Potato *(Solanum tuberosum L.)*

French: Pommes de terre; Spanish: Patatas; Italian: Patatas; German: Kartoffeln

Crop data

Annual, but some crops in some areas overwintered in the ground prior to harvesting.

Planted (tubers) spring to early summer; in some areas doublecropped in one season by planting very early in spring, harvesting early - before full maturity - then again planting in summer.

Planting from true potato seeds (TPS) occurs in parts of Africa, Asia and South America. TPS can be sown directly into the field (although this has not developed beyond the experimental stage) or sown to produce plants for transplanting into the field (a technique which appears to be less favoured currently) or grown under controlled conditions to produce high numbers of small tubers per unit area (minitubers) which are then grown on in the field in a relatively traditional manner.

Flowers: some cultivars rarely, if ever, produce full flowers; others produce flowers but sterile seed; whereas yet others produce flowers, fruits (commonly called berries) and viable seed.

Initiation of "daughter" tubers occurs 5-12 weeks after planting of "mother" tubers, presuming these latter to have reached the end of their normal dormancy at planting and depending upon the extent to which the mother tuber has been physiologically aged.

Plant density: 30 000-100 000 tubers/ha dependant on cultivar ("normal" range in temperate conditions 30 000 - 60 000 tubers/ha). Within this range, planting density is varied according to the final market requirement in tuber size, the availability of moisture (especially irrigation) and, in some countries, the relative cost of seed tubers and ware (consumption) tubers.

Potatoes will grow on most soils but, where mechanical harvesting is operated, then lighter and medium bodied soils cause less difficulty in harvesting when weather conditions are adverse. Potatoes are grown on organic as well as mineral soils. Soil pH requirement: minimum 5.5 but below about pH 4.8 growth is impaired. Alkaline conditions can adversely affect skin quality and highly alkaline conditions can induce micronutrient deficiencies.

Continuous cropping with potatoes only occurs in a few special situations and therefore it is normally necessary to strike a compromise in pH requirement between the needs of potatoes and other rotational crops. In most mineral soil situations a compromise recommendation for pH is 6.0-7.0. It is imprudent to apply lime immediately before a potato crop except in cases of extreme acicidity.

The crop responds well to moisture; irrigation is commonplace where it is grown on any scale. Irrigation at tuber initiation can affect the skin quality of daughter tubers by influencing phytopathogens, either favourably or adversely according to conditions**,** and amount of moisture present.

Nutrient uptake/removal

Nutrient demand/uptake/removal - Macronutrients								
Tuber yield t/ha	**Source**	kg/ha						
		N	**P2O5**	**K2O**	**MgO**	**CaO**	**S**	**Cl**
100	Burton, 1989	250-450	35-65	350-550	10-30	10-20	20-40	20-100
57.9	Anderson and Hewgill, 1978	105 (1.8)*	60 (1.0)	315 (5.4)	12 (0.2)	5 (0.08)	- -	- -
77.7	Evans, 1977	250 (3.2)	80 (1.0)	325 (4.1)	-	-	-	-
90.0	ADAS (unpub-lished), 1976	306 (3.4)	93 (1.0)	487 (5.4)	19 (0.2)	8 (0.08)	-	-
50.0	Cooke, 1972	80 (1.6)	57 (1.1)	240 (4.8)	15 (0.3)	10 (0.19)	-	-
46.1	Widowson and Penny, 1975	154 (3.3)	47 (1.0)	290 (6.2)	-	-	-	-
50.0	Cooke, 1974	180 (3.6)	25 (0.5)	200 (4.0)	15 (0.3)	10 (0.20)	20 (0.4)	-
30.0 (whole plant)	Wirsing, 1990	150 (5.0)	25 (0.8)	200 (6.7)	20 (0.6)	60 (2.0)	-	-
36.0 (tops) (tubers)	Smith, 1990	58 153 211 (7.0)	8 32 40 (1.3)	112 209 321 (10.7)	22 16 38 (1.3)	40 5 45 (1.5)	6 10 16 (0.5)	- - - -
	Harris, 1978 quoting Kunkel et al., 1973	(2.68)	(0.62)	(3.93)	(0.27)	(0.07)	(0.21)	-
	Bedin; Malet, 1989	(3.2)	(1.6)	(6.0)	-	-	-	-
* in brackets kg/t tubers								

