Balanced Fertilization Increases Cauliflower Yield and Marketability

By Feng Wenqiang, Tu Shihua, Liu Yinfa, Qin Yusheng, and Liao Minglan

Potassium (K) is the main yield-limiting factor, but proper levels of magnesium (Mg) and molybdenum (Mo) significantly increased cauliflower yield, farmers' net income, and product marketability. This technology should be extended to all vegetable growers on the Chengdu plain.

Located on the Chengdu plain in Sichuan Province, Pengzhou County has a long vegetable growing history. Over the last two decades the region has been developed into a national vegetable production base. Soils on the Chengdu plain are characterized by light texture and low K content. Vegetable growers have tended to use nitrogen (N) and phosphorus (P) fertilizer, but apply little or no K in their fertilization programs. This imbalance is intensifying soil nutrient deficits and is severely limiting productivity in the region. Cauliflower is a popular vegetable having a strong traditional market and acceptance by consumers and high economic returns to the farmer. However, cauliflower yield and quality are sensitive to low soil K supply. Hence, the region would benefit from a fertilizer management plan that provides optimal soil K availability.

Cauliflower showing K deficiency symptoms.

A replicated field experiment conducted in Li'an township used seven treatments based on soil analyses supplying one rate of N and P fertilizer and various combinations of K, Mg, boron (B), and Mo (**Table 1**). Nitrogen and K were applied basally in four splits at pre-seeding, seeding, flower bud emergence, and flower head peak growing stage. Ammonium molybdate [$(NH_4)_6Mo_7O_{24}$] was applied as a foliar spray during flower bud emergence.

Table 1. Plant nutrients applied in the different treatments (kg/ha) in Pengzhou, Sichuan.

Treatment	N	P_2O_5	K_2O	Mg	B	Mo
1	207	75	-	-	-	-
2	207	75	225	-	-	-
3	207	75	450	-	-	-
4	207	75	225	-	7.5	-
5	207	75	225	-	-	20
6	207	75	225	29.4	-	-
7	207	75	225	29.4	7.5	20

Nutrient sources were urea, single-superphosphate (SSP), potassium chloride (KCl), magnesium sulfate ($MgSO_4$), borax, and $(NH_4)_6Mo_7O_{24}$.

Yield and Income Benefits

Results found that K fertilizer was the most yield-limiting factor for cauliflower (**Table 2**). Yield increased

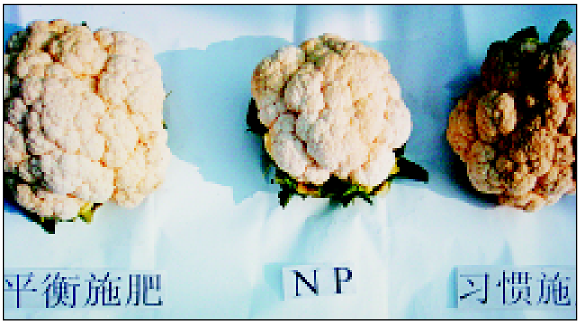
Table 2. Effect of balanced fertilization on cauliflower yield and profitability, Sichuan, China.

Treatment	Yield[1], t/ha	Yield increase, %	Cost of fertilizer, $US/ha	Net profit, $US/ha
1	17.6c	0	122	4,165
2	29.1b	65.3	186	6,903
3	29.9ab	69.9	250	7,034
4	29.2b	65.9	188	6,925
5	29.4ab	67.0	186	6,976
6	29.6ab	68.2	223	6,988
7	30.3a	72.2	225	7,156

[1] Means with the same letters are not significantly different at p=0.05 level. $LSD_{0.05}$=0.8

The cauliflower variety was Donghua, planted at a density of 33,800 plants/ha.

with K application rate up to 225 kg/ha, beyond which yields changed little and higher production costs reduced the net return. Individually amongst the nutrients applied, B had the least impact on yield while the effects of Mg and Mo were greater. A maximum yield was obtained with the complete treatment supplying N, P, K_{225}, Mg, B, and Mo.



