.00^{b}	1060.14^{b}	846.04^{b}
150: 150: 200	4.407	1.98	1.67	1.17^{e-g}	58.10^{j}	33.97^{l}	1908.33^{bc}	647.96^{bc}	581.81^{bc}
150: 200: 100	4.423	1.96	1.64	1.18^{d-g}	62.67^{c}	35.95^{i-k}	2775.00^{b}	997.57^{b}	846.04^{b}
150: 200: 150	4.417	1.95	1.64	1.17^{e-g}	59.56^{g-i}	36.58^{e-k}	2545.00^{b}	930.98^{b}	775.91^{b}
150: 200: 200	4.438	1.99	1.65	1.18^{d-g}	60.33^{e-h}	38.30^{a-f}	2630.00^{b}	1007.29^{b}	801.83^{b}
0:0:0	4.300	1.80	1.56	0.88^{h}	56.50^{k}	40.07^{a}	875.00^{c}	350.58^{c}	266.77^{c}
S.E.±	0.0007	0.014	0.0003	0.04	0.29	0.59	335.90	129.44	102.41

Note: The means followed by the same lower case letter/letters did not differ significantly by DMRT

application of 100:100:150 kg $N:P_2O_5:K_2O$ ha^{-1} followed by 150:200:100 kg $N:P_2O_5:K_2O$ ha^{-1} (846.04 l ha^{-1}). This may be attributed to higher seed yield and increased oil content as compared to rest of the treatment combinations.

Seed yield:

Application of 100 kg N, 100 kg P_2O_5 and 150 kg K_2O ha^{-1} recorded significantly higher seed yield of Jatropha (3937.50 kg ha^{-1}) followed by 150:150:150 kg $N:P_2O_5:K_2O$ ha^{-1} (2775 kg ha^{-1}) which was superior over all other treatment combinations. This might be due to the established fact that nitrogen, phosphorus and potassium nutrients govern utilization of each other more effectively (Kausadikar *et al.*, 2003). Application of 100:100:150 kg $N:P_2O_5:K_2O$ ha^{-1} to Jatropha is optimum for getting higher yield and at the same time can save 50 kg N, 100 kg P_2O_5 and 50 kg K_2O ha^{-1} without any reduction in the seed yield. The increase in yield at 100 kg N ha^{-1} might also be due to increased availability of nitrogen, causing accelerated photosynthetic rate leading to more production of carbohydrates and improvement in growth and yield attributes. The reduction in photosynthesis and radiation use efficiency under low phosphorus supply (Lauer *et al.*, 1989) explains the reduced yield. The increase in the yield at 150 kg K_2O ha^{-1} may be attributed to higher rate of phloem tissue development leading in the plants with better potassium supply and better provision of ATP enhanced by sink translocation and sink strength thus improving yield.

It may be concluded that, application of 100:100:150 kg $N:P_2O_5:K_2O$ ha^{-1} was found for higher yield and quality of Jatropha as compared to the rest of the levels.

REFERENCES

Bandopadhyay, P. and Samul, R.C.(1999). Response of *kharif* groundnut to varying levels of phosphorus, potassium and sulphur in West Bengal. *J. Oilseeds Res.*, **16** (1) : 82-85.

Beevers, L.and Hageman, R.H. (1969). Nitrate reduction in higher plants. *Ann. Rev. Pl. Physiol.*, **20**: 495-522.

Bhatia, C.R. and Rabson, R. (1976). Bio-energetic considerations in cereal breeding for protein improvement. *Sci.*, **194** : 1418-1421.

Dahatonde, B.N. (1978). Response of varying levels of irrigation and N, P fertilization on summer groundnut. *J. Maharashtra Agril Ov.*, **3** (2) : 137-138.

Giaquinta, R.T. and Quebedeaux, B. (1980). Phosphate induced changes in assimilate partitioning in soybean leaves during pod filling. *Pl. Physiol.*, **65** : 119-125.

Gour, V.K. (2004). Production practices including post harvest management of *Jatropha curcas*. *http://www.jatrophaworld.org/dr-v-k-gour-58.html*.

Kausadikar, H.K., Phadnawis, A.N., Malewar, G.U. and Khandare, R.N. (2003). Effect of graded levels of nitrogen, phosphorus and potassium fertilizers on yield and quality of soybean (*Glycine max* L. Merill) growth on vertisol. *J. Soil and Crops*, **13** (1): 81-84.

Lauer, M.J., Pallardy, S.G., Blevins, D.G. and Randall, D.D. (1989). Whole leaf carbon exchange characteristics of phosphate deficient soybean. *Pl. Physiol.*, **91**: 848-854.

Laxminarayana, K. and Patiram (2005). Influence of inorganic, biological and organic manures on yield and nutrient uptake of groundnut (*Arachis hypogaea*) and soil properties. *Indian J. Agric. Sci.*, **75**(4): 218-221.

Punia, M.S., Kureel, R.S. and Ashutosh, P. (2006). Status and potential of tree borne oilseeds (TBOS) in biofuel production in India. *Indian J. Agroforest.*, **8**(2): 80-86.

Yin, X. and Vyn, Y.J. (2002). Soybean response to potassium placement and tillage alternatives following no till. *Agron. J.*, **94 :** 1367-1374.

Received : January, 2009; Accepted : March, 2009