Nutrient demand/uptake/removal - Micronutrients							
Tuber yield t/ha	**Source**	kg/ha					
		Fe	**Mn**	**Zn**	**Cu**	**B**	**Mo**
100	Burton, 1989	0.5-2	0.1-2	0.4	0.1-0.2	0.1-0.2	0.1
	Harris, 1978 quoting Kunke et al., 1973	(0.042)*	(0.0134)	(0.018)	(0.0014)	(0.0062)	-
* in brackets kg/t tubers							

Plant analysis

Plant analysis data - Macronutrients									
Plant part	**Growth stage**	**Source**	**% of dry matter**						
			N	**P**	**K**	**Mg**	**Ca**	**S**	**Na**
Tuber	60 days	Kunkel et al., 1973	1.8	-	-	-	-	-	-
	195 days		1.4	-	-	-	-	-	-
Foliage	-	Laughlin et al., 1974	0.19-3.8	0.16-0.25	-	-	-	-	-
Tuber	Mature	Painter and Augustin, 1976	1.16	-	1.47	0.084	0.019	-	0.022
Tuber	Mature	Rexen, 1976	1.23-1.50	-	-	-	-	-	-
Tuber	Mature	Kraus and Marschner, 1973	-	-	-	-	1.4-8.2	-	-
Aerial tissue	Actively growing	ADAS, 1990 (unpublished)	>3.5*s <1.5d	>0.2s -	>2s <1.5d	>0.1s	-	-	-
* s = satisfactory d = deficient									

Plant analysis data - NO3 and micronutrients						
Plant part	**Growth satge**	**Source**	**ppm dry matter**			
			NO3	**Fe**	**Cu**	**Mn**
Tuber	Mature	Painter and Augustin, 1976	-	15.7	1.3	-
Aerial tissue	Actively growing	ADAS, 1990	-	-	-	>30s*
		(unpublished)	-	-	-	<20d
Petiole	Tuberisation	Kleinkopf und	15 000	-	-	-
(4th)	Tuber growth	Westerman,	15 000	-	-	-
	Maturation	1987	<10 000	-	-	-
* s = satisfactory d = deficient						

Fertilizer recommendations

Available organic manures are normally applied before seedbed preparation and ploughed or cultivated into the soil before planting. Frequently the nutritive value of such organic manures is unknown, and generally the amounts used are not recorded. It has been suggested that organic manures would enhance the water-holding capacity of the soil. However, pot experiments reported by Harris (1960) indicated such effects to be small, whilst Holliday et al.(1965) demonstrated yield benefits of up to 14 % from use of FYM in dry seasons. Experiments carried out by ADAS in England during the 1970s and 1980s have indicated that organic manures can have detrimental effects upon dry matter content (specific gravity) of potatoes for processing.

Timing of application of fertilizers

N: Potatoes use large amounts of N, frequently more than the total applied as fertilizer (Anderson & Hewgill, 1978). Normally all N is applied to the seedbed at planting but in cases

where leaching by rainfall is likely (e.g. on sandy soils) there are often benefits from applying half in the seedbed and half at tuber initiation. On heavier soils in temperate areas the benefits from splitting N application are less predictable.

P: generally best applied in spring.

K: Where large amounts (e.g. > 400 kg/ha K2O) are to be applied, they are probably better split. Theory would suggest several months between the two applications, the last at or about planting, but agricultural field practice suggests that 6-8 weeks between dressings in temperate conditions is adequate. On all except the lightest or most K-deficient soils, there appears to be no disadvantage in autumn application of K fertilizer followed by spring potato planting.

Micronutrients: deficiences are usually most efficiently corrected by foliar application.

Preferred nutrient forms

N: usually as readily soluble materials.

P: generally as materials containing a high proportion of water-soluble phosphate applied at or immediately prior to planting.

K: application as sulphate rather than chloride provides some small benefits in the form of relative increases in tuber dry matter (specific gravity) and is most appropriate to potatoes for processing. The chloride, however, through its effects on reducing tuber dry matter, has beneficial effects in reducing tuber bruising at harvest, other factors being unchanged. Large dressings of KCl at planting will have a deterious effect on crop emergence in dry soils.

Mg: can be applied as a foliar spray where deficiency symptoms occur in the absence of extenuating circumstances (e.g. drought); more normally it would be applied in a Mg-containing fertilizer or, as a routine on inherently Mg-deficient soils, in Mg-containing lime.

Fertilizer placement

Placement in close proximity but not in contact with seed tubers will produce more efficient fertilizer use. The risks of damage to tubers increase in dry conditions, on light soils, where pre-sprouted seed is planted, or where more than 250 kg/ha N plus K2O are applied together.