Cauliflower heads in storage as affected by balanced fertilization. Result in farmers' practice is shown at right, NP in center, and balanced treatment at left.

Marketing Benefits

Potassium application produced large increases in plant height and head weight and diameter (**Table 3**). However, compared to plants receiving NPK_{225}, the addition of B, Mg, and Mo fertilizers, either separately or in combination, appeared to enhance these marketable plant characteristics even more. Total plant biomass was definitely affected by K, although similar advantage from the complete treatment was less apparent.

Potassium fertilizer prolonged product shelf life and reduced moisture loss from harvested heads. Compared to NP alone, NPK_{225} increased shelf life by six days. When B, Mo, or Mg fertilizer was applied individually, a further 1 to 4 days of storage time resulted. The complete treatment provided an additional 6 days (27 in total) and moisture loss was substantially minimized. These two traits are very important when considering their impact on transportation and consumer appeal, thereby ensuring premium prices.

Table 3. Effect of balanced fertilization on cauliflower marketability, Sichuan, China.

No.	Plant height, cm	Head weight, g	Head diameter, cm	Biomass, t/ha	Shelf life, days	Moisture loss[2], %
1	45.8	530	10.1	36.8	15	20.5
2	61.5	870	12.8	79.6	21	15.2
3	61.9	910	13.6	81.2	21	14.7
4	61.4	880	13.0	79.9	22	15.1
5	62.3	880	13.3	81.1	25	14.8
6	62.0	900	13.3	81.6	25	14.0
7	62.6	920	13.8	81.8	27	11.2

[1] Shelf life refers to the number of days after harvest until vegetables turn brown or rot.
[2] Amount of moisture lost during storage.

Field Demonstration Program Results

As part of an extension program designed to transfer the research results into farmer practice and increase community awareness on the benefits of balanced fertilization, six farmers'

Cauliflower with balanced fertilization at left compared to NP treatment at right.

field demonstration trials were established throughout the county to contrast balanced fertilization (BF) with two farmer practices (FP_1 and FP_2) (**Table 4**).

Table 4. Demonstrating the effect of balanced fertilization (BF) on cauliflower yield, Sichuan, China.

Household	Treatment	Yield, t/ha	Yield reduction vs. BF ±%
Zhang Huaifu	BF[1]	40.5	–
	FP_1[2]	35.4	-14.4
	FP_2[3]	30.9	-31.1
Zhang Huaitian	BF	30.1	–
	FP_1	25.0	-20.3
	FP_2	30.7	+1.8
Zhang Huaitian	BF	39.8	–
	FP_1	30.7	-21.9
	FP_2	35.4	-12.6
Liu Yonghuai	BF	31.8	–
	FP_1	25.4	-25.1
	FP_2	28.2	-12.8
Liu Yonghuai	BF	42.9	–
	FP_1	34.7	-23.7
	FP_2	39.1	-9.8
Liu Zhonghan	BF	43.9	–
	FP_1	36.0	-22.2
	FP_2	39.4	-11.6

[1] 112.5, 90, and 22.5 kg K_2O/ha (KCl) applied basally, at flower bud emergence, and at flower head peak growth, plus 1,500 kg slaked lime/ha, 30 kg Mg/ha ($MgSO_4 \cdot 7H_2O$) applied basally, and 750 kg 0.05% $(NH_4)_6Mo_7O_{24}$ as foliar spray at flower bud emergence stage.
[2] 41, 62 and 104 kg N/ha as urea applied basally, flower bud emergence, and flower head peak growth, respectively, plus 90 kg P_2O_5/ha (SSP) applied basally.
[3] 750 kg 15-15-15/ha applied basally plus 128 kg N/ha (ammonium bicarbonate) at flower bud emergence.

