Effect of Different Soil Fertilizing Systems (Chemical, Organic and Integrated) and Barvar Phosphate Biofertilizer (BPB) on Seed Yield, Essence Content and P Concentration in Black Cumin (*Nigella Sativa L.*)

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A greenhouse experiment was carried out to investigate the effects of chemical fertilizers including N and P (Chemical fertilizing system), animal manure (Organic fertilizing system), combined use of manure and chemical fertilizers (Integrated fertilizing system) and Barvar phosphate biofertilizer (BPB) on seed yield, essence content and seed P concentration in black cumin at the Agriculture Research Center, Vali-Asr Rafsanjan University, Rafsanjan, Iran. The results showed that the BPB inoculation significantly increased the seed yield, essence content and seed P concentration. The results also showed that seed yield and essence content were significantly affected by fertilizing systems. Animal manure and combined use of manure and chemical fertilizers resulted in a higher seed yield, essence content and P concentration than solitary application of chemical fertilizer. Totally, the most seed yield (4.58 g pot^{-1}) and essence content (0.2%) were observed under integrated use of animal manure and chemical fertilizer with BPB inoculation.

Tillage and Nutrient Management in Napier-Bajra-Hybrid + *Leucaena leucocephala* alley-based Food-Fodder and Fuel Production under Diversified Cropping Systems

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The present investigation was carried out under field conditions at the Indian Grassland and Fodder Research Institute, Jhansi for three years 2003-06. Twenty treatment combinations were tried in the experiment using 5 cropping systems i.e. CS1 sorghum (fodder) + pigeonpea, CS2 sorghum (fodder)–chickpea, CS3 sorghum + cowpea (fodder) – wheat, CS4 sorghum (fodder)-berseem + mustard (fodder)and CS5 sorghum + cowpea (fodder)- oats (fodder) and four depths of cultivation and application of nutrients viz. AN1-shallow cultivation with 100% nutrients through fertilizers, AN2 shallow cultivation with 50% nutrients through fertilizer + 50% nutrients through organic (FYM), AN3 deep cultivation with 100% nutrients through fertilizers, and AN4, deep cultivation with 50% nutrients through fertilizer + 50% nutrients through organic (FYM) in split-plot design with three replications. In addition to this napier-bajra-hybrid (IGFRI-3) was also planted at 8 m interval and alley of *Leucaena* at 2 m for continuous supply of green fodder for the livestock.

Treatment CS3 *i.e.* sorghum + cowpea (fodder)–wheat was significantly superior to other treatments and produced maximum green (100 t ha^{-1}) as well as dry (47.1 t ha^{-1}) from one cut of sorghum + cowpea and three cuttings of napier-bajra-hybrid. The yield levels of other treatments were low. Further, this rotation gave a sum of 537458 MJ ha^{-1} output in terms of energy in three seasons. Further, CS4 rotation gave a sum of 523640 MJ ha^{-1} energy, CS2 (421190), CS5 (484655) and least energy produced by CS1 (393322 MJ ha^{-1}). In terms of economic yield and net profit CS3 rotation gave a sum of Rs. 54373 ha^{-1} followed by CS2 (Rs. 47480 ha^{-1}) CS1 (Rs. 44213), CS4 (Rs. 43915), and least in CS5 (Rs. 37355). However, maximum B:C ratio of 2.34 was observed in CS1 that was followed by CS2 (2.27), CS3 (1.88), CS5 (1.19) and least in CS4 (1.14). Among the depth of cultivation and application of nutrients AN3 produced highest