Present fertilizer practices

The Netherlands

Seed potatoes: fertilizer use depends upon cultivar and harvest date; the later a seed crop is harvested, the less N is applied.

Ware potatos:

N fertilizer requirement is calculated from the formula:
N requirement = 285 - (1.1 mineral N J/F*) (kg/ha)
* J/F - January/February

Mineral N is assessed in soil during January/February of the harvest year (= Mineral N J/F) and generally amounts to approximately 40 kg/ha N.

P and K requirements are calculated from soil status for these nutrients; whilst new soils high in Ca are given extra P.

Extra K is occasionally given to control bruising, presumably by its effect on dry matter.

Netherlands - Recommended nutrient rates			
Crop use	kg/ha		
	N	**P2O5**	**K2O**
Seed potatoes	90-130	120-180	ca. 200
Potatoes for human consumption	ca. 240	120-180	250-400
Industrial potatoes	ca. 240	120-180	100-200

France

France - Recommended nutrient rates			
Maturity group	kg/ha		
	N	**P2O5**	**K2O**
Early varieties	100-120	60-100	100-220
Second early varieties	80-100	60-100	100-200
Maincrop varieties	60- 80	60-100	100-200
New potatoes	120-150	100-150	200-250
Storage potatoes	150-200	80-110	300-400
Industrial potatoes	150-200	80-120	250-300

Boron is used in deficient soils at no more than 15-20 kg/ha because of its potential toxicity.

Germany: Former GDR

Nutrient supply to potatoes in organic manures and mineral fertilizers should match the crop requirement, which for P2O5 and K2O, is calculated from potential yield and soil nutrient status. A 30 t/ha crop would require 25 kg/ha P2O5 and 200 kg/ha K2O.

The N fertilizer recommendations which are set out below are for supplies from both mineral and organic sources for potatoes after a cereal crop (without overhead irrigation).

Germany (former GDR) - Recommended nitrogen rates				
Intended use	**Soil type**			
	Sand	**Loamy**	**Sandy**	**Loam/Clay**
	kg/ha N			
Ware potatoes for human consumption	130-170	130-170	130-170	120-160
Seed potatoes	80-120	80-120	80-120	70-100
Industrial potatoes for starch production	120-140	130-150	140-160	110-140

Where potatoes are intended for stock feed, an extra 20 kg/ha N is recommended. Where irrigation is used, a further 20 kg/ha N is advised.

N fertilizer dressings are sometimes split, especially on light sandy soils

Germany: Original FRG

Germany (original FRG) - Recommended nutrient rates*					
Type of potatoes	**Expected yield(t/ha)**	kg/ha			
		N	**P2O5**	**K2O**	**MgO**
Early potatoes	15-20	100-140	70- 80	180-240	50-60
	20-30	140-200	80-100	240-330	50-60
Maincrop potatoes	25-30	100-120	70- 80	250-275	50-60
	30-40	120-160	80-100	275-330	50-60
* For sites with good nutrient supply (Class C)					

Italy

Italy - Recommended nutrient rates			
Type of potatoes	kg/ha		
	N	**P2O5**	**K2O**
Early harvested potatoes	150-200	100-150	150-200
Human consumption potatoes	150-180	150-180	150-200
Industrial potatoes	120-150	150-180	100-150
Seed potatoes	100-120	120-160	100-150
Where FYM is used rates of mineral fertilizers are reduced proportionally.			

UK: England & Wales

Recommendations are given according to maturity on harvest date, soil nutrient status index for each nutrient, and soil type. N rates relate to previous cropping (index 0 is normal after cereals) and use of organic manures, whilst P2O5, K2O and Mg rates are based on soil analysis.