Five out of six demonstration trials found that farmers' fertilizer practices produced far less yield (from -9.8 to -31.1%). In the majority of cases, FP_1 (i.e., NP fertilization) produced lower yields than FP_2 which used a 15-15-15 compound fertilizer and ammonium bicarbonate as part of the fertilization package. Reliance on these two fertilizer sources is largely based on product availability and not the conditions of the site. It is apparent that common farmer practice supplies an imprecise nutrient prescription which is not matched to the region's soils or the nutrient demands of cauliflower.

Conclusions

Field experiments on the Chengdu plain found K to be the main yield-limiting factor, although Mg and Mo deficiencies significantly affected cauliflower quality factors. Balanced fertilization can significantly increase cauliflower yield, marketability, and farmers' net income. Extension of this technology to vegetable growers in southwestern China will raise farmer income and further improve the region's reputation for producing quality vegetable produce. BC

Mr. Feng Wenqiang is Associate Professor, Mr. Qin Yusheng, and Ms. Liao Minglan are Assistant Professors, Soil and Fertilizer Institute, Sichuan Academy of Agricultural Sciences, Chengdu, China. Liu Yinfa is Technician in vegetable management in Pengzhou County. Dr. Tu is Deputy Director, PPI/PPIC China Program; e-mail: stu@ppi-ppic.org.

Potassium Responses Observed in South Australian Cereals

By Nigel Wilhelm and Jonnie White

Recent field trials in the dryland cropping region of South Australia have demonstrated that unrecognized potassium (K) deficiencies have the potential to severely limit yields.

Potassium deficiency is not currently recognized as a problem in the dryland cropping regions of South Australia. However, the 2001 National Land and Water Resources Audit reported that the region had a highly negative K balance (that is, much more K is exported off-farm in produce than is replaced in fertilizer). Recently it has become apparent that, on some soil types, poor growth of cereal crops may be attributable to K deficiency. In 2002, the South Australian Research and Development Institute (SARDI) established an experimental site in a farmer's field near Laura in the mid North region of South Australia to examine the extent to which cereals may respond to K. The experimental site was on an undulating field with a duplex soil (sandy loam topsoil over a clay loam to clay, calcareous subsoil) and an average annual rainfall of 470 mm. Three field trials were established to test: 1) K rate response, 2) NxPxK interaction, and 3) K application method.

Soil chemical properties from each individual trial area are shown in **Table 1**. Wheat was no-till sown in June and harvested in December 2002. The 2002 season was particularly dry. However, growth of wheat in the trials appeared quite vigorous in the high K treatments. The best treatment at the site yielded 2.78 t/ha, comparable to the region's yield potential based on the amount of rain received.

Rate Response Trial This trial received basal applications of 56 kg nitrogen (N)/ha, 46 kg P_2O_5/ha, 15 kg sulfur (S)/ha, and 1 kg zinc (Zn)/ha. Eleven rates of K (between 0 and 180 kg K_2O/ha) were applied as muriate of potash (MOP) drilled under the seed row at planting.

Table 1. Soil chemical properties measured from trial areas at the Laura site, South Australia.

	Rate response trial		Application trial		NxPxK trial	
Parameter	0-10 cm	10–20 cm	0-10 cm	10–20 cm	A horizon	B horizon
Water pH	7.3	8.1	6.2	6.8	6.6	8.0
Colwell K, mg/kg	45	46	121	53	42	69
Colwell P, mg/kg	27	17	25	16	16	5
Nitrate N, kg/ha	20	11	11	6	4	3
Sulfur, mg/kg	12	11	14	7	6	23
Exchangeable Ca, meq/100 g	5.8	8.5	4.9	5.8	4	11.6
Exchangeable Mg, meq/100 g	0.5	0.5	0.4	0.7	0.4	1.7
Exchangeable Na, meq/100 g	0.10	0.08	0.10	0.06	0.04	0.09
Exchangeable K,meq/100 g	0.13	0.07	0.08	0.14	0.11	0.18
Walkley-Black organic carbon, %	1.4	1.0	1.6	1.0	0.9	0.7