output and profit (497237 MJ ha^{-1} energy and net profit of Rs. 50319 that was followed by which AN2. AN4 gave 486302 MJ ha^{-1} energy with 50425 Rs ha^{-1} net profit and least in AN1 produced 478018 MJ ha^{-1} energy and net profit of Rs. 46938. The highest energy output -input ratio may be attributed to more output of energy with less input 32.59 in CS2. In the existing crops/cropping systems input energy was tested as per requirement and tractor-drawn machinery was used to complete the operations. It was found that field was prepared with the help of tractor drawn farm implements like disc harrow, cultivator for shallow tillage and mould board plough for deep tillage on research farms as well as on farmers fields. The FYM was transported and mixed in the soil on tractor-drawn four wheel trailer. Fertilizers were applied with the help of ferti-seed drill. However, harvesting was partially done with the help of machines and partially with the help of manual labourers. Transplanting of napier-bajra-hybrid were transplanted in rows at 8 m interval and 1 m spacings and subabool (*Leucaena leucocephala*) in between rows at 2 m interval with the help of manual labourers. Spreading of FYM was done manually due to lack of farm tools. Mechanization of irrigation - still on research farm as well as on farmers fields flood irrigation - is popular that otherwise requires saving of water and modern tools/implements.

Water Saving Planting Techniques for Summer Groundnut (*Arachis hypogaea* L.) under Rice-based Cropping System

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Water is the most limiting factor for crop production in canal command areas of eastern India especially during dry season. Thus, saving of irrigation water and enhancing water use efficiency (WUE) of crops is extremely important for crop production. Crop management viz. efficient planting techniques compared to flat method is a potential option for saving of water and increasing irrigation water use efficiency. A field experiment was conducted at the WTCER Research Farm, Deras, Orissa to study the improved planting techniques on groundnut (*Arachis hypogaea* L.) var. TAG-24 with the aim of saving of irrigation water and enhancing WUE. The soil at the study site was sandy clay loam (46% coarse sand, 17% fine sand, 16% silt and 21% clay), with bulk density of 1.44 Mg m^{-3}, saturated hydraulic conductivity (Ks) 1.14 cm hr^{-1}, maximum water holding capacity (θ_s) 0.47 cm^3 cm^{-3} and available water capacity (θ_{AWC}) 0.18 cm^3 cm^{-3} in the 0-15 cm soil. Three planting techniques viz. planting at 30x10 cm spacing on flat-bed (FB); planting on ridges spaced at 30 cm on ridge and furrow system (RF) and paired row planting on ridges/ beds spaced at 45 cm (PR) were superimposed on four irrigation treatments *viz*. one, two, three and four irrigations. The irrigations were scheduled at critical growth stages. The crops for each treatment were grown with common agronomic practices. The preceding crop was rice during rainy season. The total rainfall received during the crop growing period was 14.09 mm.

Results revealed that the pod yields (adjusted to 15% moisture) in RF (2. 07 t ha^{-1}) and PR (2. 04 t ha^{-1}) were significantly greater than FB (1.78 t ha^{-1}) method. Total dry matter (TDM) production (adjusted to 15% moisture) was also significantly influenced by the planting techniques. The TDM was 5.08, 6.38 and 6.27 t ha^{-1} in FB, RF and PR, respectively. However, the harvest index (32.9-35.2%) was statistically similar. About 15-18% higher pod yield in RF and PR was attributed to better interception of photosynthetically active radiation (PAR) by the crop canopy. The intercepted PAR on 99 through 122 Julian day ranged from 46.3 to 57.7% in FB, 52.8 to 61.8% in RF and 64.5 to 74.4% in PR. The soil moisture extraction (0-90 cm) by the crop was more in PR and RF than FB method, as was evident from changes in soil moisture ($\Delta\theta$) values. In PR, rate of photosynthesis (Pn) and transpiration (E) was 21.6 µmole m^{-2} s^{-1} and 7.2 mmol m^{-2} s^{-1}, respectively. The estimated irrigation water depth was 12.48 and 9.98 cm in RF and PR, respectively compared to 17.37 cm in FB; implying a significant reduction in irrigation water requirement by 28 and 42% in RF and PR, respectively compared to FB. The crop WUE was significantly greater in PR (7.07) than RF (6.68) and FB (5.09 kg pod $ha^{-1}mm^{-1}$ET); the corresponding irrigation water use efficiency (IWUE) was 12.6, 20.8 and 25.1 kg pod mm^{-1} depth of irrigation in FB, RF and PR planting method, respectively. Thus, it is inferred that with the paired row planting on ridges/ beds it would be possible to save a significant amount of irrigation water and enhance both IWUE and WUE of summer groundnut.