England & Wales - Recommended nutrient rates					
Variety	**Soil index**	**kg/ha**			
		N	**P2O5**	**K2O**	**MgO**
Early and	0	180a	350b	180	170
canning potatoes	1	130	300b	150	80
	2	80	250b	120	-
	3	-	250b	60	-
	over 3	-	250b	60	-
Seed potatoes	0	180	350	350	170
(grown specifically	1	130	300	300	80
for seed and burnt	2	80	250	250	-
off early)	3	-	150	150	-
	over 3	-	100	100	-
Second earlies	0	220	350	350	170
and maincrop:	1	160	300	300	80
Mineral soils	2	100	250	250	-
	3	-	200	150	-
	over 3	-	100	100	-
Second earlies	0	130	350	350	170
and maincrop:	1	90	300	300	80
Peaty soils	2	50	250	250	-
(except moss	3	-	200	150	-
soils)	over 3	-	200	100	-
Second earlies	0	180	350	350	170
and maincrop:	1	130	300	300	80
Organic, moss	2	80	250	250	-
and warp soils	3	-	200	150	-
	over 3	-	200	100	-
a For every early lifts, 150 kg/ha N is adequate					
b Early potatoes have shown much larger response on slightly acid soils in Dyfed and Cornwall than on calcareous soils in S.E. England. The latter have shown little response to P at soil P Index 4, and 125 kg/ha P2O5 is sufficient.					

Potatoes for processing: crops grown for 'French fry' production should receive the same fertilizer treatment as if grown for the ware market.
The variety Record grown for crisping should not receive more N than is recommended for ware.

Choice of source and rate of K will depend on whether higher dry matter or reduced internal bruising is the priority. High rates of animal manure can result in excessive nutrient application and reduced crisp quality.

UK: Scotland

Similar recommendations as for England & Wales, except as below:

Scotland - Recommended nutrient rates for specialist seed potato crops								
kg/ha								
N Soil N Status			**P2O5** Soil P2O5 status			**K2O** Soil K2O status		
Low	**Moderate**	**High**	**Low***	**Moderate**	**High**	**Low***	**Moderate**	**High**
100	70	40	250	200	150	160	110	60
* Soils of very low P or K status require additional 40 kg/ha P2O5 or K2O								

Adjustments for N			
	kg/ha soil N status		
	Low	Moderate	High
Average annual rainfall: > 850 mm	-25	-25	-25
Average annual rainfall: < 700 mm	+25	+25	+25
Sandy soils	+35	+35	+35
Very low organic matter (all arable)	+25	-	-

Sweden

Sweden - Recommended nutrient rates					
Use	**Region**	**Variety**	**kg/ha**		
			N	**P2O5**	**K2O**
Human consumption	South	Bintje	100-140	40-80	120-180
		King Edward	100-140	40-80	120-180
		Magnum Bonum	80-110	40-80	120-180
	Central	Bintje	100-120	40-80	120-160
		King Edward	80-100	40-80	120-160
		Magnum Bonum	60- 80	40-80	120-160
	North	Bintje	80-100	60-80	80-120
		King Edward	70- 90	60-80	80-120
		Magnum Bonum	50- 70	60-80	80-120
Starch/Alcohol	South	Dianella etc.	120-150	40-80	120-180
Chips	South	Bintje	100-120	60-80	120-200
(Pommes frites)	West	Saturna			
Seed	The whole of Sweden	Most	80-100	60-100	120-180
The recommended rates of P have generally a residual effect enough for a cereal crop.					

Finland

N requirements are taken from basic standards. Basic requirements for P2O5, K2O and Mg are calculated from soil analysis.

For all nutrients corrections are made for:

- effect of preceding crop
- organic manures
- irrigation/moisture stress
- method of fertilizer distribution, e.g. placement or broadcast

Computer programs are used to produce final individual recommendations.

USA: New York State

New York State - Recommended N rates		
Soil type	**Varieties**	**kg/ha N**
Mineral	Hudson, Kennebec	135-170
	Belrus, Monona, Norchip, Rosa, Superior, Wauseon*	170-200
Muck	Hudson, Rosa	85- 90
	Atlantic, Chieftain, Katahdin	110
	Belrus, Monono**, Norland**, Superior, Wauseon**	170
* Apply only 135-170 kg/ha N for early yields ** Apply only 110 kg/ha N for early yields		

New York State - Recommended P2O5 rates							
Soil type	**Soil test P**	**kg/ha P2O5 Soil iron + aluminium**			**kg/ha P2O5 pH**		
		<100	**100-200**	**>200**	**5.2**	**5.2-5.6**	**>5.6**
Mineral:							
- Upstate	<20	270-335	270-335	270-335	270-335	270-335	270-335
	≥20	135-170	170-270	270-335	270-335	170-270	135-170
- Long Island	<60	270-335	270-335	270-335	270-335	270-335	270-335
	≥60	135-170	170-270	270-335	270-335	170-270	135-170
Muck	<100	-	110	-	-	-	-
	≥100	-	55	-	-	-	-

New York State - Recommended K2O rates		
Soil type	**Soil Test K**	**kg/ha K2O**
Mineral	<175	270-335
	175-275	170-270
	275-375	85-170
	>375	55
Muck	<400	110
	≥400	55

New York State - Recommended MgO rates		
Soil type	**Soil test Mg**	**kg/ha MgO**
Mineral	<100 or pH <5.0	55
	≥100	none
Muck	<100	55
	≥100	none

For Long Island Mineral Soil apply Mg and at least 90 kg/ha each of N and P2O5 and all or part of K2O in bands at planting. If need is indicated by soil test, supplemental P2O5 and K2O can be applied between planting and emergence. The remainder of the N should be applied as a sidedressing when plants are 10-15 cm high.

For Upstate Mineral Soil, the entire application can be banded at planting, or at least 90 kg/ha N and all P2O5 and K2O can be applied at planting, with the remaining N applied as a sidedressing when the plants are 10-15 cm high.

In both locations, supplemental N applications may be needed if heavy rains occur early in the season, but they should not be made after plants are 20-25 cm high.

For Shallow Mucks, band all N at planting unless foliar applications of manganese sulphate are to be made; P2O5 and K2O can be broadcast or banded with N. For Deep Mucks, band or broadcast the required amount of fertilizer.

USA: Idaho

N recommendations vary from 22 to 337 kg/ha N based on the calculation:

$$\text{Requirement} = \frac{\text{Crop need - (mineralized N + soil test N)}}{\text{0.65 (\% recovery fertilizer N)}}$$

Idaho - P2O5 recommendations		
Soil test P 0 - 30 cm ppm	**kg/ha P2O5**	
	< 5 % free lime	**>15 % free lime**
5	180	450
10	90	360
20	0	180
30	0	0

Idaho - K2O recommendations	
Soil test K 0-30 cm ppm	**kg/ha K2O**
0	270
55	180
100	90
>158	0

Some N is applied in irrigation water. P2O5 and K2O can be applied in the autumn before planting of the spring potato crop.

Recommendations are not specifically given for sulphur but, where the level of S04-S in the 0-30 cm soil depth is less than 8 ppm, then treatment is advised in the form of water-soluble sulphate.

Canada

General recommendations for the Atlantic regions are:

kg/ha		
N	**P2O5**	**K2O**
110-150	120-180	120-180

Mg fertilization is rarely required.

India

Fertilizer recommendations based on data from the Departments of Horticulture of the various states				
State	**N**	**P2O5**	**K2O**	**farmyard manure t/ha**
	kg/ha			
Andhra Pradesh	100*	50	100	25-30
Assam				
- Irrigated	60	100	100	10
- Rainfed	60	50	50	10
Bihar	120*	80	60	20-30
Haryana	125-150*	50	100	50
Karnataka				
- Irrigated	125*	100	125	25
- Rainfed	75*	100	125	25
Madhya Pradesh	150*	100	100	25
Maharashtra	100	70	50	40-50
Punjab	125*	62	125	100
Orissa	100	62	100	-
Tamil Nadu	100	125	50	15
Uttar Pradesh	120*	80	100	20-30
West Bengal	150-200*	100-150	100-150	15
* Split application of N recommended				
Source : Tandaon, 1987				

South Africa

N recommendations		
Predicted yield t/ha	**kg/ha N**	
	Dryland	**Irrigation**
15	70	100
30	130	150
45	170	200
52	200	230

P2O5 recommendations		
Yield potential t/ha	**P2O5 status in soil**	**kg/ha P2O5**
10	a	30-100
20	b	40-115
30	c	50-130
40	d	60-145
50	e	70-160
a = ambic 0-4; Bray 1 0-5; Olsen 0-3 ppm P2O5		
e = ambic 20+; Bray 1 25+; Olsen 15 ppm P2O5		

Required K is calculated from cation exchange capacity and soil analysis. Mg and Ca are applied as dolomitic or calcitic limestone.

Other countries

Country	kg/ha		
	N	P2O5	K2O
Europe			
Austria	120	60	100
Hungary	138	125	236
Ireland	88	181	233
Poland	95	70	140
Asia			
Japan	120	152	136
South Korea	87	53	54
Sri Lanka	125	160	125
America			
Colombia	85	175	40
Dominican Republic	95	95	95
Venezuela	120-150	150-300	150-225
Africa			
Mauritius	78	78	120
Zimbabwe	0-160	0-310	0-130
Abstracted from International Potash Bureau Bulletin 8, 1983			

Further reading

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